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Proposed Indicators for 2007 Report on the Environment (ROE 2007)

Chapter 1 (Air)

- Peer Review Charge - Air Indicators (PDF, 117KB, 19 pages)

Outdoor Air

- Acid Deposition (PDF, 286KB, 9 pages)
- Air Toxics Emissions (PDF, 64KB, 8 pages)
- Ambient CO Concentrations (PDF, 231KB, 8 pages)
- Ambient NO2 Concentrations (PDF, 200KB, 9 pages) New!
- Ambient Concentrations of a Selected Air Toxic: Benzene (PDF, 106KB, 7 pages)
- Ambient Concentrations of Manganese Compounds (PDF, 69KB, 7 pages) Updated!
- Ambient Lead Concentrations (PDF, 110KB, 7 pages)
- Ambient Ozone Concentrations (PDF, 552KB, 11 pages)
- Ambient PM Concentrations (PDF, 476KB, 11 pages)
- Atmospheric Concentrations of Greenhouse Gases (PDF, 128KB, 9 pages)

- Atmospheric Deposition of Mercury (PDF, 152KB, 8 pages)
- CO Emissions (PDF, 177KB, 9 pages)
- Concentrations of Ozone-depleting Substances (PDF, 59KB, 5 pages)
- Number and Percent of Days with AQI values greater than 100 (PDF, 219KB, 9 pages)
- Lead Emissions (PDF, 82KB, 8 pages)
- Mercury Emissions (PDF, 63KB, 8 pages)
- NOx Emissions (PDF, 150KB, 9 pages)
- Ozone and PM for US/Mexico Border Counties (PDF, 89KB, 12 pages) **Updated!**
- Ozone Injury to Forest Plants (PDF, 89KB, 7 pages)
- Ozone Levels over North America (PDF, 140KB, 6 pages)
- PM Emissions (PDF, 252KB, 12 pages)
- SO2 Emissions (PDF, 148KB, 9 pages)
- U.S. Greenhouse Gas Emissions (PDF, 88KB, 10 pages)
- Visibility (PDF, 108KB, 8 pages)
- VOC Emissions (PDF, 171KB, 9 pages)

Indoor Air

- Blood Cotinine Level (PDF, 72KB, 7 pages)
- US Homes Above EPA's Radon Action Level (PDF, 61KB, 6 pages)

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Chapter 2 (Water)

- Peer Review Charge - Water Indicators (PDF, 109KB, 18 pages)

Water and Watersheds

- Benthic Macroinvertebrates in Wadeable Streams (PDF, 124KB, 8 pages) **New!**
- Chesapeake Bay Blue Crabs: Mature Females - Spawning Stock Abundance (PDF, 60KB, 7 pages)
- Coastal Benthic Index (PDF, 127KB, 7 pages)
- Coastal Condition Index (PDF, 143KB, 5 pages)
- Coastal Habitat Index (PDF, 59KB, 6 pages)
- Coastal Sediment Quality Index (PDF, 66KB, 8 pages) **Updated!**
- Coastal Water Quality Index (PDF, 141KB, 7 pages)
- Extent of Hypoxia in the Gulf of Mexico and Long Island Sound (PDF, 154KB, 13 pages)
- Harmful Algal Bloom Outbreaks (PDF, 62KB, 7 pages) **Updated!**

- Lake & Stream Acidity (PDF, 121KB, 6 pages)
- Nitrate and Pesticides in Groundwater in Agricultural Watersheds (PDF, 85KB, 11 pages)
- Submerged Aquatic Vegetation in Chesapeake Bay (PDF, 78KB, 7 pages)
- Wetland Extent, Change, and Sources of Change (PDF, 357KB, 13 pages)
- Nitrate, Phosphorus, and Pesticides in Streams in Agricultural Watersheds (PDF, 103KB, 13 pages)
- Nitrogen and Phosphorus Discharges from Large Rivers (PDF, 116KB, 15 pages)
- Nitrogen and Phosphorus in Wadeable Streams (PDF, 181KB, 8 pages) New!
- Streambed Stability in Wadeable Streams (PDF, 119KB, 8 pages) New!

Drinking Water

- Populations Served by Community Water Systems with No Reported Health-Based Violations (PDF, 137KB, 11 pages)

Consumption of Fish and Shellfish

- Coastal Fish Tissue Contaminants Index (PDF, 161KB, 7 pages)
- Contaminants in Lake Fish Tissue (PDF, 192KB, 13 pages) New!

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Chapter 3 (Land)

- Peer Review Charge - Land Chemical Indicators (PDF, 100KB, 16 pages)
- Peer Review Charge - Land Waste Indicators (PDF, 100KB, 16 pages)

Land Cover

- Forest Extent and Type (PDF, 86KB, 9 pages)
- Land Cover (PDF, 178KB, 9 pages)

Land Use

- Land Use (PDF, 82KB, 10 pages)
- Urbanization and Population Change (PDF, 91KB, 10 pages)

Chemicals

- Fertilizer Applied for Agricultural Purposes (PDF, 61KB, 8 pages)
- Pesticide Poisonings (PDF, 58KB, 7 pages)
- Pesticide Residues in Food (PDF, 77KB, 10 pages)
- Pesticide Resistant Arthropod Species (PDF, 53KB, 6 pages)
- Reported Toxic Chemicals in Wastes Released, Treated, Recycled, or Recovered for Energy Use (PDF, 217KB, 8 pages)

Waste

- Quantity of Municipal Solid Waste Generated and Managed (PDF, 81KB, 8 pages)
- Quantity of RCRA Hazardous Waste Generated and Managed (PDF, 72KB, 7 pages)

Contaminated Lands

- Contaminated Groundwater Under Control on Contaminated Lands (PDF, 79KB, 8 pages)
- Human Exposure Under Control on Contaminated Lands (PDF, 63KB, 8 pages)

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Chapter 4 (Human Health)

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Health Status

- General Mortality (PDF, 151KB, 6 pages)
- Infant Mortality (PDF, 200KB, 7 pages)
- Life Expectancy (PDF, 72KB, 6 pages)

Human Disease and Conditions

- Asthma Prevalence & Mortality (PDF, 155KB, 13 pages)
- Birth Defects Incidence and Mortality (PDF, 309KB, 12 pages)
- Cancer Incidence & Mortality (PDF, 214KB, 15 pages)
- Childhood Asthma Prevalence & Mortality (PDF, 171KB, 12 pages)
- Childhood Cancer Incidence & Mortality (PDF, 169KB, 12 pages)
- COPD Mortality (PDF, 178KB, 12 pages)
- CVD Mortality (PDF, 146KB, 12 pages)

- Infectious Gastrointestinal and Arthropod-Borne Disease Prevalence (PDF, 74KB, 7 pages)
- Low Birthweight (PDF, 85KB, 6 pages)
- Preterm Delivery (PDF, 64KB, 7 pages)

Biomeasures of Exposure

- Blood Lead Level (PDF, 86KB, 7 pages)
- Blood Mercury Level (PDF, 96KB, 7 pages)
- Blood Cadmium Level (PDF, 83KB, 7 pages)
- Blood POPs Level (PDF, 94KB, 9 pages)
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- Urinary Pesticide/Herbicide level (PDF, 89KB, 9 pages)

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Chapter 5 (Ecological Condition)

- Peer Review Charge - Ecological Condition Indicators (PDF, 143KB, 24 pages)

Extent and Distribution of Ecological Systems

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- Extent of Coral Reef Cover (PDF, 101KB, 9 pages)
- Forest Pattern and Fragmentation (PDF, 67KB, 6 pages)
- Land Cover Change in the Puget Sound Basin (PDF, 263KB, 8 pages)
- Relative Ecological Condition of Undeveloped Land (PDF, 205KB, 6 pages)

Diversity and Biological Balance

- Bird Populations (PDF, 72KB, 7 pages)
- Fish Faunal Intactness (PDF, 496KB, 7 pages)
- Non-Indigenous Species in the Estuaries of Oregon and Washington (PDF, 56KB, 8 pages)
- Terrestrial Plant Growth Index (PDF, 105KB, 10 pages)
- Threatened and Endangered Species (PDF, 92KB, 5 pages)

Ecological Processes

- Forest Disturbance (PDF, 84KB, 12 pages)

Critical Physical and Chemical Attributes

- Changing Streamflows (PDF, 127KB, 14 pages)
- Carbon Storage in Forests (PDF, 71KB, 11 pages)
- Sea Level (PDF, 269KB, 13 pages) New!
- Sea Surface Temperature (PDF, 208KB, 10 pages) New!
- US and Global Mean Temperature and Precipitation (PDF, 594KB, 8 pages)

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Charge to the Peer Reviewers: Air and Other Relevant Indicators for the U.S. Environmental Protection Agency's 2007 *Report on the Environment* Technical Document May 20, 2005

The U.S. Environmental Protection Agency (EPA) has asked that independent peer reviewers critically review the indicators that the Agency proposes to use for its 2007 *Report on the Environment*—Technical Document (ROE07 TD). The purpose of this peer review is to ensure that the proposed indicators are appropriate, adequate, and useful for evaluating our nation's air in general; useful for answering the questions posed in ROE07; meet technical requirements (including the indicator definition and criteria); are properly documented; and are scientifically sound. Separate peer reviews will be conducted for the indicators proposed for each of the five main chapters in the ROE07. This charge provides background and instructions for peer review of the *air* indicators. It includes the following sections and attachments:

- Section 1: Background information on ROE07 TD
- Section 2: Indicator definition and criteria
- Section 3: Charge and materials for the individual pre-workshop review
- Section 4: The peer review meeting
- Attachment 1: Questions and Proposed Indicators for the ROE07 Technical Document
- Attachment 2: Comment Sheet for Group 1 Indicators
- Attachment 3: Comment Sheet for Group 2 Indicators
- Attachment 4: Comment Sheet for General Questions for Group 1 and 2 Indicators
- Attachment 5 Comment Sheet for Group 3 Indicator
- Attachment 6: List of and EPA Rationale for Withdrawn ROE03 Indicators (will be posted by 6/10/05)
- Attachment 7: Indicator Materials for Review (included as subsequent sections of this binder).

Section 1: Background

In 2003, EPA published its first draft *Report on the Environment* (ROE03). ROE03 is a set of two question-driven reports comprising:

- A Technical Document (TD), which provides the scientific foundation for the ROE.
- A shorter Public Document that distills information in the TD for a non-technical audience.

These two reports were intended to identify and present the best available national-level indicators to help answer broad questions about the state of the nation's environment in five topic areas (chapters): air, water, land, human health, and ecological condition. In addition to reporting what we know, the ROE03 was also intended to point out where current data and understanding fall short of fully answering the questions in terms of delivering national, consistent, comprehensive data about the state of the nation's air, water, land, human health, and ecological condition. The ROE03 also presented some contextual information from other scientific sources in order to provide background and explain indicator data gaps.

EPA's Administrator has requested that the generation of Reports on the Environment be continued into the future. Current plans are for future reports to be developed on an approximately 3-year reporting cycle. To support the next anticipated ROE release in 2007, EPA has compiled a set of proposed indicators to help answer the questions posed for the 2007 Technical Document. EPA proposes reporting on both national-level indicators, national-level indicators that are provided at the scale of EPA regions, as well as several region-level indicators. As with ROE03, the questions are organized into five topic areas: air, water, land, human health, and ecological condition. There will be a separate chapter in the ROE07 Technical Document for each topic area. Each chapter will describe the set of questions for the topic area and the indicators that answer those questions.

Many of the indicators proposed for ROE07 were presented in ROE03, but some are new and others have new data sources. In addition, after refining the indicator definition and criteria (see boxes on the following pages), and applying both more consistently to the proposed indicator list, EPA recommends that some indicators from ROE03 not be presented in 2007.

To ensure that the indicators presented in the ROE07 TD are supported by data that are technically sound, meet the established indicator definition and criteria, and help answer the questions posed in the ROE, EPA has contracted with ERG to organize an independent peer review of the proposed ROE07 indicators.

Reviewers for the air indicators are charged with four tasks:

1) Assess whether the proposed air indicators are appropriate, adequate, and useful for evaluating and establishing an overall picture of our nation's air.

2) Evaluate the proposed indicators with respect to their importance in terms of their ability to respond to the question.

3) Evaluate the proposed air and related indicators and their underlying data with respect to the ROE indicator definition and criteria presented below.

4) Identify any additional *national-level* air indicators that currently exist which meet the ROE indicator definition and criteria, help to answer one of the ROE questions, and for which data are readily available such that text and graphics describing the indicator could be developed within a short time frame (approximately 6 weeks).

Section 2: Indicator Definition and Criteria

Each indicator in ROE07 should conform to the following definition.

Definition: Indicator

For purposes of the ROE, an “indicator” is ***a numerical value derived from actual measurements of a pressure, ambient condition, exposure, or human health or ecological condition*** *over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment*. Indicators and their underlying data must meet criteria (see box below) for data quality, comparability, representativeness, and adequate coverage in time and space. Note that indicators rely on an underlying database or set of databases, but the databases themselves are not indicators.

In the above definition, "derived from" means that trends in *actual environmental observations* (e.g., rather than estimates or projections) must serve as the principal driver for trends in the indicators.

EPA has defined six indicator levels, as follows. Note that levels 1 and 2 are administrative indicators that measure progress in implementing environmental programs, and compliance with or response to those programs. They are *not* the subject of ROE07. Levels 3 through 6 indicators reflect environmental results/condition and are the subject of ROE07.

Description of Indicator Levels

Level 1 (Administrative—not covered by ROE07): Government Regulations/Activities. Examples: policy leadership, statutes, regulations, guidance, information.

Level 2 (Administrative—not covered by ROE07): Actions/Responses by Regulated and Non-regulated Parties. Examples: Pollution prevention and control, recycling, changes in consumer behavior, best management practices.

Level 3 (Environmental): Changes in Pressure or Stressor Quantities. Examples: Pollutants entering media, habitats altered or destroyed, hydrologic alteration.

Level 4 (Environmental): Ambient Conditions. Examples: Pollutant concentrations in media, food and drinking water, solid wastes in landfills, radiation; temperature, habitat condition, hydrology.

Level 5 (Environmental): Exposure or Body Burden/Uptake. Examples: Biological markers of uptake in people, plants, animals, or microorganisms.

Level 6 (Environmental): Changes in Human Health or Ecological Condition. Examples: Morbidity, mortality, biotic structure, and ecological processes.

Each indicator in ROE07 should conform to the following criteria:

Indicator Criteria

1) The indicator makes an important contribution to answering a question for the ROE. (In this context, "important" means that the indicator answers a substantial portion of and/or a critical part of the question.)
2) The indicator is objective. It is developed and presented in an accurate, clear, complete, and unbiased manner.
3) The underlying data are characterized by sound collection methodologies, data management systems that protect their integrity, and quality assurance procedures.
4) Data are available to describe changes or trends, and the latest available data are timely.
5) The data are comparable across time and space, and representative of the target population. Trends depicted in this indicator accurately represent the underlying trends in the target population.
6) The indicator is transparent and reproducible. The specific data used and the specific assumptions, analytic methods, and statistical procedures employed are clearly stated.

Section 3: Charge and Materials for the Individual Pre-Workshop Review

Attachment 1 lists all the ***proposed questions*** and ***associated indicators*** for the 2007 ROE by topic area. Pages 1 to 2 list the indicators to be reviewed by air reviewers. Note that, for review purposes, there are three groups of indicators:

- **Group 1: Proposed Air Indicators.** Indicators that are proposed to answer one of the three questions posed in the air chapter *and* that will be *written up in that chapter*.

- **Group 2: Two Air Indicators That Are Also Being Reviewed by Other Reviewers.** Two air indicators are being given a Group 1-level review by reviewers for another chapter. Air reviewers will provide a more abbreviated review of these two indicators.

- **Group 3: One Air-related Indicator from the Ecological Condition Chapter.** This indicator is *proposed to answer a question in the ecological condition chapter* and will be written up in that chapter, but peer-reviewed by air reviewers because it is air-related.

The materials and instructions for reviewing each group of indicators are described below. Please conduct the review in the sequence indicated. Forms are provided as Attachments 2 through 5 to this charge to structure your review. Attachment 6 provides background for Step 3, below. The materials to be reviewed are provided in Attachment 7.

Step 1: Review Group 1 Indicators

For each indicator in Group 1, Attachment 7 provides:

- *Draft text* introducing the indicator, identifying the underlying data used to evaluate the indicator, and describing data interpretations. EPA proposes including this text in the ROE07 TD.

- *Draft graphic(s)/table(s)* to help readers visualize spatial and temporal trends in the indicator. EPA proposes including these graphics in the ROE07 TD.

- *An information quality review form* that presents detailed background information on the indicator and its supporting data (e.g., data quality, coverage, processing). EPA documents this information for the overall project record and to facilitate peer review of the indicators.

Collectively, these three items should adequately present each indicator and thoroughly document the information that EPA considered when evaluating the indicators for ROE07. For each indicator in this category, you should thoroughly review the draft text, draft graphics/tables, and information quality review forms provided. Then, document your review comments by filling out the "Comment Sheet" in Attachment 2 *for each indicator*.

This sheet asks you a series of questions about each indicator. For questions 1 through 4, you are asked to provide a numerical response on a scale of 1 to 4 and then a written explanation of the rationale for your numerical response. Question 5 asks about graphical presentation and question 6 asks you to provide any other comments, concerns, or suggestions about the indicator that you did not already cover in your responses to Questions 1 through 5. Question 7 asks you to state whether you think the indicator merits inclusion in ROE07.

Step 2: Review Group 2 Indicators

Group 2 comprises two air indicators that are receiving a Group 1-level review by other reviewers because they is fall within their area of expertise. For each Group 2 indicator, Attachment 7 provides the draft text, associated graphic(s), and information quality review form. Note that:

- The information quality review forms for these indicators are provided *as background only. You do not need to review them and you are not required to read them.* They are there for your perusal if you are interested.

- Other reviewers will be responding to the full suite of Attachment 2 review questions for these indicators. Therefore*, you do not need to consider or answer the Attachment 2 questions for these indicators*.

You are asked to read the text and graphic that present each indicator and to state:

- The appropriateness and usefulness of the indicator, and the extent to which you think this indicator contributes to answering the specific question in your topic area that it is referenced as answering.

- Any other comments or suggestions you may have concerning this indicator.

Attachment 3 provides a form for you to fill out *for each indicator in this category*.

Step 3: Consider General Questions for Group 1 and 2 Indicators

After completing your reviews for the individual Group 1 and 2 indicators, as described above, please use Attachment 4 to answer the following two questions for these indicators:

- **General Question 1:** Considering the Group 1 and Group 2 indicators collectively, do any of these indicators clearly seem to be more appropriate, adequate, or useful for evaluating our nation's air or for establishing an overall picture of our nation's air than others? Do any seem to be more important than the others for answering the question they are intended to answer? Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators or if it covers an area of diminishing interest environmentally.

- **General Question 2:** Are there any additional *national-level* indicators that currently exist, but were not proposed for ROE07, that you would recommend for ROE07? Proposed indicators should meet the ROE indicator definition and criteria, be national in scale, make an important contribution to answering one of the ROE questions in your topic area, be of a quality that likely would pass this type of peer review, and have data that are readily available (i.e., could be compiled within 6 weeks or less). For any new indicators proposed, provide detailed justification for their inclusion and list references or citations for the associated underlying data sources. As you consider this question, please read Attachment 6, which provides the list of air and other indicators presented in ROE03 that EPA does not intend to carry forward to ROE07, along with EPA's rationale for withdrawing them. If you disagree with EPA's rationale and feel any of these indicators should be included in ROE07, please so indicate in your response to this question, along with your rationale for why they should be included. Note: The full text and graphics for the ROE03 indicators can be viewed on-line at: http://www.epa.gov/indicators/roe/html/tsd/tsdAir.htm

Step 4: Review Group 3 Indicator

Group 3 consists of one indicator that is *proposed to answer a question in another chapter* and will be written up in that chapter, but peer-reviewed by air reviewers since it is related to air. You are asked to review this indicator in the same way you reviewed Group 1 indicators under Step 1. For the Group 3 indicator, Attachment 7 provides:

- *Draft text* introducing the indicator, identifying the underlying data used to evaluate the indicator, and describing data interpretations.

- *Draft graphic(s)/table(s)* to help readers visualize spatial and temporal trends in the indicator.

- *An information quality review form* that presents detailed background information on the indicator and its supporting data (e.g., data quality, coverage, processing).

Collectively, these three items should adequately present the indicator and thoroughly document the information that EPA considered when evaluating the indicators for ROE07.
For the Group 3 indicator, you should thoroughly review the draft text, draft graphic/table, and information quality review form in Attachment 7. Then, document your review comments by filling out the “Comment Sheet” in Attachment 5.

Preparing for the Peer Review Workshop

After receiving the reviewers’ pre-meeting comments, ERG will compile these comments and distribute them to all peer reviewers. Please familiarize yourself with the pre-meeting comments of the other air peer reviewers prior to the peer review workshop.

Note that the pre-meeting comments are preliminary in nature and are intended to help initiate discussion at the peer review meeting. Reviewers may change their comments based on discussion at the peer review meeting.

Section 4: The Peer Review Meeting

Most of the peer review meeting will take place with the peer reviewers split into breakout groups by topic area. Within each group, reviewers will consider the same questions they answered individually in their pre-meeting comments:

- Reviewers will discuss the merits of the individual Group 1 and 3 indicators based on responses provided on the “Comment Sheets” and, where possible, agree on a composite score for each indicator.

- Then, considering the Group 1 and 2 indicators collectively, reviewers will identify any indicators that clearly do not seem to be on the same level of importance as the other indicators.

- Finally, reviewers will discuss and, where possible, reach agreement on any possible other national-level indicators they believe EPA should consider for the ROE07 TD.

ERG will prepare a summary report of the discussions at the peer review workshop. This report will document the peer reviewers’ final conclusions and recommendations regarding the indicators for ROE07 TD. You will have a chance to check ERG’s draft report of the meeting for accuracy and completeness before it is finalized.

Attachment 1:

Questions and Proposed Indicators for the ROE07 Technical Document

Attachment 2: Comment Sheet for Group 1 Indicators

Please fill out a separate sheet for each Group 1 indicator.

Your Name: ______________________________
Topic Area: **Air**
Indicator Name: ____

1) Please indicate the extent to which you think the proposed indicator is appropriate, adequate, and useful (AA&U) for evaluating our nation's air and therefore useful for contributing to an overall picture of our nation's air.

1	2	3	4
Indicator is not AA&U	Indicator is of somewhat AA&U	Indicator is largely AA&U	Indicator is completely AA&U

Comments:

2) Please indicate the extent to which you think the proposed indicator makes an important contribution to answering the specific ROE question it is intended to answer (see Attachment 1 for list of questions). (Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators, or if it covers an area of less or diminishing importance environmentally.)

1	2	3	4
Indicator is not important	Indicator is of minor importance	Indicator is important	Indicator is critical

Comments:

3) To what extent do you think the indicator meets the following <u>indicator definition</u>:

> *An "indicator" is* ***a numerical value derived from actual measurements of a pressure, ambient condition, exposure, or human health or ecological condition*** *over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment.*

1	2	3	4
Doesn't meet the definition	Only partly meets the definition	Largely meets the definition	Fully meets the definition

Please explain:

4) To what extent do you think the indicator meets each of the following <u>indicator criteria</u>:

a) The indicator makes an important contribution to answering a question for the ROE. (In this context, "important" means that the indicator answers a substantial portion of and/or a critical part of the question.)

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

b) The indicator is objective. It is developed and presented in an accurate, clear, complete, and unbiased manner.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

c) The underlying data are characterized by sound collection methodologies, data management systems that protect its integrity, and quality assurance procedures.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

d) Data are available to describe changes or trends, and the latest available data are timely.

1	2	3	4
Doesn’t meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

e) The data are comparable across time and space, and representative[1] of the target population. Trends depicted in this indicator accurately represent the underlying trends in the target population.

1	2	3	4
Doesn’t meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

f) The indicator is transparent and reproducible. The specific data used and the specific assumptions, analytic methods, and statistical procedures employed are clearly stated.

1	2	3	4
Doesn’t meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

Please explain:

[1] An indicator seeks to describe trends in an overall target “population” (e.g., land area, type of surface water, type of emissions, U.S. population), yet data often can only be sampled from a subset of this population. The validity of the trends described by the indicator will depend on the degree to which the sampled population is representative of the target population.

5) Do you have any suggestions for more effective graphic presentation of the data? If yes, please describe.

6) Please provide any additional comments, suggestions, or concerns regarding the indicator that you have not already noted in Questions 1 through 5. In particular, note any limitations to the indicator that you have not already described in your responses to the preceding questions.

7) Overall, this indicator:

_____ Should be included in ROE07 TD.

_____ Should be included in ROE07 TD with the modifications identified above.

_____ Should *not* be included in ROE07 TD.

Attachment 3: Comment Sheet for Group 2 Indicators

Please fill out a separate sheet for each Group 2 indicator.

Your Name: ______________________________
Topic Area: **Air**
Indicator Name: ______________________________

1) To what extent do you agree with this statement:

   This indicator is appropriate, adequate, and useful (AA&U) for evaluating our nation's air and therefore useful for contributing to an overall picture of our nation's air.

1	2	3	4
Indicator is not AA&U	Indicator is of somewhat AA&U	Indicator is largely AA&U	Indicator is completely AA&U

Comments:

2) To what extent do you agree with this statement:

   This indicator makes an important contribution[2] to answering the specific ROE question it is intended to answer (see Attachment 1 for list of questions).

1	2	3	4
Indicator is not important	Indicator is of minor importance	Indicator is important	Indicator is critical

Comments:

3) Please provide any additional comments, suggestions, or concerns regarding the indicator that you may have.

[2] Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators, or if it covers an area of less or diminishing importance environmentally.

Attachment 4: Comment Sheet for General Questions for Group 1 and 2 Indicators

Your Name: ______________________________
Topic Area: **Air**

1) Considering the Group 1 and 2 indicators *collectively*, do any of these indicators clearly seem to be more appropriate, adequate, or useful for evaluating our nation's air or for establishing an overall picture of our nation's air than others? Do any seem to be more important than the others for answering the question(s) they are intended to answer? (Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators or if it covers an area of diminishing interest environmentally.)

2) Are there any additional ***national-level*** indicators that make an important contribution to answering one of the ROE questions in your topic area, but were not proposed for ROE07, that you would recommend? (Proposed indicators should meet the ROE indicator definition and criteria, be national in scale, be of a quality that likely would pass this type of peer review, and have data that are readily available. For any new indicators proposed, provide justification for their inclusion and list references or citations for the associated underlying data sources.)

   As you consider this question, ***please read Attachment 6***, which provides the list of air and other indicators presented in ROE03 that EPA does not intend to carry forward to ROE07, along with EPA's rationale for withdrawing them. If you disagree with EPA's rationale and feel any of these indicators should be included in ROE07, please so indicate in your response to this question, along with your rationale for why they should be included. Note: The full text and graphics for the ROE03 indicators can be viewed on-line at: http://www.epa.gov/indicators/roe/html/tsd/tsdAir.htm

Attachment 5: Comment Sheet for Group 3 Indicator

Your Name: ______________________________
Topic Area: **Ecological Condition**
Indicator Name: U.S and Global Mean Temperature and Precipitation

1) To what extent do you think the indicator meets the following indicator definition:

An "indicator" is ***a numerical value derived from actual measurements of a pressure, ambient condition, exposure, or human health or ecological condition*** *over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment*.

1	2	3	4
Doesn't meet the definition	Only partly meets the definition	Largely meets the definition	Fully meets the definition

Please explain:

2) To what extent do you think the indicator meets each of the following indicator criteria:

a) The indicator makes an important contribution to answering a question for the ROE. (In this context, "important" means that the indicator answers a substantial portion of and/or a critical part of the question.)

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

b) The indicator is objective. It is developed and presented in an accurate, clear, complete, and unbiased manner.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

c) The underlying data are characterized by sound collection methodologies, data management systems that protect its integrity, and quality assurance procedures.

1	2	3	4
Doesn’t meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

d) Data are available to describe changes or trends, and the latest available data are timely.

1	2	3	4
Doesn’t meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

e) The data are comparable across time and space, and representative[3] of the target population. Trends depicted in this indicator accurately represent the underlying trends in the target population.

1	2	3	4
Doesn’t meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

f) The indicator is transparent and reproducible. The specific data used and the specific assumptions, analytic methods, and statistical procedures employed are clearly stated.

1	2	3	4
Doesn’t meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

Please explain:

[3] An indicator seeks to describe trends in an overall target “population” (e.g., land area, type of surface water, type of emissions, U.S. population), yet data often can only be sampled from a subset of this population. The validity of the trends described by the indicator will depend on the degree to which the sampled population is representative of the target population.

3) Do you have any suggestions for more effective graphic presentation of the data? If yes, please describe.

4) Please provide any additional comments, suggestions, or concerns regarding the indicator that you have not already noted in Questions 1 through 3. In particular, note any limitations to the indicator that you have not already described in your responses to the preceding questions.

5) Overall, this indicator:

_____ Should be included in ROE07 TD.

_____ Should be included in ROE07 TD with the modifications identified above.

_____ Should *not* be included in ROE07 TD.

Attachment 6: List of and EPA Rationale for Withdrawn ROE03 Indicators

Background:
A number of indicators were included in EPA's 2003 Draft Report on the Environment (DROE03) that are not proposed to be included in ROE07. The general reasons for these changes are described below, followed by indicator-specific explanations.

> EPA's Science Advisory Board Committee review of the DROE03 recommended EPA develop and utilize a more precise definition of "indicator" than was used for DROE03.
>
> EPA developed a set of specific indicator criteria to provide a more precise conformance to Office of Management and Budget (OMB) and EPA Information Quality Guidelines.
>
> The ROE07 introduced a Regional Pilot Project and developed and implemented a relevant process. Sub-national or regional indicators that were included in DROE03 but did not go through this pilot are not recommended to be included in ROE07.

When screened against these factors, the ROE07 development team identified a small number of the indicators in DROE03 that did not appear to conform to one or more of these requirements. A group decision was made that developing indicator write-ups, quality forms, and graphics for these indicators was not the best use of team resources. Broadly speaking, the rationales for withdrawal fall into four categories, coded as follows:

> **(D) Definition** – The indicator fails to meet the improved indicator definition for ROE07 (most often because the indicator was a level 1 or 2 indicator, rather than a level 3, 4, 5, or 6 indicator).
>
> **(C) Criteria** – The indicator fails to meet one of the six indicator criteria that were established to conform with EPA Information Quality Guidelines.
>
> **(N) New indicator** – The indicator is replaced by a "new" and superior indicator that was not available for the DROE03.
>
> **(R) Regional –** The indicator is not national in scope and is not part of the ROE07 EPA Regional Pilot Project.

The following information briefly explains the rationale for excluding specific indicators from development for the ROE07 Indicator Peer Review. Each indicator is categorized as D, C, N, or R. The indicators are organized by general peer review topic.

Air

Production of Ozone Depleting Substances - C

This DROE03 indicator presents estimates of the amount of ODSs produced worldwide in 1986 and 1999, and annual U.S. production from 1958 to 1993. This indicator is being withdrawn because of issues concerning data reliability and relevance. Global ODC production data are not reliable with respect to comparability among reporting countries. The US estimates are more reliable because of legal reporting requirements and the small number of sources. However, the data set fails to account for imports, and annual production is not a good surrogate for emissions of ODCs into the environment because of the time between production and eventual entry into the environment is highly variable among the various products and recovery systems.

Number of People Living in Counties with Ambient Air Concentrations Above the NAAQS - C

This DROE03 indicator conveyed how many people (based on census) lived in counties where air pollutant levels at times were above the level of the NAAQS during the year stated. It was intended to give the reader some indication of the number of people potentially exposed to unhealthy air. Because of changing populations and air quality standards, however, this indicator masks actual trends in the levels of air pollutants. It is not a valid exposure indicator because it is not based on measurement of an actual marker of exposure measured on individuals.

Percent of Population Living in Homes Where Someone Smokes Regularly Inside the Home - D

This DROE indicator portrayed the percentage of homes in the U.S. in which young children were exposed to tobacco smoke in 1998 versus 1957. The survey is based on a questionnaire (do children live in the home, and does someone who smokes regularly live in the home), rather than on actual measurements of the amount of smoke actually present or the degree to which children are exposed to the resulting smoke. This indicator violates the ROE indicator definition, requiring that indicators be based on actual measurements, and blood cotenine (Indicator 102) provides a better indicator of children’s exposure to smoke.

Water

Altered Fresh Water Ecosystems – C
Percent Urban Land Cover in Riparian Areas – C
Agricultural Lands in Riparian Areas - C

These DROE03 indicators are based on the percentage of land within 30 m of the edge of a stream or lake that is classified as urban or agriculture based on 1991 satellite data (NLCD). Baseline data are incomplete, and there are no reference points for the appropriate percentage of such cover, and it is not clear that the indicators could be reproduced with newer satellite data. There are no data for other alterations such as damming, channelization, etc.

Number of Watersheds Exceeding Criteria for Mercury, PCBs, & Dioxin – C

This DROE03 indicator is based on voluntary reporting of Hg contamination using data that has not undergone formal QA/QC review. It is not representative of the nation, or suitable for trend monitoring.

Lake Trophic State Index – R, C

This DROE03 indicator is based on phosphorous data collected in a one-time a statistical sample of lakes in the Northeast US during 1991-94. It is not included in the ROE07 Regional Pilot Project.

Sedimentation Index – R, C

This DROE03 indicator is based on data collected on freshwater streams in the Mid Atlantic Highlands Region during a one-time 1993-94 statistical survey. It is not included in the ROE07 Regional Pilot Project.

Contaminants in Fresh Water Fish (NAWQA) – C

This DROE03 indicator is based on reported concentrations of contaminants in fish collected by the US Geological Survey NAWQA program. While the data are collected from a large number of streams and are of high and consistent quality, the sample is not statistically representative of the nation, there are no national guidelines to serve as reference values for tissue concentrations, and Cycle II of NAWQA will not include comparable routine monitoring of trace organics and trace elements in fish tissues at sampling sites across the Nation.

Fish Index of Biotic Integrity – R, C

This DROE03 indicator is based on fish community data collected on freshwater fish in the Mid Atlantic Highlands Region during a one-time1993-96 statistical survey. Condition cannot be assessed in streams where no fish were caught, because data were insufficient to indicate whether the stream had poor quality or simply no fish. It is not included in the ROE07 Regional Pilot Project.

Macroinvertebrate IBI (MAIA) – R, C

This DROE03 indicator is based on benthic macroinvertebrate community data collected in freshwater streams in the Mid Atlantic Highlands Region during a one-time 1993-96 statistical survey. It is not included in the ROE07 Regional Pilot Project.

Beach Days Open – D
Waters with Fish Consumption Advisories - D

These DROE03 indicators are based on the frequency of beach closures or fish consumption advisories as reported to EPA voluntarilyby states and local government organizations. The data are not nationally or temporally consistent because of different and changing criteria for closing beaches or issuing fish consumption advisories in the different states, many of which do not involve actual water quality measurements. They are therefore level 1 indicators and fail to meet the definition for ROE indicators.

Contaminated Sediments in Fresh Water - C

This DROE03 indicator is based on reported concentrations of sediment contaminants collected by a large number of organizations focusing particularly on places where sediment contamination is perceived to be a problem (the EPA National Sediment Inventory). The database suffers from a number of limitations: the data are heavily biased toward sites at which there is a known or suspected toxicity problem and to particular geographic areas (non-representative of the nation), the data cover different dates in different locations- making estimation of trends difficult, and the data and procedures used to assign sites to a toxicity category are not uniform from watershed to watershed. It is unsuitable for trend estimation.

Chemical Contamination in Streams and Groundwater – C

This DROE03 indicator is based on data from a large number of NAWQA watersheds. The sampling and analytical protocols (including the analytes measured) are not comparable across all NAWQA watersheds.

Nitrate in Farmland, Forested and Urban Streams and Groundwater
Phosphorus in Farmland, Forested, and Urban Streams – N

These DROE03 indicators are being replaced by two new indicators, "Nitrate, Phosphorus, and Pesticides in Streams in Agricultural Watersheds" and "Nitrate and Pesticides in Groundwater in Agricultural Watersheds." The NAWQA streams in forested and urban watersheds were based on a small sample size, and may not be representative of forested and urban streams in general.

Phosphorus in Large Rivers - C

The indicator is based on phosphorus concentrations in large rivers sampled periodically by the USGS National Stream Quality Accounting Network (NASQAN). Monitoring at many of the large river NASQAN sites has been discontinued.

Chemicals

Sediment Runoff Potential from Croplands and Pasturelands - C

This DROE03 indicator represents the estimated sediment runoff potential for croplands and pasturelands based on topography, weather patterns, soil characteristics, and land-use land cover and cropping patterns for the U.S. and the Universal Soil Loss equation www.brc.tamus.edu/swat. The indicator addresses "potential" and not actual/current condition, and relies on a model to predict ambient characteristics (level 4 indicators) based on level 3 measurements, which violates a fundamental ROE protocol on the use of models in indicators. Trends in this indicator would likely be associated only with trends in land cover, cropping practices, and weather (topography and soil type are unlikely to change). No reliable spatial trend data at the appropriate scale exist for either cropping practices or land cover, and consequently trends in this indicator would be difficult to calculate.

Potential Pesticide Runoff from Fields - C
Pesticide Leaching Potential - C

These DROE03 indicators represent the potential movement of agricultural pesticides from the site of application to ground and surface waters, based on estimates of pesticide leaching and runoff losses derived from soil properties, field characteristics, management practices, pesticide properties, and climate for 243 pesticides applied to 120 specific soils in growing 13 major agronomic crops. The indicators address "potential" and not actual/current condition, and rely on models to predict ambient characteristics (level 4 indicators) based on level 3 measurements, which violates a fundamental ROE protocol on the use of models in indicators.

Risk of Nitrogen Export - C
Risk of Phosphorus Export - C

These DROE03 indicators represent the potential movement of N and P from the site of application to surface waters, based on a large empirical dataset relating land use to N and P observed in receiving streams over several decades at a variety of locations. The indicators address "potential" and not actual/current conditions, and rely on statistical models to predict ambient characteristics (level 4 indicators) based on level 3 measurements, which violates a fundamental ROE protocol on the use of models in indicators.

Pesticide Use - C

Agricultural pesticide usage data, measured at the national aggregate level for all pesticides is very difficult to interpret, given the wide year to year changes in the types of pests being controlled for and changes in agricultural production/chemical usage from year to year. From one time period to another the mix of pesticides changes, pest pressures change, agricultural practices change, agricultural acreage changes, regulatory status of key uses changes, and many other important variables change. Moreover, the effects of pesticide usage are encountered at three levels of the product's life cycle: production, usage, and residues on foods. The geographic distribution of those effects renders difficult the interpretation of national usage levels for all pesticides, taken as a group. While it is of course possible to compare magnitudes of aggregates at different times, the real significance for the environment is in the differences in the content and geographic distribution of the aggregates, not in the magnitude of the aggregate.

Contaminated Lands

Number and Location of Superfund NPL Sites - D

This DROE03 indicator is a category 1 indicator (it represents an administrative decision to force a cleanup, rather than an amount of waste present or removed), and therefore does not meet the ROE07 indicator definition.

Number of RCRA Corrective Action Sites - D

This DROE03 indicator, by itself, is a category 1 indicator (it represents an administrative decision to force a cleanup, rather than an amount of waste present or removed), and therefore does not meet the ROE07 indicator definition. The data are being combined into a new indicator, Quantity of RCRA Hazardous Waste Generated and Managed (which combines information from several DROE03 indicators).

Radioactive Waste Storage and Disposal - C

This DROE03 indicator is based on production and inventory data collected by the Department of Energy. Although the data continue to be collected, they are no longer publicly available post-September 11, 2001; therefore ongoing data trends are not and will not in the future be available for this indicator. Moreover, the earlier data reflected two distinct periods in the history of waste generation in the nuclear weapons complex. The first reflected a period during which wastes and other materials were being generated as an integral part of the production of weapons grade nuclear materials and components. The period after 1989 reflected the cessation of large-scale production of such materials and the initiation of clean-up activities and wastes from those initiatives. Thus, even before the truncation of data in the post 9/11 period, there were significant issues with the comparability of the data over time.

Human Health

Cardiovascular Disease Prevalence - C

This DROE03 indicator was based on data from NHANES III (1988-1994). Currently, no national trend data are available on cardiovascular disease (CVD) prevalence.

Blood VOC – C

This DROE03 indicator was based on a convenience sample whose representativeness cannot be determined or necessarily used as a baseline for future sampling. The indicator is based on detects only, so there is no reference level, and VOCs are cleared from the bloodstream rapidly (~ 1hr), so there is a significant possibility of false negatives, considering that exposures tends to be associated with occupational and indoor settings.

Urinary Arsenic - R
This DROE03 indicator was based on data from EPA Region 5 only, and is not part of the ROE07 Regional Pilot.

Ecological Condition

The Farmland Landscape - C
This DROE03 indicator represents croplands and the forests or woodlots, wetlands, grasslands and shrublands, that surround or are intermingled with them, and the degree to which croplands dominate the landscape http://www.heinzctr.org/ecosystems/farm/lndscps.shtml. The indicator relies on data generated using early 1990's satellite data, and it is unclear whether the definition of "farmland landscape" is sufficiently precise to be replicated independently, especially with respect to any future satellite data availability.

Extent of Estuaries and Coastline – C
This DROE03 indicator is based on remote sensing data, but is unlikely to show trends unrelated to sea level rise and changing tides, so it is not a very useful indicator for trends.

Coastal Living Habitats - C
This DROE03 indicator is based on remote sensing data of coastal wetlands, mudflats, sea-grass beds, etc., but the only system for which a national indicator has been developed is coastal vegetated wetlands, which already is covered in another indicator.

Shoreline Types - C
This DROE03 indicator is based on NOAA's Environmental Sensitivity Index. The index is based on a standardized mapping approach, but coverage is not complete for large parts of the coastline and the data in some of the atlases are more than 15 years old. Consequently, this indicator is not appropriate for measurement of representative, national trends.

Extent of Ponds, Lakes, and Reservoirs – C
This DROE03 indicator is based on data from the USGS National Wetlands Inventory. While these data are based on a valid statistical sampling design, the total amount of surface water is less than half of the area of lakes, reservoirs and ponds greater than 6 acres in size in the USGS National Hydrography Data Set. Until this discrepancy is resolved, the indicator may not satisfy the ROE criteria.

At-Risk Native Species – C
At-Risk Native Grassland and Shrubland Species – C
At-Risk Native Forest Species – C
Populations of Representative Forest Species – C
Non-Native Fresh Water Species – C
At-Risk Fresh Water Plant Communities – C
The Ecological Condition chapter is being restructured from the DROE03 organization per the recommendation of EPA's Science Advisory Board and numerous stakeholders. As such, the chapter

no longer requires that the above indicators be broken out by ecosystem. In addition, the ability to track trends of many of these indicators is currently in question.

Population of Invasive and Non-invasive Bird Species – R
This DROE03 indicator is based on an analysis of USGS Breeding Bird Survey data in grassland and shrubland ecosystems for 5 year periods ranging from the late 1960s to 2000. Because the ecological condition questions are no longer directed at specific ecosystems types, this appears to be a regional indicator. It is not clear at this time that this indicator will be updated.

Bird Community Index – R
This DROE03 indicator is not national in scope or part of the ROE EPA Regional Pilot.

Fish Diversity – R
This DROE03 indicator is based on a statistical sample of fish trawls in Mid-Atlantic estuaries during 1997-98. This indicator is not part of the ROE07 Regional Pilot project, and EMAP is no longer collecting fish samples to support this indicator.

Fish Abnormalities - C
This DROE03 indicator is based on a statistical sample of fish trawls in estuaries in the Atlantic and Gulf, but the data are no longer being collected by EMAP to support this indicator.

Unusual Marine Mortalities – C
This DROE03 indicator is based on voluntary reporting of unusual mortality events to NOAA. Because there is no systematic requirement to report, these data are not suitable to support national trends in the indicator.

Animal Deaths and Deformities – C
This DROE03 indicator is based on data reported by a number of different organizations to USGS on incidences of death or deformities in waterfowl, fish, amphibians, and mammals. Trends are available only for waterfowl, and because data reporting is voluntary rather than systematic, the data are not adequate to determine actual trends versus trends in reporting.

Tree Condition – C
This DROE03 indicator is based on an ongoing statistical sample of forests across the conterminous US and comprises components that relate to crown (tree canopy condition), the ratio of dead to live wood, and the fire class. This indicator likely relates more to forest management practices than to environmental condition, and for this reason has low relevance value to EPA.

Processes Beyond the Range of Historic Variation – C
This DROE03 indicator is based on an analysis of recent Forest Inventory and Analysis data on climate events, fire frequency, and forest insect and disease outbreaks, which were then compared to anecdotal data for the period 1800-1850. Because the early data are anecdotal, and because the data mostly relate to forest management practices, etc., it is proposed that this indicator has low relevance and that trend data are of questionable utility as an ROE indicator.

Soil Compaction – C
Soil Erosion – C
These DROE03 indicator are based on an ongoing statistical sample of soils in forests across the conterminous US, but the actual indicators are based on models rather than measurement, and they likely relate more to forest management practices than to environmental condition, and for this reason have low relevance value to EPA.

Soil Quality Index - R

This DROE03 indicator was based on a survey of soils in the Mid Atlantic region during the 1990s, and was neither repeated and is not part of the Regional Pilot Project for ROE07.

Chemical Contamination – C

This DROE03 indicator combines data from the USGS NAWQA program that are not consistent in terms of sampling frequency or analytical protocols.

Attachment 7: Indicator Materials for Review

NOTE: ATTACHMENT 7 COMPRISES THE SUBSEQUENT SECTIONS OF THIS BINDER

Indicator: Acid Deposition (011, 218, 032)

Every year, millions of tons of sulfur dioxide and nitrogen oxides are emitted to the atmosphere as a result of the burning of fossil fuels (EPA, 2003, p. 18). These gases react with water, oxygen, and oxidants to form acidic compounds, which may be carried hundreds of miles by the wind – even across state or national borders. Acid deposition occurs when these compounds fall to the Earth in one of two forms: wet (dissolved in rain, snow, and fog) or dry (solid and gaseous particles deposited on surfaces during periods of no precipitation). While wet deposition is the more widely recognized form (more commonly referred to as “acid rain”), dry deposition can account for 20 to 60 percent of total acid accumulation (EPA, 2001, p. 115).

In the environment, acid deposition causes soils and water bodies to acidify, which can make the water unsuitable for some fish and other wildlife. It also damages some trees, particularly at high elevations, and speeds the decay of buildings, statues, and sculptures that are part of our national heritage (EPA, 2003b, p. 18).The nitrogen portion of acid deposition also contributes to eutrophication in coastal ecosystems, the symptoms of which include potentially toxic algal blooms, fish kills, and loss of plant and animal diversity. Acidification of lakes and streams can increase the amount of methylmercury available in aquatic systems, which indicator 038 discusses further. Finally, increased levels of sulfate in ground-level air – a phenomenon related to dry deposition – can contribute to decreased visibility as well as a variety of human health problems (EPA, 2003b, p. 18).

Total acid deposition in this indicator is determined using both wet and dry deposition measurements. Wet deposition is measured through chemical analysis of rainwater collected at sites across the United States. The chemical components of wet deposition include sulfate, nitrate, and ammonium. Dry deposition is not measured directly. Rather, EPA measures ambient air concentrations of acidic compounds and then calculates deposition rates using a model that depends on meteorology and vegetative cover (http://www.epa.gov/castnet/.) Chemicals measured include components of particulate matter [sulfate (SO_4) and nitrate (NO_3)], gaseous nitric acid (HNO_3), sulfur dioxide (SO_2), and ammonium (NH_4). This indicator uses the three-year average from 1989-1991 as a baseline, as this period immediately predates controls on sulfur and nitrogen oxide emissions mandated by the 1990 Clean Air Act Amendments.

What the Data Show

Analyses of long-term monitoring data from the National Atmospheric Deposition Program (NADP) show that *wet deposition* of both sulfur and nitrogen compounds has decreased over the last 15 years:

Wet sulfate deposition decreased significantly across much of the United States over the 1990s (Figure 011-1). The greatest reductions in wet sulfate deposition occurred in the Mid-Appalachian region (Maryland, New York, West Virginia, Virginia, and most of Pennsylvania) and the Ohio River Valley. Less dramatic reductions were observed across much of New England and portions of the Southern Appalachians. Average regional decreases in wet deposition of sulfate between the periods 1989-1991 and 2001-2003 were 39 percent in the Northeast, 36 percent in the Midwest, and 17 percent in the Southeast.

Concentrations of nitrate in precipitation decreased approximately 15 percent across the Northeast and Mid-Atlantic regions during the 1990s, but other areas did not show much change (Figure 011-2).

As with wet deposition, *total deposition* (the sum of wet and dry deposition) also decreased between 1989-1991 and 2001-2003, and reductions were more significant for sulfur compounds than for nitrogen compounds (figures 011-3 and 011-4).

Indicator Limitations

- Geographic coverage is limited, particularly for dry deposition (and thus total deposition as well), but the concentration of sites in the Midwest and Northeast is justified by the fact that acid rain is much more of a problem in those regions than it is in the West, Great Plains, or Southeast.
- Measurement techniques for dry deposition have improved substantially, but characterization of dry deposition still requires a combination of measurements and modeling, which has inherent uncertainties.

Data Sources

Wet deposition: EPA's National Acid Deposition Program (NADP): http://nadp.sws.uiuc.edu/. Dry deposition: EPA's Clean Air Status and Trends Network (CASTNet): http://www.epa.gov/castnet/.

References

U.S. Environmental Protection Agency. 2003a. Latest Findings on National Air Quality: 2002 Status and Trends, EPA 454/K-03-001. Research Triangle Park, NC: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, August 2003. http://www.epa.gov/airtrends/2002_airtrends_final.pdf.

U.S. Environmental Protection Agency. 2003b. National Air Quality and Emissions Trends Report, 2002, EPA 454/R-01-004. Research Triangle Park, NC: U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, August 2003. http://www.epa.gov/airtrends/2002_airtrends_final.pdf

For a description of EPA's Acid Rain program, see http://www.epa.gov/airmarkets/arp/index.html/ .

Graphics

Figure OII-1: Wet sulfate deposition, 1989-1991 vs. 2001-2003

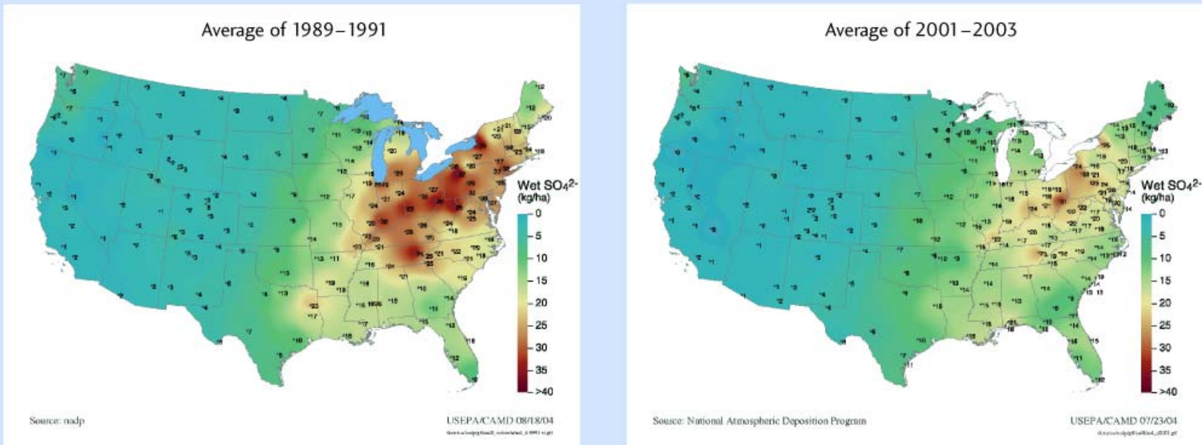


Figure OII-2: Wet nitrate deposition, 1989-1991 vs. 2001-2003

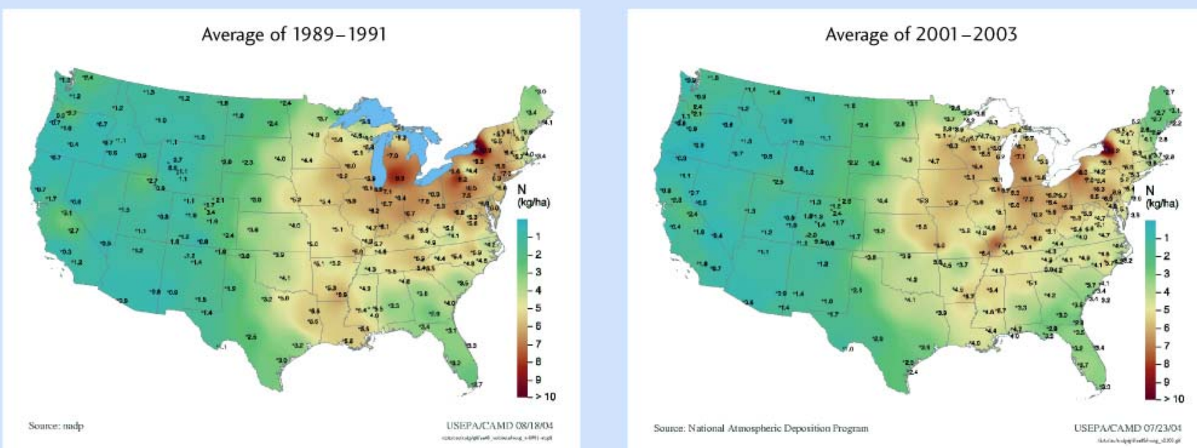


Figure OII-3: Total sulfur deposition, 1989-1991 vs. 2001-2003

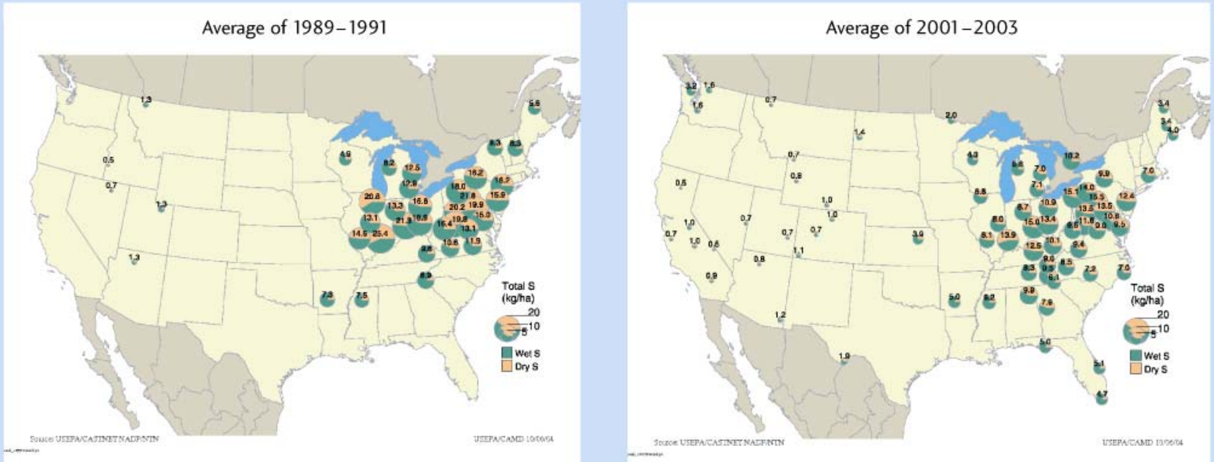
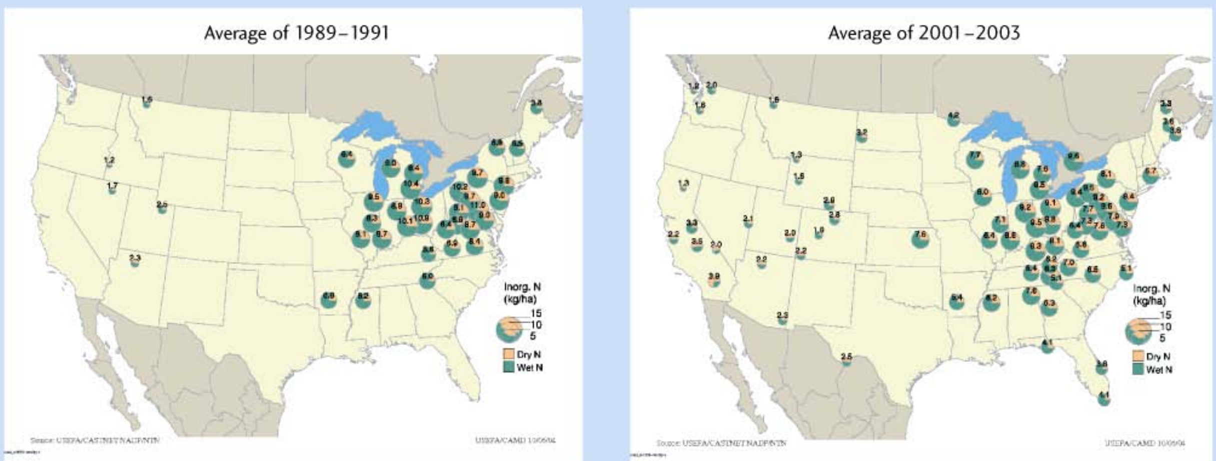


Figure OII-4: Total nitrogen deposition, 1989-1991 vs. 2001-2003



R.O.E. Indicator QA/QC

Data Set Name: ACID DEPOSITION
Indicator Number: 011 (89083)
Data Set Source: CASTNet, see http://www.epa.gov/castnet/ and for NADP, see http://nadp.sws.uiuc.edu/
Data Collection Date: ongoing:1989-1991, 2001-2003
Data Collection Frequency: hourly and weekly
Data Set Description: Acid Deposition (Wet Sulfate, Wet Nitrate, Total S, Total N)
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes, both CASTNET and NADP measurements are widely accepted as scientifically and technically valid. Measurements and Sampling Methods: Each CASTNET site measures atmospheric sulfur and nitrogen pollutants (i.e. SO2, SO42-, HNO3, NO, total Nitrate, NH4), cations (NA, K, MG, and Ca), and hourly measurements of meteorological conditions and supporting information on vegetation and land use. Concentrations of ambient sulfur and nitrogen species are collected and measured weekly via a 3-stage filter pack. In addition to sulfur and nitrogen, many CASTNET sites have hourly measurements of O3 concentrations. Ambient O3 concentrations are measured via ultraviolet (UV) absorbance. Measured meteorological variables and information on vegetation and land use are used as input into a Multilayer Resistance Model (MLM) to determine flux. NADP/NTN analyzes the constituents important in precipitation chemistry, including those affecting rainfall acidity and those that may have ecological effects. The NADP/NTN measures sulfate, nitrate, hydrogen ion (measure of acidity), ammonium, chloride, and base cations (calcium, magnesium, potassium). Each site has a precipitation chemistry collector and a rain gage (to determine the amount of precipitation) and samples are collected weekly. To ensure comparability of results, laboratory analyses for all samples are conducted by the NADP's Central Analytical Lab at the Illinois State Water Survey. References Methods: " CASTNET Quality Assurance Project Plan http://www.epa.gov/CASTNET/library/qapp_v2/qapp_a-f.pdf. " NADP/NTN Quality Assurance Plan http://nadp.sws.uiuc.edu/QA/ CASTNET Bias and Uncertainty has been identified by the following: " Allegrini, I., DeSantis, F., DiPalo, V., Febo, A., Perrino, C., Possanzini, M., Liberti, A., 1987. Annular denuder method for sampling reactive gases and aerosols in the atmosphere. Science of the Total Environment 67, 1-16. " Harrison, R.M., Kitto, A.-M.N., 1990. Field intercomparison of filter pack and denuder sampling methods for reactive gaseous and particulate pollutants. Atmospheric Environment 24A, 2633-2640. " Sickles, J.E., II, Hodson, L.L., 1989. Fate of nitrous acid on selected collection surfaces. Atmospheric Environment 23, 2321-2324.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes, the sampling design and monitoring plan for CASTNET and NADP are based on sound scientific principles. Network Design: CASTNET network design involves the measurement of rural, regionally representative concentrations of sulfur and nitrogen species to estimate dry deposition fluxes and to assess trends over time and space. Eastern U.S. sites are selected based on regional representation (overall similarity of the site to a characteristic area), distance from major pollutant sources (i.e. located approximately 100 km from a pollutant emission source), long-term availability, accessibility, and good geographic coverage. However, for the western United States, the limited number of sites and higher diversity of the region makes it difficult to determine spatial patterns. Therefore, site selection in the West focuses primarily on locations where specific research issues can be addressed, and where natural resources are at risk (e.g., national parks). For more information, refer to CASTNET Quality Assurance Plan (QAPP), October 2003, available at http://www.epa.gov/CASTNET/library/qapp_v2/qapp_a-f.pdf The NADP was initiated in the late 1970s as a cooperative program between federal and state agencies, universities, electric utilities, and other industries to determine geographical patterns and trends in precipitation chemistry in the United States. Monitoring sites for NADP networks are selected to represent major physiographic, agricultural, aquatic, and forested areas within states, regions or ecoregions. Sites are predominantly located away from urban areas and point sources of pollution. For more information, refer to the NADP Site Selection and Installation Manual available at http://nadp.sws.uiuc.edu/lib/manuals/siteinst.pdf.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes, the model used to estimate dry deposition from CASTNET data and the methods used to calculate wet deposition from NADP data are scientifically and technically valid. The MLM (Multi-Layer Model) is the mathematical model that simulates dry deposition processes using CASTNET data. Dry deposition (D) is a flux calculated from measured pollutant concentration (C) and a modeled Vd. Vd is calculated based on parameters such as meteorological conditions, vegetation, and land use, which are inputs to the MLM. For more detailed information on the MLM, refer the Clean Air Status and Trends Network Quality Assurance Plan (QAPP), October 2003, available at http://www.epa.gov/CASTNET/library/qapp_v2/qapp_a-f.pdf. For NADP/NTN, mean wet concentrations are precipitation-weighted averages. Wet deposition is calculated by multiplying precipitation-weighted mean concentrations by total precipitation. The NADP methods of determining wet deposition values have undergone extensive peer review. Assessments of changes in NADP methods are developed primarily through the academic community and reviewed through the technical literature process. For more information on sampling procedures and calculations, refer to the NADP/NTN Quality Assurance Plan http://nadp.sws.uiuc.edu/QA/ References: The MLM has been evaluated by the following: " Meyers, T. P., Finkelstein, P., Clarke, J., Ellestad, T.G., and Sims, P.F. 1998. A Multilayer Model for Inferring Dry Deposition Using Standard

Meteorological Measurements. J. Geophys. Res., 103D17:22,645-22,661. " Finkelstein, P.L., Ellestad, T.G., Clarke, J.F., Meyers, T.P., Schwede, D.B., Hebert, E.O., and Neal, J.A. 2000. Ozone and Sulfur Dioxide Dry Deposition to Forests: Observations and Model Evaluation. JGR. 105:D12:15,365-15,377. " Clarke, J.F., Edgerton, E.S., Martin, B.E., 1997. Dry deposition calculations for the Clean Air Status and Trends Network. Atmospheric Environment 31, 3667-3678.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The sampling design and monitoring plan for CASTNET and NADP are appropriate for answering the relevant question in the ROE regarding acid deposition. CASTNET was designed to investigate the relationship between changes in emissions (resulting from national emissions control programs) and changes in atmospheric sulfur and nitrogen concentrations and dry deposition. The current network design satisfies CASTNET objectives and used in conjunction with NADP wet deposition measurements, enables EPA to assess trends in atmospheric sulfur and nitrogen concentrations and wet and dry deposition over space and time. Total deposition is calculated as the sum of dry and wet deposition estimated at each CASTNET site and nearby NADP sites. As of December 2004, 88 CASTNET sites were operational at 86 distinct locations. CASTNET long-term data set contains dry deposition estimates from 1987 to present, with the longest data records primarily at eastern sites. The sampling frequency for the filter packs is weekly, Tuesday to Tuesday (168 hours) and the data are averaged over the one week period (refer to Deposition Flux Calculations section D.4.2.1, CASTNET QAPP, October 2003 http://www.epa.gov/castnet/library/qapp_v2.html for more information). Meteorological conditions are sampled continuously and averaged hourly. Currently, there are greater than 250 NADP/NTN sites across the U.S. Site descriptions and a site map are available at http://nadp.sws.uiuc.edu/sites/ntnmap.asp? Precipitation is collected weekly from NADP sites. The length of the data record varies based on site. The program began in 1978 and 114 sites have a data record extending back at least 20 years.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Western CASTNET sites are primarily located in sensitive ecosystems and national parks. There are a large number of CASTNET sites in acid sensitive areas of the eastern U.S. For more information on sampling design, see question T1Q2. Similarly, NADP/NTN sites are located in acid-sensitive receptor areas and also selected to represent major physiographic, agricultural, aquatic, and forested areas within states, regions, or ecoregions (e.g. hydrologic regions).

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Through NADP and CASTNET long-term monitoring programs, for comparison purposes, EPA has established deposition baselines for both sulfur and nitrogen, which is the mean deposition value for the three year period from 1989 to 1991 (before Title IV).

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The CASTNET Quality Assurance Plan (QAPP) http://www.epa.gov/CASTNET/library/qapp_v2/qapp_a-f.pdf describes sampling and analytical procedures used. Additional CASTNET documentation, such as annual reports and quality assurance annual reports, are available on the web at http://www.epa.gov/CASTNET/library.html. For NADP, detailed information and documentation on the network design, data collection, QA procedures, etc are available on the web at http://nadp.sws.uiuc.edu/lib/ and http://nadp.sws.uiuc.edu/QA/.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

CASTNET data are available on the CASTNET web site at http://www.epa.gov/CASTNET/data.html. CASTNET data are provided as ASCII comma-separated value (CSV) files compressed using PKZIP format. Documentation describing the content, format and codes of the data file is included in the compressed ZIP file. NADP data products, which include: weekly and daily precipitation chemistry data; monthly, seasonal, and annual precipitation-weighted mean concentrations; annual and seasonal wet deposition totals; daily precipitation totals, color isopleth maps of precipitation concentrations and wet deposition, and site information are available on the web at http://nadp.sws.uiuc.edu/.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes, for CASTNET, the sampling design is clearly documented in the Quality Assurance Project Plan, October 2003, available at http://www.epa.gov/CASTNET/library/qapp_v2/qapp_a-f.pdf. Yes, for NADP/NTN, the Site Selection and Installation manual documents site selection procedures and the overall sampling strategy, available at http://nadp.sws.uiuc.edu/lib/manuals/siteinst.pdf

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

CASTNET established a Quality Assurance Project Plan (QAPP) in November 2001. The QAPP is reviewed on a regular basis and updated to document any changes in quality assurance or operating procedures. The Clean Air Status and Trends Network Quality Assurance Plan and Quality Assurance Annual reports are available at http://www.epa.gov/castnet/library.html. NADP has established data quality objectives and quality control procedures for accuracy, precision and representation, available on the Internet: http://nadp.sws.uiuc.edu/QA/.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes, appropriate statistical methods have been used for spatial interpolation of wet and dry deposition, calculating annual annul average concentrations for CASNET data, and calculating annual precipitation-weighted means for NADP data. For more information, refer to the CASTNET and NADP Quality Assurance Plans and Quality Assurance Annual reports, available at http://www.epa.gov/castnet/library.html and http://nadp.sws.uiuc.edu/QA/.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

CASTNET has clearly defined Data Quality Objectives and Data Quality Indicators (DQI) for understanding the degree acceptability of the data collected. The DQI for CASTNET are precision, accuracy, bias, completeness, representativeness, and comparability. DQI are discussed in detail in Data Quality Objectives and Criteria, Section A.7, QAPP, October 2003. As there is no `standard' network against which the NADP/NTN monitoring program can be measured, the network has attempted to estimate bias by comparing NADP/NTN data to those of other similar networks. The comparisons between the NADP/NTN Monitoring Network and Other Networks can be found at http://nadp.sws.uiuc.edu/QA/intercomparisons.html. NADP also has established data quality objectives and quality control procedures for accuracy, precision and representation, available on the Internet: http://nadp.sws.uiuc.edu/QA/.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No, uncertainty and variability do not impact conclusions inferred from the data. For detailed information on uncertainty and variability, refer to the CASTNET and NADP Quality Assurance Plans and Quality Assurance Annual reports, available at http://www.epa.gov/castnet/library.html and http://nadp.sws.uiuc.edu/QA/.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

In order to improve the spatial resolution of CASTNET and dry deposition modeling, additional monitoring sites are needed as CASTNET has no geographic coverage for the Midwest areas of the country and limited coverage in the Northwest. Also, total deposition estimates are based on point measurements and may not accurately depict regional deposition. All data gaps and limitations are clearly documented for users in CASTNET datasets. For NADP, there are no limitations or gaps in the data

Indicator: Air Toxics Emissions (010)

Toxic air pollutants, or air toxics, may cause cancer or other serious health effects, such as reproductive problems or birth defects. Air toxics may also cause adverse environmental and ecological effects. Examples of air toxics include benzene, found in gasoline; perchloroethylene, emitted from some dry cleaning facilities; and methylene chloride, used as a solvent by a number of industries. Most air toxics originate from man-made sources, including mobile sources (e.g., cars, trucks, construction equipment) and stationary sources (e.g., factories, refineries, power plants), and indoor sources (e.g., building materials, cleaning solvents). Some air toxics are also released from natural sources such as volcanic eruptions and forest fires. The Clean Air Act identifies 188 air toxics associated with industrial sources. Twenty of these pollutants also are associated with mobile sources (EPA 2003, p 22).

People who inhale air toxics at sufficient concentrations may experience various health effects, including cancer, damage to the immune system, and neurological, reproductive (e.g., reduced fertility), developmental, or respiratory health problems. Air toxics also can present risks through other exposure pathways. For example, air toxics may deposit onto soils or surface waters, where they can then enter the food chain and may eventually be ingested by humans. Plants and animals also may be harmed by exposures to air toxics. (EPA 2003, p 22).

EPA tracks air toxics emissions in the National Emissions Inventory (NEI), a national emissions database compiled with input from industry and from state, tribal, and local agencies. The NEI includes baseline air toxics data for the period 1990–1993 and has been updated every 3 years since. The most recent NEI data available for air toxics are from 1999. *NEI data for 2002 will be added to this indicator once they are available.*

This indicator presents changes in the total emissions of the 188 HAPs between the baseline inventory (1990-93) and the latest period for which data are available 1999 (2002 when the ROE goes final). The baseline period 1990 to 1993 represents a mix of years depending on data availability for various source types. While NEI data were also compiled for 1996, the methodology used for that year differed significantly from the methodology that was used in 1999. Therefore, the 1996 data are not presented because comparing the two inventories might lead to invalid conclusions.

What the Data Show

Nationwide emissions of all 188 HAPS have dropped approximately 17 percent between baseline (1990–1993) and 1999 (Figure 010-1).

Indicator Limitations

- The emissions data are largely based on estimates. Although these estimates are generated using well-established approaches, the estimates have inherent uncertainties.
- The indicator is an aggregate number that represents 188 chemicals and locations, with widely varying toxicities and human exposures. The nationwide trend and the resulting health effects likely differs from emissions trends for specific air toxics and for specific locations.
- EPA’s Inspector General reported that “EPA is not certain whether reductions or increases may have resulted due, at least in part, to the Agency’s change in the way it estimated the inventory, rather than real reductions or increases in emissions. While emissions estimating techniques have improved, broad assumptions about the behavior of sources and serious data limitations still exist.” (OIG 2004) EPA acknowledges these limitations, but believes that the trends depicted in this indicator reflect real environmental trends.

Data Sources

U.S. Environmental Protection Agency. National Emissions Inventory - http://www.epa.gov/ttn/chief/net/neidata.html

References

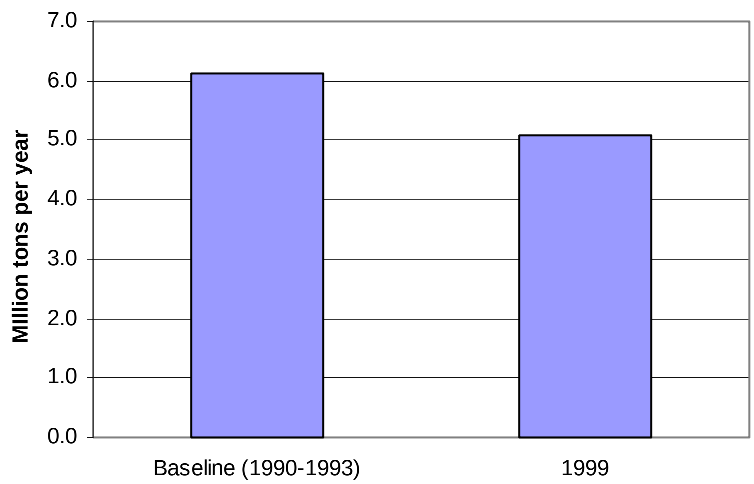
U.S. Environmental Protection Agency. Latest Findings on National Air Quality – 2002 Status and Trends, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

U.S. Environmental Protection Agency. National Air Quality and Emissions Trends Report - 2003 Special Studies Edition, EPA 454/R-03-005. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, September 2003.

United States Code. Clean Air Act, as amended in 1990, Title 1: Air Pollution Prevention and Control. 42 U.S.C. 7408 and 7409.

Graphics

Figure 110-1_: National air toxics emissions, 1990-1993, 1999 (total for 188 toxic air pollutants)



Source: U.S. EPA, Office of Air Quality Planning and Standards, National Emission Inventrory (NEI); Oct., 2004

R.O.E. Indicator QA/QC

Data Set Name: AIR TOXICS EMISSIONS
Indicator Number: 010 (89080)
Data Set Source: National Emissions Inventory
Data Collection Date: ongoing - 1990-present
Data Collection Frequency: triennially
Data Set Description: Air Toxics Emissions
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. While the NEI is a composite of data from many different data sources and methods, most of which are estimates instead of actual measurements with associated precision and accuracy, the methods are widely accepted as technically valid. These methods are considered largely sufficient in their application to derive the indicator data and conclusions presented to the typical user of the ROE. The NEI contains annual emissions (units = tons/year) of the criteria pollutants and the hazardous air pollutants (HAPs) noted in the Clean Air Act Amendments of 1990 (CAAA). The methods used to develop the NEI pollutant data vary by source sector and involve multiple data sources. A general description of methods by source sector is included below. Source emissions can be measured using monitoring equipment or estimated by using emission factors and emission process activity levels. Mathematical models may be used to characterize and simulate emissions that are influenced by several variables. For most source types, estimation techniques are the most practical. The NEI emissions are grouped into four main source sectors: Point sources and NonPoint sources (these are also referred to as stationary sources) and Onroad Mobile and Nonroad mobile sources (these are referred to as mobile sources). The Point source sector contains data on individual industrial, commercial and institutional facilities and is further divided into two subsectors: Electric Generating Units (EGUs) and NonEGUs. For the NEI sector data that is collected from state and local agencies - they either gather the data from their facilities or estimate the emissions themselves, using average and industry-specific emission factors. Some of the techniques they may use to generate their point and nonpoint estimates are referenced in a guidebook of methods which is endorsed by the EPA and the state and local agencies (STAPPA/ALAPCO). The guidebook of methods is located on http://www.epa.gov/ttn/chief/eiip/techreport/. Depending on the source sector and the pollutants of interest, the EPA uses other data sources in addition to the data received by the state and local agencies. Those other data sources, where applicable, are generally described below by sector, and identified specifically in the EPA's Preparation Plan for the 2002 NEI, located on http://www.epa.gov/ttn/chief/net/2002inventory.html. In addition to identifying the data sources, the NEI 2002 Preparation Plan also describes the EPA's current method of quality checking the different data sources, and blending and merging among them, as well as augmenting data in order to complete the data set over space and time for specific source sectors and pollutants. The EPA Preparation Plan for the 1999 NEI (http://www.epa.gov/ttn/chief/net/nei_plan_feb2001.pdf) describes the data sources and process used to compile the 1999 HAP data which is included in the indicator. There is a triennial development effort and focus on compiling data for the NEI which results in the most complete national emissions inventory data every third year. For the criteria emissions in the NEI, data is also developed for the years in between the 3-year inventory cycles. For some sectors and pollutants, the methods used may be the same as those applied for the 3-year inventory, or the data may be extrapolated from the most recent third year inventory using economic projections or more simply as a mathematical interpolation between previous and subsequent years of record. While the NEI is a composite of data from many different data sources and methods, most of which are estimates instead of actual measurements with associated precision and accuracy, the methods are widely accepted as technically valid. These methods are considered largely sufficient in their application to derive the indicator data and conclusions presented to the typical user of the ROE.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

There is not a sampling design per se for the overall NEI data development project, at least not in the typical terms of a statistical sampling design. The data methods are predominantly based on estimation techniques rather than measurement techniques with associated precision and accuracy and standard error. For most sector data, emission factors are used with average emission process rates and average activity indicators to estimate typical emissions expected from similar processes in different geographical areas. Emission factors typically are based on emission testing or other sampling observations of sources and are generally developed and revised as need arises and more data becomes available. Highway vehicle emissions factors, however, are based on relatively recent research-driven sampling approaches that are documented in information collection plans implemented by the EPA's Office and Transportation and Air Quality Planning (http://www.epa.gov/otaq/ap42.htm). For onroad mobile sources, estimates are made by month or by season to account for typical temperatures and fuel properties. Estimates of vehicle miles traveled are based on the United States Department of Transportation (US DOT) Highway Performance Monitoring System, which makes use of a formal sample panel of roadway segments. Like onroad mobile sources, emissions from some other processes are estimated for time periods less than annual. As an example, pollutant emissions for seasonal processes are estimated for only a portion of the year in which they occur (i.e., winter burning season). The NEI attempts to capture the full universe of large point source facilities, which are closely monitored and located individually by the state and local agencies. Most Point EGU emissions are individually measured with continuous monitoring devices. These data are summarized to annual average emissions for all 50 states and their counties, D.C., the U.S. territories of Puerto Rico and Virgin Islands, and as available, for some of the territories of federally-recognized American Indian nations, and are widely used and accepted as an indicator of national and regional emission trends over time.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The annual emissions are directly estimated in most cases, or are simply totaled from monthly or seasonal estimates - there is no transformation.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The NEI is designed to explicitly answer the question posed in the ROE. This indicator estimates emissions from all anthropogenic sources of a primary air pollutant.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The emission estimates that comprise the NEI are non-specific for sensitive populations or ecosystems. Rather, the data are specific for types of emission processes and as such, are representative of how much and where those process emissions occur by county for the nonpoint sources and by individual facility location for the point sources.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator(s) directly addresses changes in air pollutant emissions from year-to-year and the contributions of various types of emissions sources, by county, and for every state. Air pollutant emissions are a reliable gauge of impact on the environment and when considered along with air quality transport and transformation issues, are the foundation for air quality analysis, including health indicators. Emission reductions generally indicate positive impact on air quality. Average annual pollutant emission trends over time may also reference a specific year or years in the time series, during which emission reductions were realized due to previous year implementation of federal, regional, or local control and compliance programs. There are no thresholds or ranges of values associated with safe levels of emissions for this indicator.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The NEI is a composite of many data sources, much of which is provided by state and local agencies and comes to EPA with little or no documentation on the specific methods used to generate the estimates. An emission inventory guidebook of methods, which is endorsed by the EPA and the state and local agencies (STAPPA/ALAPCO), is generally used by state and local agencies as reference for acceptable methods. The guidebook of methods is located on http://www.epa.gov/ttn/chief/eiip/techreport/. For emissions that are reported by the states as direct measurements from monitoring devices, the analytical procedures are referenced on http://www.epa.gov/ttn/emc/. Documentation of the procedures that EPA used to compile the NEI data for some of the more recent years in the time series is located on http://www.epa.gov/ttn/chief/net/neidata.html and is more organized and descriptive than documentation for previous year data. Documentation for the earlier years noted in the time series is located on http://www.epa.gov/ttn/chief/trends/procedures/. Some of the methods noted have subsequently been revised for specific processes and years as EPA has gone back to update and apply improved methods. The documentation sources noted above will also describe use of emission factors. Documentation on process specific emission factors and how they were derived is located on http://www.epa.gov/ttn/chief/ap42/index.html.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The national annual NEI criteria emission trends summaries, as presented in the indicator, are publicly available on http://www.epa.gov/airtrends/econ-emissions.html. The national annual NEI hazardous air pollutant (HAP) data for year 1999, as presented in the indicator, are publicly available on http://www.epa.gov/air/data/index.html. Data format information typically resides at the same location as the data itself.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The EPA's documentation (see that noted in T3Q1) of how the NEI data estimates are generated will facilitate reproduction of some emission process estimates. As the EPA's documentation has evolved and improved over the years, it is expected that the more recent data years are documented in a more organized and transparent manner and would best enable reproducibility of emission estimates. Where EPA's documentation for specific years indicates that data was incorporated as that received from the state and local agencies, there is no additional documentation available by which to reproduce the state-derived values.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Much of the data that is used to compile the NEI is gathered indirectly from multiple and numerous sources, as referenced in the estimation methods information under T1Q1. These indirect data sources are presumed to have their own QA practices. Where state-supplied emissions estimates are used for some sectors and pollutants, it is presumed that states have QA plans in most cases but EPA does not systematically obtain information on QA practices from the states. The EPA contractors who use data sources and EPA-developed emissions factors to make emissions estimates operate under general contract-wide quality assurance plans, which can be made available on request. In addition, the EPA's more recent QC practices performed during the blending and merging of data from numerous sources, are described in the 2002 NEI Preparation Plan located on http://www.epa.gov/ttn/chief/net/2002inventory.html.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

No statistical generalization is performed to generate the national annual emissions trends presented in the indicator. The annual pollutant totals are developed at the plant or county level and then simply totaled and summarized at the regional and national levels.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No. At present, statistical uncertainty measures are not available for the underlying data that comprise the indicator. Most of the QA routines that are currently performed by EPA are sector data comparisons between different years or geographic areas, rather than on individual data variables. Much of the associated data variables for a specific sector are implied or not highly characterized, and therefore do not lend themselves well at present to quantitative uncertainty analysis.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Yes, OAQPS has developed standardized procedures for quality assuring the NEI as discussed in the "2002 NEI Preparation Plan" (http://www.epa.gov/ttn/chief/net/2002neiplan_081004final.pdf). The procedures include use of software to facilitate and standardize review of the data by EPA regional offices and state, local and tribal agencies. During the review process, industries often closely review their emission estimates to ensure they have been correctly incorporated in the NEI. In addition, OAQPS is able to use techniques which contrast data from various sources and from several inventory years to understand variability and identify areas in need of additional review. Where several data sources are available, assessments of data quality are conducted by OAQPS to ensure use of the highest quality emissions data when developing the NEI. The sum of the review procedures used for developing the NEI is believed to yield data of sufficient quality to support the conclusions which typical users will derive from the indicators. However, for the most rigorous applications, the NEI may be used in conjunction with ambient monitoring data and air quality and source receptor models to better characterize air quality problems and thus reduce uncertainties.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The indicator represents aggregated data. Most of the data is the result of a calculation that combines an emission rate per unit of input or output and a measure of that input or output, rather than a direct measurement of emissions. All states and counties are represented in the NEI, however not all states and local agencies may provide the same data or level of detail for a given year. State and local agencies may prioritize their data development efforts on emissions in county and metropolitan areas that are nonattainment for specific ambient air quality standards, i.e., ozone or PM2.5 NAAQS. The result may be more complete and quality assured data submissions to the NEI for these areas. Where data is absent or incomplete, EPA performs some data extrapolation from previous year data or other data sources. Inference follows many processes, depending on source type, etc. To the extent possible, facility-specific or county-specific information is used. In some cases, all counties in a state are assumed to have common properties influencing emissions, for example daily low and high temperatures. Best available or at most plausible substitutes are used where needed. For example, gasoline fuel properties are not available for all counties, known fuel properties in nearby counties subject to similar regulations on gasoline are used instead. Various and not fully consistent methodologies have been used to develop the emission estimates in the NEI. This is to be expected considering the variety of organizations that have contributed the estimates.

Indicator: Ambient Concentrations of Carbon Monoxide (331)

Carbon monoxide (CO) gases form when carbon fuels are not burned completely. Motor vehicle exhaust currently accounts for the majority of CO emissions nationwide, and as much as 95 percent of CO emissions in cities with high traffic congestion. Other anthropogenic emissions sources of CO include fuel combustion, metals processing, and chemical manufacturing. The highest ambient air concentrations of CO often occur during nighttime inversion conditions, which trap pollutants near ground level. These conditions are most frequently observed during the cold winter months (EPA, 2003).

Elevated ambient air concentrations of CO are hazardous because inhaled CO enters the bloodstream and reduces the amount of oxygen that the blood ordinarily delivers to the body's organs and tissues. If exposure concentrations are high enough, potentially serious cardiovascular and neurological effects can result, even among healthy individuals. Visual impairment, reduced work capacity, reduced manual dexterity, poor learning ability, and difficulty in performing complex tasks are all associated with exposure to elevated CO levels (Air Quality Criteria for Carbon Monoxide, EPA 600-P-99-001F, 2000).

This indicator reflects ambient concentrations in parts per million (ppm) of CO from 1980 to 2003, based on 8-hour measurements. The 8-hour standard is indicative of exposures occurring over a sustained period of time, for example, an outdoor worker's exposure over the course of a work day. This indicator displays trends in the second highest annual 8-hour average CO concentrations, averaged over 168 sites that have consistent data for the period of record in the National Air Monitoring Stations (NAMS), State and Local Air Monitoring Stations (SLAMS) network and other special purpose monitors.

What the Data Show

The 2003 average CO concentrations concentration is 70 percent lower than that for 1980, and is the lowest level recorded during the past 25 years (Figure 331-1). The downward trend in CO concentrations in the 1990s parallels the downward trend observed in CO emissions, which has been attributed largely to decreased emissions from mobile sources (see Indicator "CO Emissions").

Consistent with the nationwide trend, CO levels in all ten regions have steadily decreased since 1980, with net reductions over this time frame ranging from 66% to 79% (Figure 331-2).

Indicator Limitations

- Because ambient monitoring for CO occurs almost exclusively in urban high traffic areas, the average concentrations presented in this indicator likely do not reflect CO levels in rural areas.

Data Sources

US EPA Air Quality System (http://www.epa.gov/air/data/index.html).

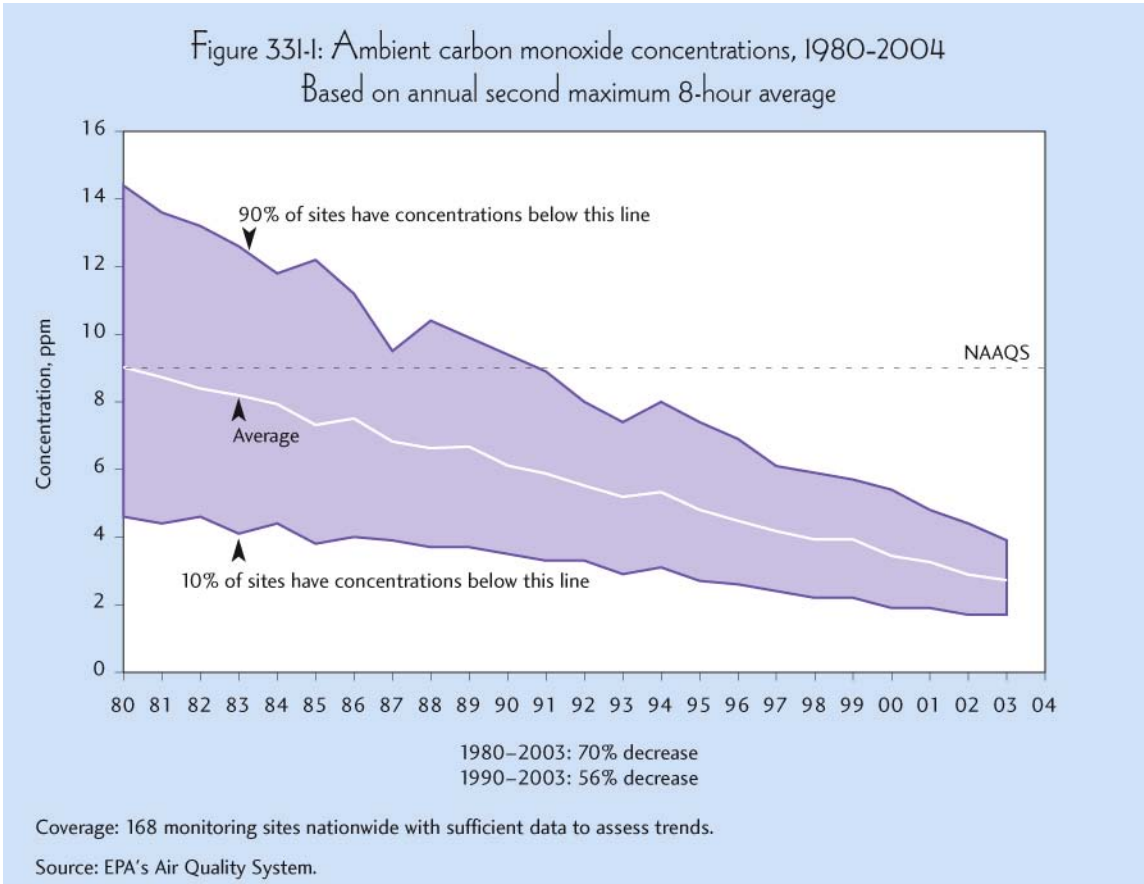
References

U.S. Environmental Protection Agency. Latest Findings on National Air Quality – 2002 Status and Trends, EPA 454/K-03-001. Research Triangle Park, NC; U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

U.S. Environmental Protection Agency. National Air Quality and Emissions Trends Report - 2003 Special Studies Edition, EPA 454/R-03-005. Research Triangle Park, NC; U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, September 2003.

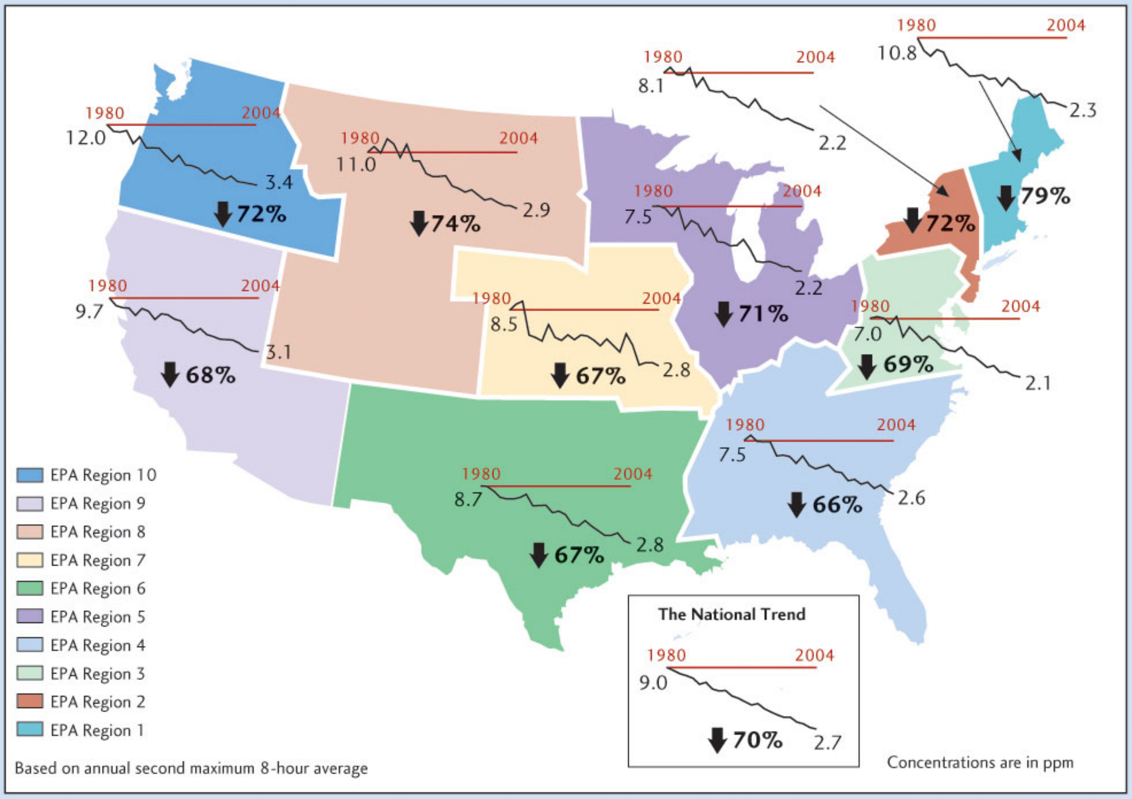
U.S. Environmental Protection Agency. Air Quality Criteria for Carbon Monoxide, 2000, EPA 600-P-99-001F, 2000. Research Triangle Park, NC; U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, June 2000.

Graphics



Note: Figure will be updated with 2004 data, once the data are available.

Figure 331-2: Trends in carbon monoxide levels, 1980-2004, averaged across EPA regions



Source: EPA's Air Quality System.

Note: Figure will be updated with 2004 data, once the data are available.

R.O.E. Indicator QA/QC

Data Set Name: AMBIENT CO CONCENTRATIONS
Indicator Number: 331 (89169)
Data Set Source: EPA Air Quality System
Data Collection Date: Ongoing: since at least 1980-present
Data Collection Frequency: Varies. See 40 CFR Parts 53 & 58 & attached QA/QC
Data Set Description: Ambient CO Concentrations
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The ambient air quality data are based on data retrieved from the Air Quality System (AQS) in August 2004. These are direct measurements of pollutant concentrations at monitoring stations operated by tribes and state and local governments throughout the nation. The monitoring stations are generally located in larger urban areas. EPA and other federal agencies also operate some air quality monitoring sites on a temporary basis as a part of air pollution research studies. The national monitoring network conforms to uniform criteria for monitor siting, instrumentation, and quality assurance. The program under which the data are collected is the NAMS/SLAMS network. A description of this network includes: 1) 40 CFR 50 - National ambient air quality standards (NAAQS) and reference methods for determining criteria air pollutant concentrations in the atmosphere; 2) 40 CFR 53 - Process for determining reference or equivalent methods for determining criteria air pollutant concentrations in the atmosphere; 3) 40 CFR 58 - Ambient air quality surveillance (monitoring) requirements. These results have been peer reviewed. The most recent review was as a part of the National Air Quality and Emissions Trends Report, 2001 EPA 454/K-02-001, September 2002. This report is available at: http://www.epa.gov/airtrends.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. In 2003, thousands of monitoring sites reported air quality data for one or more of the six National Ambient Air Quality Standards (NAAQS) pollutants to AQS. The sites consist of National Air Monitoring Stations (NAMS), State and Local Air Monitoring Stations (SLAMS), and other special-purpose monitors. NAMS were established to ensure a long-term national network for urban area-oriented ambient monitoring and to provide a systematic, consistent database for air quality comparisons and trends analysis. SLAMS allow state or local governments to develop networks tailored for their immediate monitoring needs. The monitoring objectives for the NAMS/SLAMS network are found in: 1) 40 CFR 58, Appendix D, http://www.epa.gov/ttn/amtic/; 2) 40 CFR 58.2(c); 3) EPA 454/R-98-004, Part I, Section 3.2, http://www.epa.gov/ttn/amtic/cpreldoc.html.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The conceptual model used to derive these indicators has been used and thoroughly reviewed as part of the Agency's national report on air quality trends for 25 years. Carbon monoxide air quality monitoring sites meet the annual trends data completeness requirement if they have at least 3285 hourly measurements for the year. This is based on 50 percent of hourly data for the CO season, which varies by state, but typically runs from August to April. The model basically has three elements: 1) Determine if year is valid for inclusion. Must have greater than or equal to 3285 valid hours. 2) Determine if site is valid for trends. Must have greater than or equal to 75% of possible years in the time series. For the 24-year period 1980-2003, trend sites must have at least 18 valid years and must not be missing more than 2 consecutive years of data. 3) Interpolate for missing years. Simple linear interpolation is used to fill in for missing years in the following way. Missing annual summary statistics for the in-between years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since endpoint rates of change are dampened by the interpolated estimates. References include: U.S. Environmental Protection Agency. The Ozone Report - Measuring Progress through 2003, EPA 454/K-04-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, April 2004. Latest Findings on National Air Quality - 2002 Status and Trends, 2003, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The data for these indicators are collected under a single national program of ambient air quality surveillance known as the National Air Monitoring Stations (NAMS)/State or Local Air Monitoring Stations (SLAMS) network. The NAMS/SLAMS network focus is on providing data for assessing public health consequences of criteria pollutants and, therefore, the monitors tend to be concentrated in urban areas that have the highest population density, with modest coverage in most rural areas. Pollutant specific guidance for establishing NAMS/SLAMS networks is provided in 40 CFR 58, Appendix D.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The network is not focused on sensitive populations like children, the elderly, asthmatics, etc., but samples them proportion to their occurrence in the general populations of the areas monitored.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Yes, the level of the corresponding national ambient air quality standard (NAAQS) is 9.5 ppm. This level is indicative of the state of the environment with respect to ambient air concentrations of carbon monoxide.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Standard data documentation is available to support these data and can be accessed at: 1) General Air Quality and National Monitoring Network (http://www.epa.gov/ttn/amtic/moninfo.html); 2) National Air Quality and Emissions Trends Report, 2003 Special Studies Edition (http://www.epa.gov/air/airtrends/aqtrnd03/).

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. The data used to develop these indicators are available through the Air Quality Subsystem of the Aerometric Information Retrieval System (AIRS). Information on AIRS can be obtained at: http://www.epa.gov/ttn/airs/. In addition, data from AIRS can be accessed via the Internet at: http://www.epa.gov/air/data/index.html.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The Ambient Monitoring Technology Information Center (AMTIC) contains information and files on ambient air quality monitoring programs, details on monitoring methods, relevant documents and articles, information on air quality trends and nonattainment areas, and federal regulations related to ambient air quality monitoring. This information can be found in Section 3, EPA - TTN - AMTIC National Air Monitoring Strategy: http://www.epa.gov/ttnamti1/monstratdoc.html.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The QA/QC of the national air monitoring program has several major components: the Data Quality Objective (DQO) process, reference and equivalent methods program, EPA's National Performance Audit Program (NPAP), system audits, and network reviews (Available on the Internet: www.epa.gov/ttn/amtic/npaplist.html). To ensure quality data, the SLAMS are required to meet the following: 1) each site must meet network design and site criteria; 2) each site must provide adequate QA assessment, control, and corrective action functions according to minimum program requirements; 3) all sampling methods and equipment must meet EPA reference or equivalent requirements; 4) acceptable data validation and record keeping procedures must be followed; and 5) data from SLAMS must be summarized and reported annually to EPA. Finally, there are system audits that regularly review the overall air quality data collection activity for any needed changes or corrections. Further information available on the Internet (http://www.epa.gov/cludygxb/programs/namslam.html) and through United States EPA's Quality Assurance Handbook (EPA-454/R-98-004 Section 15). There is a Quality Assurance Project Plan from each state or local agency operating a NAMS/SLAMS monitor meeting the AEPA Requirements for Quality Assurance Project Plans, EPA QA/R-5. The quality assurance plans for specific sites are publicly available by request to the reporting agency or the corresponding EPA Regional Office. The plans are audited at least once every three years as required in 40 CFR 58, Appendix A, Section 2.5. In addition, the data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

The air quality statistics presented relate to the pollutant specific NAAQS and comply with the recommendations of the Intra-Agency Task Force on Air Quality Indicators. A composite average of each trend statistic is used in the graphical presentations. All sites were weighted equally in calculating the composite average trend statistic. Missing annual summary statistics for the second through ninth years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since endpoint rates of change are dampened by the interpolated estimates.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. The data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No, We are not aware of any sources of error that may affect the findings developed from these data.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The national air monitoring network for the six criteria air pollutants is extensive; however, there are far more monitors in urban areas than in rural areas. Monitoring in urban areas helps to characterize population exposures, because population tends to be concentrated in urban areas. More rural monitoring might help scientists assess transport and ecological effects, although EPA uses additional tools and techniques (e.g., models and spatial analyses) to augment limited monitoring in some areas and to better characterize pressures on ecological condition. EPA is currently conducting a national assessment of the existing ambient monitoring networks and is analyzing, among other issues, the need for and appropriateness of each of the nation's urban monitors.

Indicator: Ambient Concentrations of Nitrogen Dioxide (355)

Nitrogen dioxide is a reddish-brown, highly reactive gas that is formed in the ambient air through the oxidation of nitric oxide (NO). Nitrogen oxides (NOx), the term used to describe the sum of NO, NO_2, and other oxides of nitrogen, play a major role in the formation of ozone in the atmosphere through a complex series of reactions with VOCs. A variety of NOx compounds and their transformation products occur both naturally and as a result of human activities. Nitrogen dioxide is the most widespread and commonly found nitrogen oxide (EPA, 2003).

Short-term exposures (e.g., less than 3 hours) to low-levels of NO2 may lead to changes in airway responsiveness and lung function in individuals with preexisting respiratory illnesses. These exposures may also increase respiratory illnesses in children. Long-term exposures to NO2 may lead to increased susceptibility to respiratory infection and may cause irreversible alterations in lung structure. (EPA, 1995).

Atmospheric transformation of NOx can lead to the formation of ozone and nitrogen-bearing particles (e.g., nitrates and nitric acid). Nitrogen oxides contribute to a wide range of effects on public welfare and the environment, including global warming and stratospheric ozone depletion. Deposition of nitrogen can also lead to fertilization, eutrophication, or acidification of terrestrial, wetland, and aquatic (e.g., fresh water bodies, estuaries, and coastal water) systems. These effects can alter competition between existing species, leading to changes in the number and type of species (composition) within a community. For example, eutrophic conditions in aquatic systems can produce explosive algae growth leading to a depletion of oxygen in the water and/or an increase in levels of toxins harmful to fish and other aquatic life (Air Quality Criteria for Oxides of Nitrogen, EPA 600-8-91-049aF-cF, 1993).

This indicator reflects ambient concentrations in parts per million (ppm) of NO_2 from 1980 to 2004, based on the annual arithmetic average. This indicator displays trends averaged over 91 sites that have consistent data for the period of record in the National Air Monitoring Stations (NAMS), State and Local Air Monitoring Stations (SLAMS) network and other special purpose monitors.

What the Data Show

(Note: discussion of annual median concentrations will be added to this section)

Figure 355-1 shows that the national annual mean NO_2 concentration in 2004 was 37 percent lower than that recorded in 1980. The highest annual mean NO_2 concentrations are typically found in urban areas.

Consistent with the nationwide trend, NO_2 levels in all ten regions have steadily decreased since 1980, with net reductions over this time ranging from 25% to 44% (Figure 355-2).

Figures 355-1 and 355-2 also show the 90th and 10th percentiles of NO_2 concentration based on the distribution of annual statistics at the monitoring sites. Thus, the graphics display for each year, the concentration range where 80 percent of measured values occurred.

Indicator Limitations

- Because ambient monitoring for NO_2 occurs almost exclusively in urban high traffic areas, the average concentrations presented in this indicator likely do not reflect NO_2 levels in rural areas.
- In rural and remote areas, air mass aging could foster greater relative levels of peroxyacetyl nitrate (PAN) and nitric acid. These compounds interfere with the measurement of NO_2. Consequently, concentrations of NO_2 in rural and remote areas may be overestimated.

Data Sources

US EPA Air Quality System (http://www.epa.gov/air/data/index.html).

References

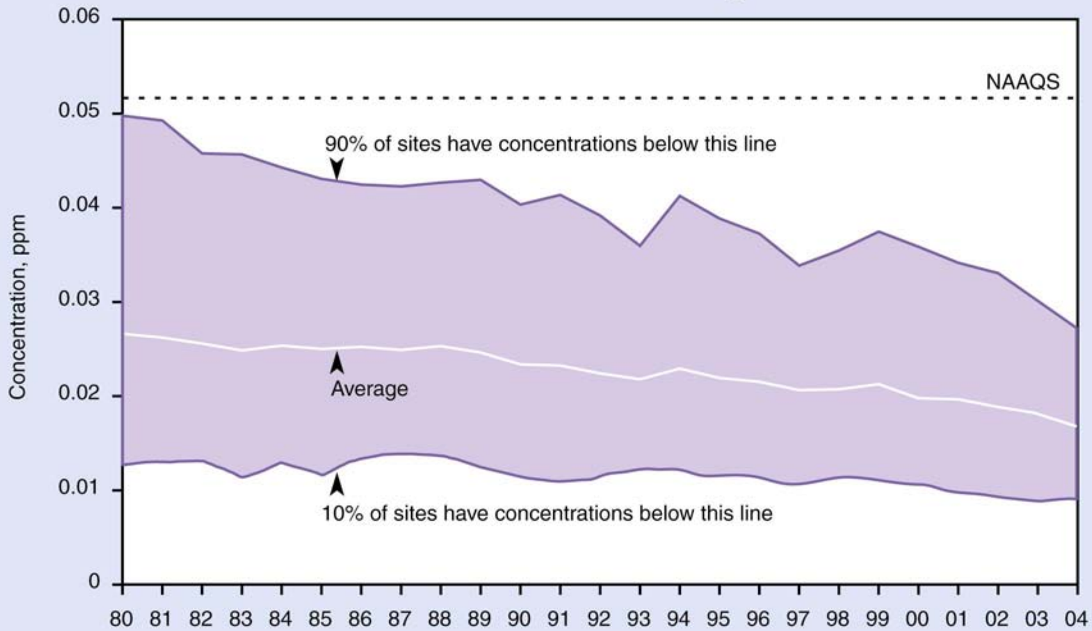
U.S. Environmental Protection Agency. Latest Findings on National Air Quality – 2002 Status and Trends, EPA 454/K-03-001. Research Triangle Park, NC; U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

U.S. Environmental Protection Agency. National Air Quality and Emissions Trends Report - 2003 Special Studies Edition, EPA 454/R-03-005. Research Triangle Park, NC; U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, September 2003.

U.S. Environmental Protection Agency. Review of the National Ambient Air Quality Standards for Nitrogen Oxides: Assessment of Scientific and Technical Information, EPA-452/R-95-005. Research Triangle Park, NC; U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, September 1995.

Graphics

Figure 355.1: Ambient nitrogen dioxide concentrations, 1980-2004
Based on annual average

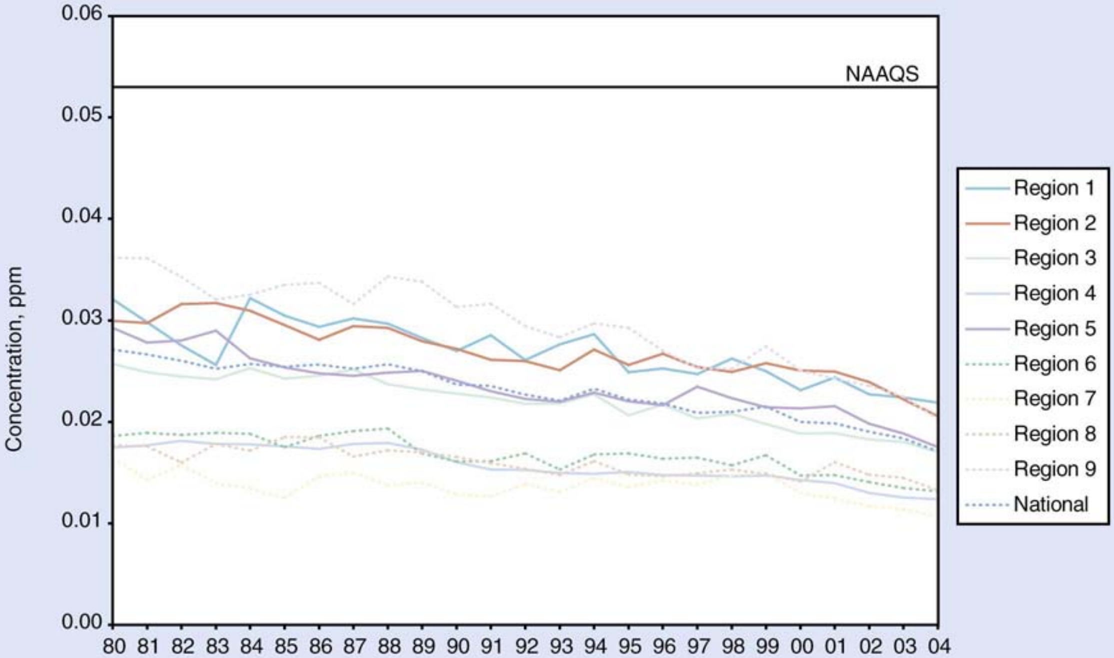


Coverage: 91 monitoring sites nationwide with sufficient data to assess trends.

Source: EPA's Air Quality System.

A trend line with median concentrations will be added to this graph after the data points are generated.

Figure 355.2: Trends in nitrogen dioxide levels, 1980-2004, by EPA region
Based on annual average concentrations



Source: EPA's Air Quality System.

Note: The figure does not include data for Region 10, because an insufficient number of monitoring sites were available to estimate a trend.

R.O.E. Indicator QA/QC

Data Set Name: AMBIENT NO2 CONCENTRATIONS
Indicator Number: 355 (138764)
Data Set Source:
Data Collection Date:
Data Collection Frequency:
Data Set Description: Ambient NO2 Concentrations
Primary ROE Question: What are the trends in outdoor air quality and their effects on human health and the environment?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The ambient air quality data presented are based on data retrieved from the Air Quality System (AQS) in Sept. 2005. These are direct measurements of pollutant concentrations at monitoring stations operated by tribes and state and local governments throughout the nation. The monitoring stations are generally located in larger urban areas. EPA and other federal agencies also operate some air quality monitoring sites on a temporary basis as a part of air pollution research studies. The national monitoring network conforms to uniform criteria for monitor siting, instrumentation, and quality assurance. The program under which the data are collected is the NAMS/SLAMS network. A description of this network includes: 1) 40 CFR 50 - National ambient air quality standards (NAAQS) and reference methods for determining criteria air pollutant concentrations in the atmosphere; 2) 40 CFR 53 - Process for determining reference or equivalent methods for determining criteria air pollutant concentrations in the atmosphere; 3) 40 CFR 58 - Ambient air quality surveillance (monitoring) requirements. These results have been peer reviewed. The most recent review was as a part of the National Air Quality and Emissions Trends Report, 2001 EPA 454/K-02-001, September 2002. This report is available at: http://www.epa.gov/airtrends.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. In 2004, thousands of monitoring sites reported air quality data for one or more of the six National Ambient Air Quality Standards (NAAQS) pollutants to AQS. The sites consist of National Air Monitoring Stations (NAMS), State and Local Air Monitoring Stations (SLAMS), and other special-purpose monitors. NAMS were established to ensure a long-term national network for urban area-oriented ambient monitoring and to provide a systematic, consistent database for air quality comparisons and trends analysis. SLAMS allow state or local governments to develop networks tailored for their immediate monitoring needs. The monitoring objectives for the NAMS/SLAMS network are found in: 1) 40 CFR 58, Appendix D, http://www.epa.gov/ttn/amtic/; 2) 40 CFR

58.2(c); 3) EPA 454/R-98-004, Part I, Section 3.2, http://www.epa.gov/ttn/amtic/cpreldoc.html.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The conceptual model used to derive these indicators has been used and thoroughly reviewed as part of the Agency's national report on air quality trends for 25 years. The model has three basic elements: 1) Determine if year is valid for inclusion. Must have greater than or equal to 3285 valid hours of measurements to meet the annual trends data completeness requirement. 2) Determine if site is valid for trends. Must have greater than or equal to 75% of possible years in the time series. For the 25-year period 1980-2004, trend sites must have at least 19 valid years and must not be missing more than 2 consecutive years of data. 3) Interpolate for missing years. Simple linear interpolation is used to fill in for missing years in the following way. Missing annual summary statistics for the in-between years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since endpoint rates of change are dampened by the interpolated estimates. References include: U.S. Environmental Protection Agency. The Ozone Report - Measuring Progress through 2003, EPA 454/K-04-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, April 2004. Latest Findings on National Air Quality - 2002 Status and Trends, 2003, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The data for these indicators are collected under a single national program of ambient air quality surveillance known as the National Air Monitoring Stations (NAMS)/State or Local Air Monitoring Stations (SLAMS) network. The NAMS/SLAMS network focus is on providing data for assessing public health consequences of criteria pollutants and, therefore, the monitors tend to be concentrated in urban areas that have the highest population density, with modest coverage in most rural areas. Pollutant specific guidance for establishing NAMS/SLAMS networks is provided in 40 CFR 58, Appendix D.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The network is not focused on sensitive populations like children, the elderly, asthmatics, etc., but samples them in proportion to their occurrence in the general populations of the areas monitored.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Yes, the level of the corresponding national ambient air quality standard (NAAQS) is 0.053 ppm. This level is indicative of the state of the environment with respect to ambient air concentrations of nitrogen dioxide.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Standard data documentation is available to support these data and can be accessed at: 1) General Air Quality and National Monitoring Network (http://www.epa.gov/ttn/amtic/moninfo.html); 2) National Air Quality and Emissions Trends Report, 2003 Special Studies Edition (http://www.epa.gov/air/airtrends/aqtrnd03/).

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. The data used to develop these indicators are available through the Air Quality Subsystem of the Aerometric Information Retrieval System (AIRS). Information on AIRS can be obtained at: http://www.epa.gov/ttn/airs/. In addition, data from AIRS can be accessed via the Internet at: http://www.epa.gov/air/data/index.html.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The Ambient Monitoring Technology Information Center (AMTIC) contains information and files on ambient air quality monitoring programs, details on monitoring methods, relevant documents and articles, information on air quality trends and nonattainment areas, and federal regulations related to ambient air quality monitoring. This information can be found in Section 3, EPA - TTN - AMTIC National Air Monitoring Strategy: http://www.epa.gov/ttnamti1/monstratdoc.html.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The QA/QC of the national air monitoring program has several major components: the Data Quality Objective (DQO) process, reference and equivalent methods program, EPA's National Performance Audit Program (NPAP), system audits, and network reviews (Available on the Internet: www.epa.gov/ttn/amtic/npaplist.html). To ensure quality data, the SLAMS are required to meet the following: 1) each site must meet network design and site criteria; 2) each site must provide adequate QA assessment, control, and corrective action functions according to minimum program requirements; 3) all sampling methods and equipment must meet EPA reference or equivalent requirements; 4) acceptable data validation and record keeping procedures must be followed; and 5) data from SLAMS must be summarized and reported annually to EPA. Finally, there are system audits that regularly review the overall air quality data collection activity for any needed changes or corrections. Further information available on the Internet (http://www.epa.gov/cludygxb/programs/namslam.html) and through United States EPA's Quality Assurance Handbook (EPA-454/R-98-004 Section 15). There is a Quality Assurance Project Plan from each state or local agency operating a NAMS/SLAMS monitor meeting the AEPA Requirements for Quality Assurance Project Plans, EPA QA/R-5. The quality assurance plans for specific sites are publicly available by request to the reporting agency or the corresponding EPA Regional Office. The plans are audited at least once every three years as required in 40 CFR 58, Appendix A, Section 2.5. In addition, the data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

The air quality statistics presented relate to the pollutant specific NAAQS and comply with the recommendations of the Intra-Agency Task Force on Air Quality Indicators. A composite average of each trend statistic is used in the graphical presentations. All sites were weighted equally in calculating the composite average trend statistic. Missing annual summary statistics for the second through ninth years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since endpoint rates of change are dampened by the interpolated estimates.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. The data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No. We are not aware of any sources of error that may affect the findings developed from these data.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The national air monitoring network for the six criteria air pollutants is extensive; however, there are far more monitors in urban areas than in rural areas. Monitoring in urban areas helps to characterize population exposures, because population tends to be concentrated in urban areas. More rural monitoring might help scientists assess transport and ecological effects, although EPA uses additional tools and techniques (e.g., models and spatial analyses) to augment limited monitoring in some areas and to better characterize pressures on ecological condition. EPA is currently conducting a national assessment of the existing ambient monitoring networks and is analyzing, among other issues, the need for and appropriateness of each of the nation's urban monitors. Atmospheric concentrations of NO2 are determined by indirect photomultiplier measurement of the luminescence produced by a critical reaction of NO with ozone. The measurement of NO2 is based first on the conversion of NO2 to NO, and then subsequent detection of NO using this well-characterized chemiluminescence technique. This conversion is not specific for NO2, hence chemiluminescence analyzers are subject to interferences produced by response to other nitrogen-containing compounds (e.g., peroxyacetyl nitrate [PAN]) that can be converted to NO. The chemiluminescence technique has been reported to overestimate NO2 due to these interferences. This is not an issue for compliance because there are no violations of the NO2 NAAQS. In addition, the interferences are believed to be relatively small in urban areas. The national and regional air quality trends depicted are based primarily on data from monitoring sites in urban locations and are expected to be reasonable representations of urban NO2 trends. That is not the case in rural and remote areas, however, where air mass aging could foster greater relative levels of PAN and nitric acid and interfere significantly with the interpretation of NO2 monitoring data.

Indicator: Ambient Concentrations of a Selected Air Toxic: Benzene (007)

Toxic air pollutants, or air toxics, are those pollutants that cause or may cause cancer or other serious health effects, such as reproductive effects or birth defects. Air toxics may also cause adverse environmental and ecological effects. Examples of toxic air pollutants include benzene, found in gasoline; perchloroethylene, emitted from some dry cleaning facilities; and methylene chloride, used as a solvent by a number of industries. Urban areas should generally have higher levels of benzene than other areas. Most air toxics originate from man-made sources, including mobile sources (e.g., cars, trucks, construction equipment) and stationary sources (e.g., factories, refineries, power plants), as well as indoor sources (e.g., some building materials and cleaning solvents). Some air toxics are also released from natural sources such as volcanic eruptions and forest fires. The Clean Air Act identifies 188 air toxics from industrial sources. EPA has identified 20 of these pollutants that are associated with mobile sources, diesel particulate matter and diesel exhaust organic gases are also identified as mobile source air toxics. In addition, EPA has listed 33 hazardous air pollutants of concern to public health in urban areas (EPA 2003, p. 63).

People exposed to toxic air pollutants at sufficient concentrations may experience various health effects, including cancer, damage to the immune system, as well as neurological, reproductive (e.g., reduced fertility), developmental, respiratory, and other health problems. In addition to exposure from breathing air toxics, risks also are associated with the deposition of toxic pollutants onto soils or surface waters, where they are taken up by plants and ingested by animals and eventually magnified up through the food chain. Plants and animals may be harmed by exposures to air toxics (EPA 2003, pg 63).

Air quality trends for individual air toxics vary from pollutant to pollutant. The chemicals monitored and the geographic coverage of the monitors vary from state to state. Beginning in 2003, EPA, working with state and local agencies and tribes, initiated the creation of a national monitoring network for a number of toxic air pollutants, the National Air Toxics Trends Sites, to ensure that those compounds that pose the greatest risk are measured. This indicator shows trends in ambient measurements of benzene, the most widely monitored toxic air pollutant, taken from 35 urban monitoring sites across the country, based on sites that have consistent data quality from 1994 to 2003.

What the Data Show

Benzene concentrations show about a 60 percent drop in benzene levels from 1994 to 2003 (Fig 007-1). During this period, automobile emission standards were tightened; many cities began using cleaner-burning gasoline; and new standards required significant reductions in benzene emitted from oil refineries and chemical processes.

Indicator Limitations

- Benzene data represent only 35 urban sites in the U.S.
- Benzene, while an important air toxic, represents only one of many air toxics that may occur in air.

Data Sources

Analysis by Lance McCluney, Air Quality Data Analysis Group, EMAD, OAQPS based on data in AQS. US EPA Air Quality System (http://www.epa.gov/air/data/index.html) as of June 29, 2004

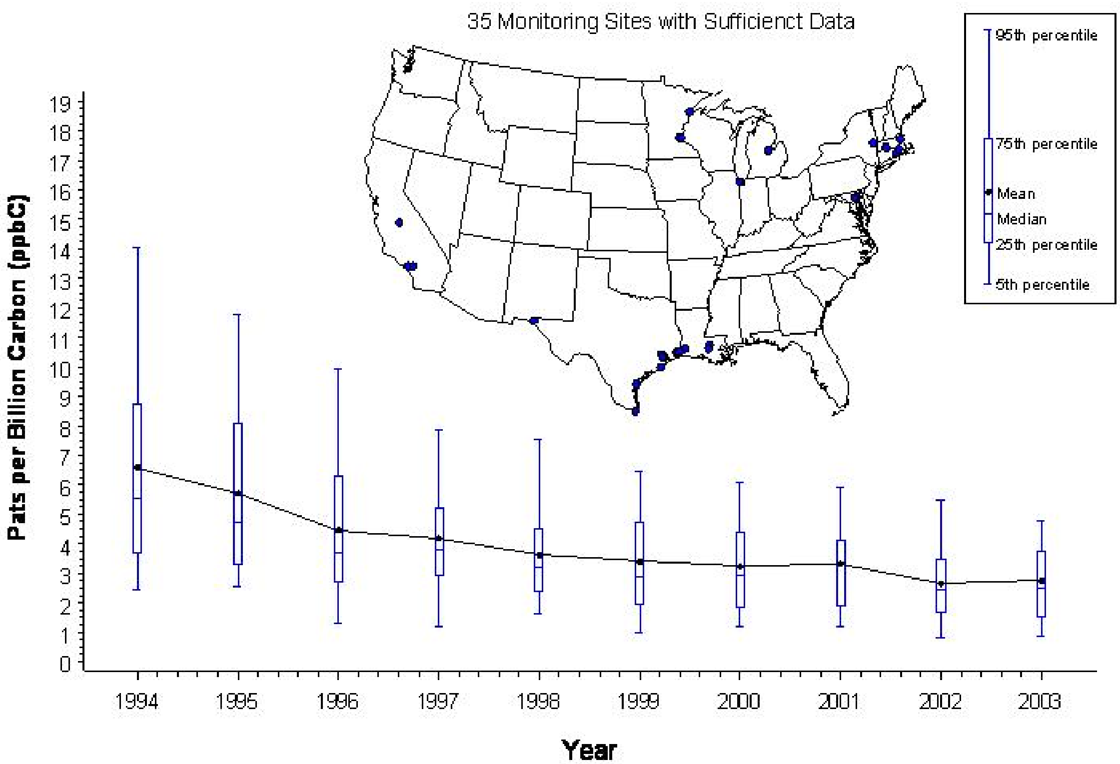
References

U.S. Environmental Protection Agency. 2003. National Air Quality and Emissions Trends Report - 2003 Special Studies Edition, EPA 454/R-03-005. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, September 2003.

Graphics

Figure 007-1

National Trend in Annual Average Benzene Concentrations, 1994-2003



R.O.E. Indicator QA/QC

Data Set Name: AMBIENT CONCENTRATIONS OF A SELECTED AIR TOXIC: BENZENE
Indicator Number: 007 (89188)
Data Set Source: EPA Air Quality System
Data Collection Date: Ongoing: 1994-present
Data Collection Frequency: Hourly
Data Set Description: Ambient Concentrations of a Selected Air Toxic: Benzene
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The toxics air quality data are based on data retrieved from the Air Quality System (AQS) in June 2004. Data used for this indicator are comprised of an assemblage of toxics monitoring programs conducted at the state and national level. The programs in this collection include but are not limited to: Photochemical Assessment Monitoring Stations program; Urban Air Toxics Monitoring Program; and Non Methane Organic Compound Monitoring Program. In addition, these data from national monitoring programs were supplemented by information collected by individual state efforts. In general, for a given pollutant, the same analytical method, or a similar alternative method, was used consistently throughout each program. In addition, all programs generally reflect the methods included in Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, EPA-625/R-96-010b.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. A description of the sampling design and monitoring plan can be found in the 2003 Urban Air Toxics Monitoring Program (UATMP) Final Report (July 2004). A copy of this report can be downloaded from http://www.epa.gov/ttn/amtic/files/ambient/airtox/2003doc.pdf. The monitoring objectives for the PAMS network are found in: 40 CFR 58, Appendix D 40 CFR 58 Subpart E. The monitoring objectives for the Nonmethane Organic Compound Monitoring Program are found in: EPA-454/4-92-010 C EPA-454/4-91-008 C EPA-454/4-90-011.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The conceptual model used to derive these indicators has been used and thoroughly reviewed as part of the Agency's national report on air quality trends for 10 or more years. All calculations were based on the measured 24-hour values. A completeness requirement was applied to the data. For each site, a winter and summer mean was calculated for each year. A winter mean was calculated using the observed values in calendar quarters 1 and 4, and the summer mean was calculated using the observed values in calendar quarters 2 and 3. For a site to have a complete year, the total number of days monitored had to be 15 or greater for the winter and 15 or greater for the summer. This is equivalent to 50% completeness based on the 1-in-3 day sampling schedule. Annual averages were calculated by averaging the complete winter and summer means for the year. Missing site years were filled in using the same interpolation used in EPA trends reports. A site meeting the completeness criteria had to have 8 out of 10 years complete. If a site's annual average for 1994 was missing, it was filled in with the 1995 annual average. If the 1995 annual average was also missing, then the 1994 and 1995 annual averages were filled in with the 1996 annual average. If a site's annual average for 2003 was missing, it was filled in with the 2002 annual average. If the 2002 annual average was also missing, then the 2003 and 2002 annual averages were filled in the 2001 annual average. Otherwise, any missing annual averages were filled in using simple linear interpolation from the two surrounding years.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The data used to derive this indicator represents the best, readily available data on ambient air toxics concentrations, and benzene is one of the most widely monitored air toxics and therefore is used to reflect the state of the environment. While EPA, states, tribes, and local air regulatory agencies collect monitoring data for a number of toxic air pollutants, however, both the chemicals monitored and the geographic coverage of the monitors vary from state to state. The Urban Air Toxics Monitoring Program (UATMP) characterizes the magnitude and composition of potentially toxic air pollution in, or near, urban locations. The PAMS data collection focuses on areas with significant ozone nonattainment problems and the NMOC program also focuses on principally on urban areas. EPA is working with these regulatory partners to build upon the existing monitoring sites to create a national monitoring network to ensure that those compounds that pose the greatest risk are measured. The nation's air toxics monitoring network continues to emerge and will do so over the next several years. The available monitoring data help air pollution control agencies track trends in toxic air pollutants in various locations around the country.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Generally toxics monitoring efforts focus on providing data for assessing public health consequences of air pollutants and, therefore, the monitors tend to be concentrated in urban areas with modest coverage in most rural areas. More rural monitoring might help scientists assess transport and ecological effects, although EPA uses additional tools and techniques (e.g., models and spatial analyses) to augment limited monitoring in some areas and to better characterize pressures on ecological condition. EPA is currently conducting a national assessment of the existing ambient monitoring networks and is analyzing, among other issues, the need for and appropriateness of each of the nation's urban monitors.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Because there are no national ambient air quality standards for air toxics as there are for criteria air pollutants, there is no consensus metric to use to simply reflect the state of the environment for these pollutants. Often a 1 in a million risk estimate will be used to identify concentrations of concern. The National-Scale Air Toxics Assessment (NATA) describes a distribution of relative cancer risk across the U.S. NATA indicates that benzene poses a nationwide carcinogenic risk. For more information, see www.epa.gov/ttn/atw/nata.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Standard data documentation is available to support these data and can be accessed at: Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, EPA-625/R-96-010b (http://www.epa.gov/ttn/amtic/files/ambient/airtox/tocomp99.pdf).

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. The data used to develop this indicator of benzene ambient air quality are based on data retrieved from the EPA Air Quality Subsystem (AQS). Information on AQS can be obtained at: http://www.epa.gov/ttn/airs/aqs/. In addition, data from AQS can be accessed via the Internet at: http://www.epa.gov/air/data/index.html.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. A description of the UATMP sampling design and monitoring plan can be found in the 2003 Urban Air Toxics Monitoring Program (UATMP) Final Report (July 2004). A copy of this report can be downloaded at http://www.epa.gov/ttn/amtic/files/ambient/airtox/2003doc.pdf. A description of the General requirements and guidance for PAMS network design by pollutant is provided in 40 CFR 58, Appendix D. The monitoring objectives for the Nonmethane Organic Compound Monitoring Program are found in EPA-454/4-90-011.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Yes, the national programs included in these analyses certainly have such quality assurance programs, and standard data documentation is available to support those data archived in the Air Quality Subsystem (AQS) of AIRS and can be accessed at http://www.epa.gov/ttn/airs/airsaqs/, and the PAMS quality assurance plan is available at http://www.epa.gov/ttn/amtic/pamsmain.html. Further, the quality assurance plans for specific sites are publicly available by request to the reporting agency or the corresponding EPA Regional Office. In addition, the data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy). Finally, some quality assurance program plans are publicly available on the Internet. For example, the California Air Resources Board quality assurance program is available at http://www.arb.ca.gov/aaqm/qmosqual/qamanual/qamanual.htm.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The air quality statistics presented comply with the recommendations of the Intra-Agency Task Force on Air Quality Indicators. (US EPA Intra-Agency Task Force Report on Air Quality Indicators, EPA-450/4-81-015, US EPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC, February 1981.) A composite average of each trend statistic is used in the graphical presentations. All sites were weighted equally in calculating the composite average trend statistic. Missing annual summary statistics for the second through ninth years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since endpoint rates of change are dampened by the interpolated estimates. (National Air Quality and Emissions Trends Report, EPA 454/R-3-005, US EPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC, September 2003.)

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. The data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

We are not aware of any sources of error that may affect the findings developed from these data.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Generally toxics monitoring efforts focus on providing data for assessing public health consequences of air pollutants and, therefore, the monitors tend to be concentrated in urban areas with modest coverage in most rural areas. However data from the IMPROVE program does provide information on trace metals in rural areas. At the present time, the collection of state and local toxics data and PAMS data is limited in its geographic scope and does not cover many air toxics for most states. The data gaps vary by pollutant. In addition, many existing sites are not necessarily at locations which represent the highest area-wide concentrations. Nevertheless, these data can still be used to provide useful information on trends in ambient air toxics. EPA is currently working with state and local air monitoring agencies to build upon the existing networks to develop a national monitoring network. In addition, there are a significant number of 188 air toxics listed in the Clean Air Act for which EPA has not yet developed a monitoring method. For this reason, EPA is targeting current resources by first focusing on 33 urban air toxics. Benzene, while an important air toxic, represents only one of many air toxics that may occur in air.

Indicator: Ambient Concentrations of Manganese Compounds (200R)

Manganese is a naturally occurring metal that is ubiquitous in the environment. Exposure to low levels of manganese in the diet is considered to be nutritionally essential for people and animals (ATSDR, 1997). However, exposures to elevated concentrations of manganese are harmful to human health and have been associated with subtle neurological effects, such as slowed eye-hand coordination. The Reference Concentration (RfC) for manganese is 0.05 micrograms per cubic meter (ug/m^3) based on impairment of neurobehavioral function in people. The RfC is an estimate of a chronic inhalation exposure that is likely to be without appreciable risk of adverse non-cancer effects during a lifetime. At exposures increasingly greater than the RfC, the potential for harmful effects increases (ATSDR, 1997 and USEPA, 1999).

Manganese compounds are emitted by iron and steel production plants, power plants, coke ovens, and many smaller metal processing facilities. In addition to these stationary sources, manganese may also be contributed in border communities by vehicles using Canadian fuel with the additive methylcyclopentadienyl manganese tricarbonyl (MMT). Although manganese compounds are air pollutants of concern nationwide, they are of special concern in Region 5. The 1999 National Emissions Inventory showed that Region 5 had the highest manganese emissions of all EPA Regions, contributing 36.6% of all manganese compounds emitted nation-wide (NEI, 1999). The Risk Screening Environmental Indicators (RSEI) tool was developed by the Office of Pollution Prevention and Toxics to model the human health related risk from multi-media exposures to over 400 Toxic Release Inventory (TRI) hazardous compounds. Based on multimedia exposure, the RSEI tool identified manganese compounds in Region 5 as the #1 risk priority based on 1998 and 1999 TRI emissions data, and identified as the #2 priority risk based on 2000, 2001, and 2002 TRI emissions data.

This indicator presents ambient concentrations of manganese compounds measured as total suspended particulates (TSP) by direct monitoring. The data are from 53 locations in the Region that had a complete year of data reported to the Air Quality System (AQS) national database in 2004. Average annual manganese concentrations were calculated for each monitoring site. A concentration trend was determined using a subset of 21 monitoring sites that had four or more complete years of data between 2000 and 2004. As annual average concentrations are representative of long-term inhalation exposures, the ambient monitoring data are displayed in comparison with the manganese RfC.

Monitor locations were divided into different categories based on land use as defined in AQS: commercial and mobile, industrial, residential, and agricultural and forest. The land use category is only somewhat indicative of the area represented by an ambient air monitor. For example, a site categorized as “industrial” may adjoin a densely populated community where many residents are exposed to ambient pollution. U.S. Census data were consulted to determine the population density within a ½-mile radius of each monitoring site, measured as persons per square mile (sq. mi.). Census data for the year 2000 were accessed via EPA’s Environmental Justice Geographic Assessment Tool (USEPA, 2005). The Census defines a population density greater than 1,000 persons per sq. mi. as “urbanized”. A density over 5,000 persons per sq. mi. is commonly termed “highly urbanized”.

What the Data Show

In 2004 average annual ambient concentrations of manganese ranged from 0.006 to 2.126 ug/m^3 at the 53 monitoring stations in the Region. The median concentrations of site annual averages by land use are as follows (Figure 200R-1): commercial and mobile (0.036 ug/m^3), industrial (0.049 ug/m^3), residential (0.035 ug/m^3), and agricultural and forest (0.020 ug/m^3). Eighteen sites had an average manganese concentration higher than the RfC; 10 of these sites are categorized as industrial, 4 commercial or mobile, and 4 residential. The average population densities within a ½-mile radius of these sites were as follows:

commercial and mobile (5,706 per sq. mi.), industrial (2,916 per sq. mi.), residential (5,107 per sq. mi.), agricultural and forest (50 per sq. mi.).

The median concentration of 21 trend sites showed a 14.7% decline in ambient manganese between 2000 and 2004 (Figure 200R-2). Despite this decline, the median concentration for these sites remained nearly equal to the RfC. These sites had the following land use designations: commercial and mobile (6 sites), industrial (9 sites), residential (6 sites), agricultural and forest (no sites).

Indicator Limitations

- AQS data represent several sites per State, but do not have full geographic or temporal coverage. Some emissions "hotspots" are included, while others may exist that have not been monitored.

Data Sources

Ambient air data as reported to the Air Quality System (AQS) database, EPA Office of Air and Radiation, is available at the following URL: http://www.epa.gov/air/data/aqsdb.html

References

Agency for Toxic Substances and Disease Registry (ATSDR). *Toxicological Profile for Manganese (Update).* Draft for Public Comment. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. 1997.

U.S. Environmental Protection Agency. *Integrated Risk Information System (IRIS) on Manganese*. National Center for Environmental Assessment, Office of Research and Development, Washington, DC. 1999.

U.S. Environmental Protection Agency. National Emissions Inventory (NEI) website, 1999, Query Link accessed by: www.epa.gov/air/data, August 2005.

U.S. Environmental Protection Agency. Environmental Justice Geographic Assessment Tool (EnviroMapper). Website updated March 2005, accessible at: http://www.epa.gov/enviro/ej/

Graphics

Figure 200R.1: Ambient manganese as TSP, Region 5 annual average concentrations, 2004

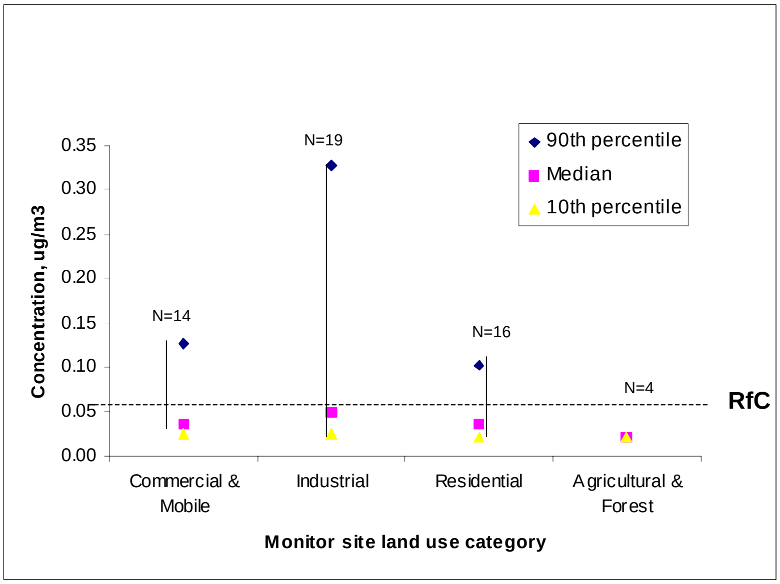
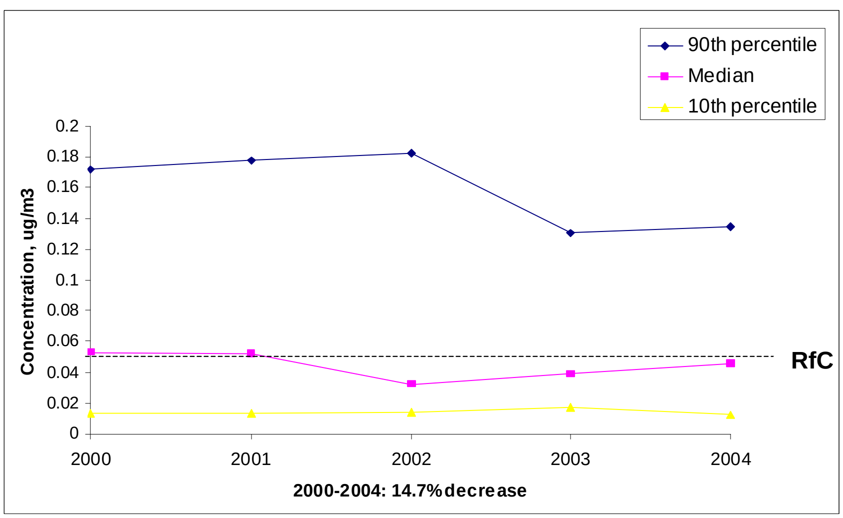


Figure 200R.2: Ambient manganese as TSP, annual average concentrations, Region 5, 2000-2004



Coverage: 21 monitoring sites with sufficient data to assess trends

R.O.E. Indicator QA/QC

Data Set Name: AMBIENT CONCENTRATIONS OF MANGANESE COMPOUNDS
Indicator Number: 200R (89159)
Data Set Source: AQS monitoring
Data Collection Date: AQS 1994 through 2003
Data Collection Frequency: AQS frequency varies
Data Set Description: Ambient Concentrations of Manganese Compounds
Primary ROE Question: What are the trends in outdoor air quality and their effects on human health and the environment?
Comment: NATA modeling results and the AQS monitoring database provide complementary views of the ambient manganese (Mn) condition in Region 5. NATA modeling is based on 1999 emissions inventories compiled by State agencies. This national dataset provides national coverage. However the model outputs are averaged across each county, so local hotspots are "smoothed" out. AQS monitoring data is spotty in terms of geographic coverage and temporal coverage. The data are valuable, however, because they identify multiple local hotspots which have been smoothed by NATA results. Taking the two data sources together, the reader may see elevated Mn in some counties (according to NATA) and may see localized areas within the county that have even higher concentrations (according to AQS). Even if AQS data were not collected in the high Mn NATA counties, the reader may expect that hotspots exist in the county. AQS data are adequate to calculate multi-year trends at sites with more than 4 years of data. NATA results for 1999 emissions will be comparable to 2002 outputs to be developed in the future.

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

AQS monitoring data are reported by State and Local agencies and industrial firms, following standard EPA metholologies and under approved QAPPs. Manganese data are collected as total suspended particulates (TSP) and samples analyzed according to EPA (IO) methods. http://www.epa.gov/air/data/aqsdb.html and http://www.epa.gov/ttn/atw/nata/natsaov.html

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

AQS data are generated following standard EPA methods and approved workplans, specific to the State or Local agency involved. The Region 5 assessment includes only AQS data from sites that are sufficient in quantity to produce valid annual averages. At a minimum, sites had 80% data completion for 3 seasonal quarters on a 1-in-12 day sampling schedule, i.e. at least 18 measurements per year.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Given adequate data completeness, ambient air monitoring data is widely used by EPA to generate annual average concentrations for individual or aggregated sites. Multi-year trends are typically calculated as a linear regression of log-transformed annual averages against year. Statistical significance of the resulting trend coefficient is determined using a t-test with 95% confidence. The trend coefficient is then converted to an annual percent change per year.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

AQS does not provide full geographic coverage, although most larger urban areas in the Region had one or more sites. AQS sites were included only if data at existing sites were adequate to generate a valid annual average concentration for one or more years. Some sites operated during the entire 10-year period of 1994-2003, but most collected less than 5 years of data. Multi-year trends were determined for sites with 4 or more years of valid data.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

AQS sites were generally selected to represent specific community exposures, including local industrial hotspots and other sites in typical urban communities. Few of the sites are "background". They are all populated areas which vary in that some are near industrial fencelines while others represent more city-wide levels. Census data indicate that each site has hundreds or thousands of residents within 1/2 mile. Sensitive populations are included in many of these urban communities.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

IRIS RfC is an established benchmark to indicate whether ambient Mn concentrations are of concern, although the RfC is not used explictly in this indicator. Ambient concentrations are also typically compared to measurements collected at other urban and rural sites nationally.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Details of AQS sampling procedures are available within the AQS database. AQS contains, for each monitoring site, the specific sampling and analytical methods used by the collecting agency and other information.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

AQS data are all fully public and available. Access to the database is limited to those with an AQS account and appropriate software, however. Summary data are accessible to the public at the AirData website: www.epa.gov/air/data/index.html Non-AQS users may obtain raw data by request (FOIA or informal) from EPA by submitting a data request to: www.epa.gov/ttn/airs/airsaqs/detaildata/datarequest.html contacting Virginia Ambrose 919-541-5454

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

AQS data is collected following standard procedures. Assumptions and methods used for data summary are easily reproducible.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

AQS data is reported by various agencies, each of which have approved workplans and QAPPs. Copies of some QAPPs are housed at EPA Region 5, others could be obtained from the respective local agency upon request. R5 air monitoring QA officer, Gordon Jones, can provide further detail about QAPPs approved for State and Local agencies.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

AQS data were summarized by Region 5 following consistent and simple assumptions. Incomplete datasets were not considered. For complete annual datasets, simple mathematical averages were calculated per year. AQS data represent specific points on the map and are not used to interpolate conditions between sites.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

AQS site averages are based on years of data with sufficient measurement quantity. Specifically, 80% data completion on a 1-in-12-day sampling schedule is required to compile a valid quarter of data; 3 valid quarters are required to comprise a valid year of data. Confidence intervals could potentially be calculated around the data averages; this should not be necessary, however, because data are restricted to sites with complete years of data.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No, AQS data used here are sufficient to demonstate that some communities have higher concentrations than others. The statistical test for temporal trends is robust (t-test at 95% confidence) and unlikely to confirm existence of a data trend where one does not exist.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

AQS monitoring sites are spotty in geographic and temporal coverage. The absence of data in an area should not be inferred to mean that there are no elevated Mn concentrations.

Indicator: Ambient Concentrations of Lead (005)

Lead is a naturally occurring metal that is found in the Earth's crust and in various manufactured products, such as batteries and metal alloys. Some chemicals containing lead were previously added to gasoline to enhance vehicle performance, but that practice was phased out during the 1970s and 1980s. As a result, air emissions of lead from the transportation sector decreased dramatically during that period (see Indicator "Lead Emissions"). Today, the highest levels of airborne lead are usually found near industrial operations that process materials containing lead, such as smelters and battery manufacturers (EPA, 2003).

Despite reduced emissions, lead remains an important environmental health issue because excessive exposure can cause serious health effects, including neurological impairments such as seizures, mental retardation, and behavioral disorders (EPA, 1986). Even at low doses, lead exposure can cause damage to the nervous systems of fetuses and young children (see Indicator "Blood Lead Level"). Lead exposure can occur by inhalation of airborne particles that contain lead, drinking contaminated water, eating contaminated food items, or by ingesting non-food items that contain lead, such as dust and paint chips.

This indicator reflects ambient lead concentrations in $\mu g/m^3$ from 1980 to 2003. Trends for this indicator are based on measurements made at the 20 monitoring stations in the National Air Monitoring Stations (NAMS) and State and Local Air Monitoring Stations (SLAMS) network that have consistently measured ambient air concentrations of lead over the entire time frame of interest. Reported values are annual maximum quarterly averages.

What the Data Show

Figure 005-1 shows how lead concentrations have changed in the United States over the last 25 years. Between 1980 and 2004, the average lead concentrations decreased 98%. This decrease, which occurred mostly during the 1980s and early 1990s, is largely attributed to reduced lead content in gasoline (Latest Findings on National Air Quality, EPA 454/K-03-001,2003). In 2003, ambient air concentrations of lead exceeded EPA's health-based air quality standards in only two counties nationwide (US EPA Green Book, http://www.epa.gov/oar/oaqps/greenbk/lindex.html).

Indicator Limitations

- Ambient monitoring for lead occurs mostly in urban areas and in areas with large industrial processes that emit lead. Consequently, the average concentrations shown here might not be representative of average concentrations in rural areas.

Data Sources

U.S. Environmental Protection Agency. Air Quality System (http://www.epa.gov/air/data/index.html)

References

U.S. Environmental Protection Agency. Latest Findings on National Air Quality – 2002 Status and Trends, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

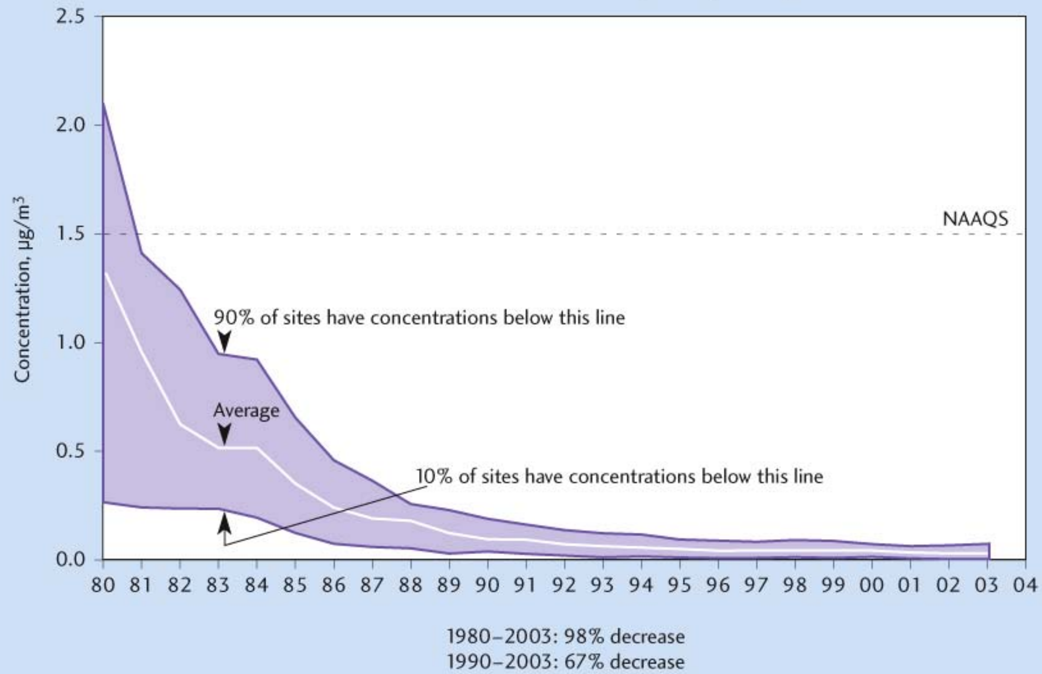
U.S. Environmental Protection Agency. Air Quality Criteria for Lead, EPA/600/8-83/028 aF-dF. Research Triangle Park, NC; U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, 1986.

U.S. Environmental Protection Agency. National Air Quality and Emissions Trends Report - 2003 Special Studies Edition, EPA 454/R-03-005. Research Triangle Park, NC: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, September 2003.

U.S. Environmental Protection Agency. Green Book - http://www.epa.gov/oar/oaqps/greenbk/lindex.html

Graphics

Figure 005-1: Ambient lead concentrations, 1980-2004
Based on annual maximum quarterly average



Coverage: 20 monitoring sites nationwide with sufficient data to assess trends.

Source: EPA's Air Quality System.

Note: Figure will be updated with 2004 data, once the data are available.

R.O.E. Indicator QA/QC

Data Set Name: AMBIENT LEAD CONCENTRATIONS
Indicator Number: 005 (89070)
Data Set Source: EPA Air Quality System
Data Collection Date: ongoing: since at least 1980-present
Data Collection Frequency: Varies. See 40 CFR Parts 53 & 58 & attached QA/QC
Data Set Description: Ambient Lead Concentrations
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The ambient air quality data are based on data retrieved from the Air Quality System (AQS) in August 2004. These are direct measurements of pollutant concentrations at monitoring stations operated by tribes and state and local governments throughout the nation. The monitoring stations are generally located in larger urban areas. EPA and other federal agencies also operate some air quality monitoring sites on a temporary basis as a part of air pollution research studies. The national monitoring network conforms to uniform criteria for monitor siting, instrumentation, and quality assurance. The program under which the data are collected is the NAMS/SLAMS network. A description of this network includes: 1) 40 CFR 50 - National ambient air quality standards (NAAQS) and reference methods for determining criteria air pollutant concentrations in the atmosphere; 2) 40 CFR 53 - Process for determining reference or equivalent methods for determining criteria air pollutant concentrations in the atmosphere; 3) 40 CFR 58 - Ambient air quality surveillance (monitoring) requirements. These methods and requirements can be found at http://www.epa.gov/ttn/amtic/. The Lead Manual Reference Method can be found in 40 CFR Part 50, Appendix G - Reference Method for the Determination of Lead in Suspended Particulate Matter Collected from Ambient Air. [Federal Register: Vol. 43, page 46258, 10/05/78]. These results have been peer reviewed. The most recent review was as a part of the National Air Quality and Emissions Trends Report, 2001 EPA 454/K-02-001, September 2002. This report is available at: http://www.epa.gov/airtrends.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. In 2003, thousands of monitoring sites reported air quality data for one or more of the six National Ambient Air Quality Standards (NAAQS) pollutants to AQS. The sites consist of National Air Monitoring Stations (NAMS), State and Local Air Monitoring Stations (SLAMS), and other special-purpose monitors. NAMS were established to ensure a long-term national network for urban area-oriented ambient monitoring and to provide a systematic, consistent database for air quality comparisons and trends analysis. SLAMS allow state or local governments to develop networks tailored for their immediate monitoring needs. For this indicator, 39 ambient Pb monitors met the trends data completeness criteria for the period from 1982 to 2001, and 96 ambient Pb monitors met the trends data completeness criteria for the 10-year period from 1992 to 2001. Point-source-oriented monitoring data were omitted from all ambient trends analysis presented in this section to avoid masking the underlying urban trends.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The conceptual model used to derive this indicators has been used and thoroughly reviewed as part of the Agency's national report on air quality trends for 25 years. Lead air quality monitoring sites meet the annual trends data completeness requirement if they have at least 6 valid daily measurements for each calendar quarter. The model basically has three elements: 1) Determine if year is valid for inclusion. Must have greater than or equal to 6 valid daily measurements for each calendar quarter. 2) Determine if site is valid for trends. Must have greater than or equal to 75% of possible years in the time series. For the 24-year period 1980-2003, trend sites must have at least 18 valid years and must not be missing more than 2 consecutive years of data. 3) Interpolate for missing years. Simple linear interpolation is used to fill in for missing years in the following way. Missing annual summary statistics for the in-between years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since endpoint rates of change are dampened by the interpolated estimates. References include: U.S. Environmental Protection Agency. Latest Findings on National Air Quality - 2002 Status and Trends, 2003, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Lead is one of six primary air pollutants controlled by the Clean Air Act Amendments of 2005, and so is important in answering the question, "What are the trends in air quality and its effects on human health and the environment?" The national air monitoring network for the six criteria air pollutants is extensive; however, there are far more monitors in urban areas than in rural areas. Point-source-oriented monitoring data were omitted from all ambient trends analysis presented in this section to avoid masking the underlying urban trends. EPA is currently conducting a national assessment of the existing ambient monitoring networks and is analyzing, among other issues, the need for and appropriateness of each of the nation's urban monitors.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The existing monitoring network captures sensitive populations. The national monitoring network is extensive. As noted in Question T2Q1, there are far more monitors in urban areas than in rural areas. Population tends to be concentrated in urban areas. Consequently, these urban areas are more likely to contain populations that are particularly sensitive to lead. EPA uses various tools and techniques (e.g., models and spatial analyses) to augment the limited monitoring in rural areas. These tools help EPA better characterize pressures on ecological condition.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Yes, the level of the corresponding national ambient air quality standard (NAAQS) for lead is 1.5 ug/m3. This level is indicative of the state of the environment with respect to ambient air concentrations of lead.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

National Air Quality and Emissions Trends Report, 2003 Special Studies Edition - http://www.epa.gov/air/airtrends/aqtrnd03/. General Air Quality and National Monitoring Network - http://www.epa.gov/ttn/amtic/criteria.html.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. The data used to develop these indicators are available through the Air Quality Subsystem of the Aerometric Information Retrieval System (AIRS). Information on AIRS can be obtained at: http://www.epa.gov/ttn/airs/. In addition, data from AIRS can be accessed via the Internet at: http://www.epa.gov/air/data/index.html.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes, The Ambient Monitoring Technology Information Center (AMTIC) contains information and files on ambient air quality monitoring programs, details on monitoring methods, relevant documents and articles, information on air quality trends and nonattainment areas, and federal regulations related to ambient air quality monitoring. This information can be found at http://www.epa.gov/ttn/amtic/criteria.html.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The QA/QC of the national air monitoring program has several major components: the Data Quality Objective (DQO) process, reference and equivalent methods program, EPA's National Performance Audit Program (NPAP), system audits, and network reviews (Available on the Internet: www.epa.gov/ttn/amtic/npaplist.html). To ensure quality data, the SLAMS are required to meet the following: 1) each site must meet network design and site criteria; 2) each site must provide adequate QA assessment, control, and corrective action functions according to minimum program requirements; 3) all sampling methods and equipment must meet EPA reference or equivalent requirements; 4) acceptable data validation and record keeping procedures must be followed; and 5) data from SLAMS must be summarized and reported annually to EPA. Finally, there are system audits that regularly review the overall air quality data collection activity for any needed changes or corrections. Further information available on the Internet (http://www.epa.gov/cludygxb/programs/namslam.html) and through United States EPA's Quality Assurance Handbook (EPA-454/R-98-004 Section 15). There is a Quality Assurance Project Plan from each state or local agency operating a NAMS/SLAMS monitor meeting the AEPA Requirements for Quality Assurance Project Plans, EPA QA/R-5. The quality assurance plans for specific sites are publicly available by request to the reporting agency or the corresponding EPA Regional Office. The plans are audited at least once every three years as required in 40 CFR 58, Appendix A, Section 2.5. In addition, the data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes, The air quality statistics presented relate to the pollutant specific NAAQS and comply with the recommendations of the Intra-Agency Task Force on Air Quality Indicators. A composite average of each trend statistic is used in the graphical presentations. All sites were weighted equally in calculating the composite average trend statistic. Missing annual summary statistics for the second through ninth years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since endpoint rates of change are dampened by the interpolated estimates. The statistic used to track ambient lead air quality is the maximum quarterly mean concentration for each year. From 1982 to 2001, a total of 39 ambient Pb monitors met the trends data completeness criteria, and a total of 96 ambient Pb monitors met the trends data completeness criteria for the 10-year period from 1992 to 2001. Point-source-oriented monitoring data were omitted from all ambient trends analysis presented in this section to avoid masking the underlying urban trends.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. The data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No, We are not aware of any sources of error that may affect the findings developed from these data.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The national air monitoring network for the six criteria air pollutants is extensive; however, there are far more monitors in urban areas than in rural areas. Monitoring in urban areas helps to characterize population exposures, because population tends to be concentrated in urban areas. For this indicator, only 39 ambient Pb monitors met the trends data completeness criteria for the period from 1982 to 2001, and 96 ambient Pb monitors met the trends data completeness criteria for the 10-year period from 1992 to 2001, so this might not be widely representative of the nation as a whole. Point-source-oriented monitoring data were omitted from all ambient trends analysis presented in this section to avoid masking the underlying urban trends.

Indicator: Ambient Concentrations of Ozone (004)

Ozone is a gas found in different parts of the atmosphere. Ozone in the upper atmosphere, or stratosphere, helps protect the earth from the sun's harmful rays. (The "Ozone Levels Over North America" Indicator describes trends in stratospheric ozone levels over the United States.) In the lowest level of the atmosphere, or troposphere, ozone is harmful to both human health and the environment. For this reason, ozone is often described as being "good up high and bad nearby" (Ozone: Good Up High Bad Nearby, EPA 451/K-03-001). Although some industrial sources release ozone directly into the environment, most ground-level ozone forms from chemical reactions involving nitrogen oxides (NO_x), volatile organic compounds (VOCs), and sunlight. Ozone levels are typically highest during the afternoon hours of the summer months, when the influence of direct sunlight is the greatest. (Latest Findings on National Air Quality, EPA 454/K-03-001, 2003)

Inhalation exposure to ozone has been linked to numerous respiratory health effects, including decreases in lung function, airway inflammation, and cough and pain when taking a deep a breath. Ozone exposure can aggravate lung diseases such as asthma, leading to increased medication use and increased hospital admissions and emergency room visits. Though people with respiratory problems are most vulnerable to the effects of ozone, even healthy people who are active outdoors can suffer from ozone-related health effects. Elevated concentrations of ozone can also affect vegetation and ecosystems, as the "Ozone Injury to Forest Plants" Indicator describes further. (Air Quality Criteria for Ozone and Related Photochemical Oxidants, EPA 600-P-93-004F-c, 1996).

This indicator reflects ambient concentrations in parts per million (ppm) of ground-level ozone from 1980 to 2003, based on 1-hour and 8-hour measurements. The 1-hour standard is useful in indicating potential effects during short-term "spikes" in concentrations. The longer 8-hour standard is indicative of exposures occurring over a more sustained period of time (e.g., an outdoor worker's exposure over the course of a work day). Trends for this indicator represent 299 sites that have data for the period of record in the National Air Monitoring Stations (NAMS) and State and Local Air Monitoring Stations (SLAMS) network and other special purpose monitors. Measurements are taken on both a daily and continuous basis to assess both peak concentrations and overall trends, which are derived by averaging direct measurements from these monitoring stations on a yearly basis. This indicator displays the annual fourth maximum 8-hour average and the annual second maximum 1-hour average.

What the Data Show

Figure 004-1 depicts the nationwide long-term trend in *1-hour average* ambient air concentrations of ozone. From 1980 to 2003, ozone levels decreased by 24%, based on the annual second highest daily maximum concentrations. Moreover, the 1-hour ozone levels observed in 2003 rank among the lowest levels on record, but the downward trend appears to be slowing. The map in Figure 004-2 shows how long-term trends in 1-hour average ozone levels have varied from one EPA Region to the next. All ten Regions experienced some decline in 1-hour average ozone levels during the past 25 years, except for the northwestern region (EPA Region 10), which showed no net change. The greatest reductions in 1-hour ozone concentrations were observed in the two EPA Regions (Regions 1 and 9) that had the highest ozone levels in 1980.

Figure 004-3 illustrates how *8-hour average* ambient air concentrations of ozone have changed in the United States over the last 24 years. Between 1980 and 2003, ambient ground-level ozone concentrations decreased by 18% based on the annual fourth highest daily maximum 8-hour average. Although the 8-hour ozone levels in 2003 ranked among the lowest on record, 474 counties (or parts of counties) in the United States experienced violations of the health-based ozone standard between 2000 and 2003 (EPA 2004, page 7). The map in Figure 004-4 shows how 8-hour average ozone levels have changed over the last 24 years in each of the EPA Regions. Again, the most consistent and substantial declines in 8-hour levels were observed in Regions that originally had the highest ozone concentrations (EPA Regions 1 and 9). Most other Regions showed either less pronounced declines (EPA Regions 2 to 7) or no net change (EPA Region 8). The one exception to this trend is observed in EPA Region 10 where the annual fourth highest daily maximum 8-hour ozone levels observed in 2003 were higher than those observed in 1980. However, it is noteworthy that the ozone levels in this Region, on average, continue to be the lowest of all EPA Regions across the country.

In summary, despite reductions in ambient air concentrations of ozone and decreases in the emissions of ozone precursors over the past quarter century (see Indicators "NOx Emissions" and "VOC Emissions"), ozone remains one of the most persistent and ubiquitous air pollution issues in the U.S. In 2003, more than 100 million people live in counties with poor ozone air quality based on the national 8-hour ozone standard (EPA 2004, page 5)

Indicator Limitations

- Short-term trends in ozone concentrations are often highly dependent on meteorological conditions. This complicates efforts to interpret data for any given year, such as the increase in 8-hour average ozone levels seen in Region 10 in 2003. Air quality trends over the longer term are far less likely to be influenced by unusual meteorological conditions.
- Because most of the monitoring sites are located in urban areas, the trends might not accurately reflect conditions outside the immediate urban monitoring areas.

Data Sources

Data can be accessed in the EPA Air Quality System (AQS)
http://www.epa.gov/ttnairs1/airsaqs/index.htm

References
U.S. Environmental Protection Agency. Ozone: Good Up High Bad Nearby, EPA 451/K-03-001. Washington, DC; US Environmental Protection Agency, Office of Air and Radiation, June 2003.
U.S. Environmental Protection Agency.

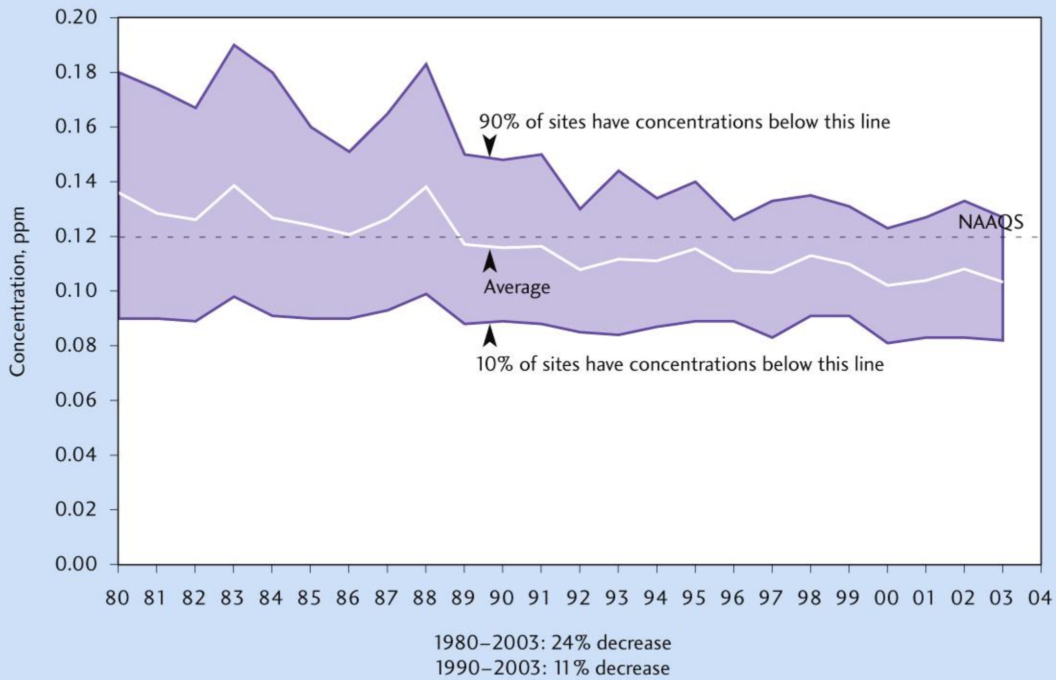
Latest Findings on National Air Quality – 2002 Status and Trends, 2003, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

U.S. Environmental Protection Agency. Air Quality Criteria for Ozone and Related Photochemical Oxidants, EPA 600-P-93-004F-cF. Research Triangle Park, NC; US Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, July 1996.

U.S. Environmental Protection Agency. The Ozone Report - Measuring Progress through 2003, EPA 454/K-04-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, April 2004.

Graphics

Figure 004-1: Ozone air quality, 1980-2004
Based on annual 2nd maximum 1-hour average

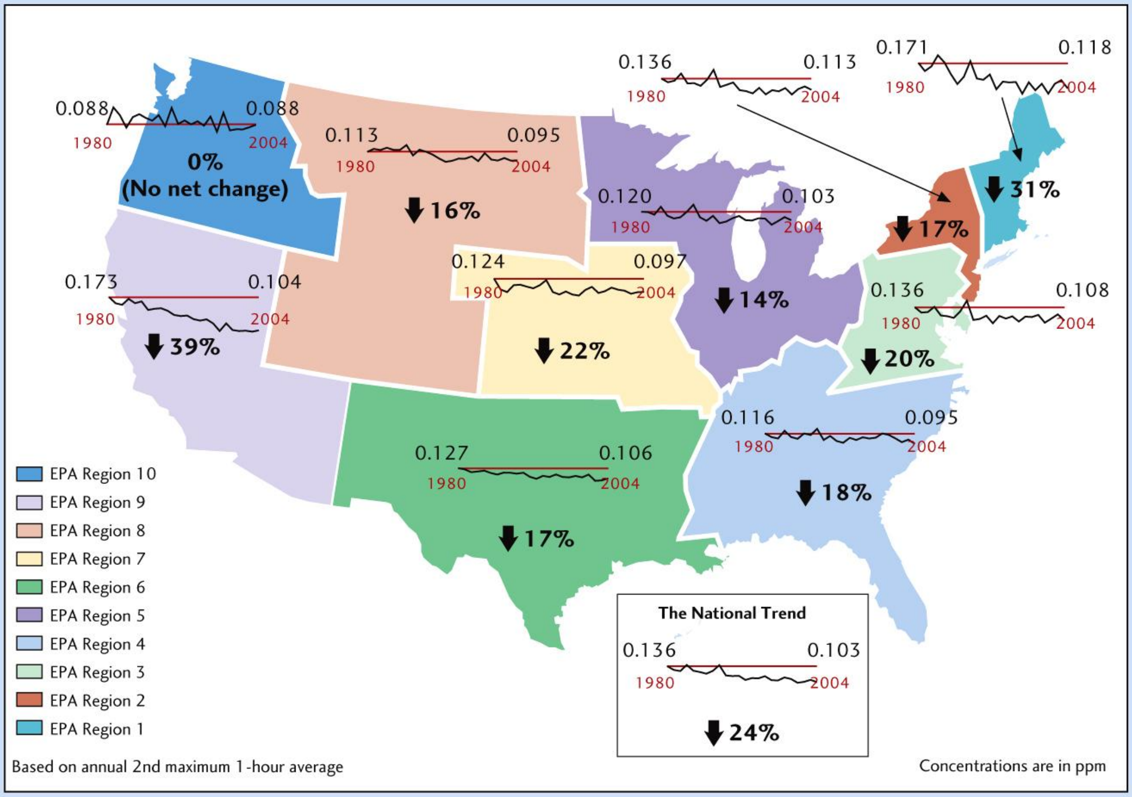


Coverage: 299 monitoring sties nationwide with sufficient data to assess trends.

Source: EPA's Air Quality System.

Note: Figure will be updated with 2004 data, once the data are available.

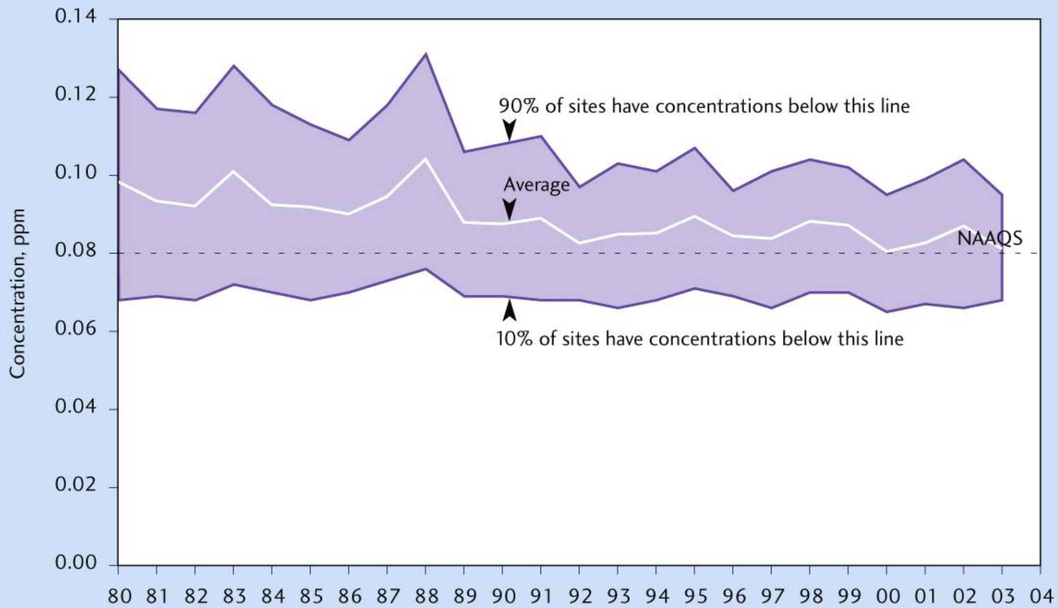
Figure 004-2 : Trends in ozone levels (1-hour), 1980-2004, averaged across EPA regions



Source: EPA's Air Quality System.

Note: Figure will be updated with 2004 data, once the data are available.

Figure 004-3: Ozone air quality, 1980-2004
Based on annual 4th maximum 8-hour average



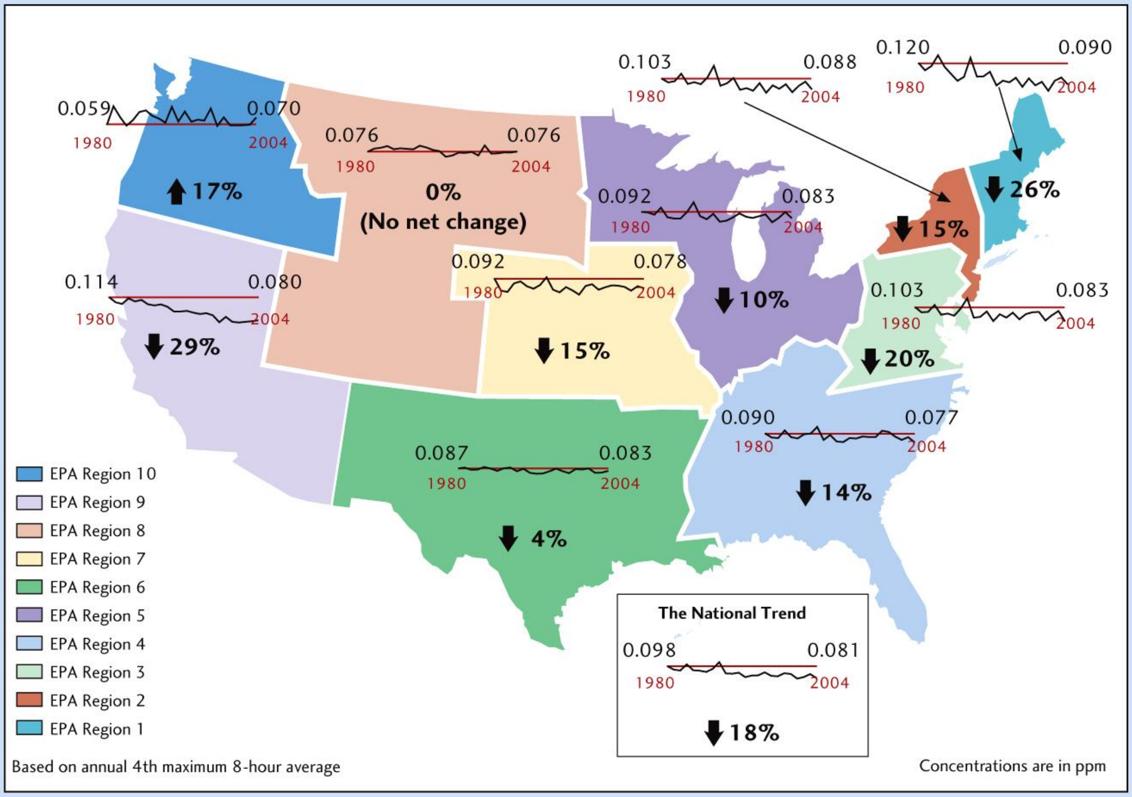
1980–2003: 18% decrease
1990–2003: 7% decrease

Coverage: 299 monitoring sties nationwide with sufficient data to assess trends.

Source: EPA's Air Quality System.

Note: Figure will be updated with 2004 data, once the data are available.

Figure 004-4: Trends in ozone levels (8-hour), 1980-2004, averaged across EPA regions



Source: EPA's Air Quality System.

Note: Figure will be updated with 2004 data, once the data are available.

R.O.E. Indicator QA/QC

Data Set Name: AMBIENT OZONE CONCENTRATIONS
Indicator Number: 004 (89073)
Data Set Source: EPA Air Quality System
Data Collection Date: 1980-2004
Data Collection Frequency: Varies. See 40 CFR Parts 53 & 58 & attached QA/QC
Data Set Description: Ambient O3 Concentrations
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The ambient air quality data are based on data retrieved from the Air Quality System (AQS in August 2004). These are direct measurements of pollutant concentrations at monitoring stations operated by tribes and state and local governments throughout the nation. The monitoring stations are generally located in larger urban areas. EPA and other federal agencies also operate some air quality monitoring sites on a temporary basis as a part of air pollution research studies. The national monitoring network conforms to uniform criteria for monitor siting, instrumentation, and quality assurance. The program under which the data are collected is the NAMS/SLAMS network. A description of this network includes: " 40 CFR 50 - National ambient air quality standards (NAAQS) and reference methods for determining criteria air pollutant concentrations in the atmosphere " 40 CFR 53 - Process for determining reference or equivalent methods for determining criteria air pollutant concentrations in the atmosphere " 40 CFR 58 - Ambient air quality surveillance (monitoring) requirements. Reference methods for ozone can be found at the following web site - http://www.epa.gov/ttn/amtic/files/ambient/criteria/ref405.pdf These results have been peer reviewed. The most recent review was as a part of the National Air Quality and Emissions Trends Report, 2001 EPA 454/K-02-001, September 2002. This report is available at: http://www.epa.gov/airtrends

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. In 2002, thousands of monitoring sites reported air quality data for one or more of the six National Ambient Air Quality Standards (NAAQS) pollutants to AQS. The sites consist of National Air Monitoring Stations (NAMS), State and Local Air Monitoring Stations (SLAMS), and other special-purpose monitors. NAMS were established to ensure a long-term national network for urban area-oriented ambient monitoring and to provide a systematic, consistent database for air quality comparisons and trends analysis. SLAMS allow state or local governments to develop networks tailored for their immediate monitoring needs The monitoring objectives for the NAMS/SLAMS network are found in: " 40 CFR 58, Appendix D http://www.epa.gov/ttn/amtic/ " 40 CFR 58.2(c) "

EPA 454/R-98-004, Part I, Section 3.2 http://www.epa.gov/ttn/amtic/cpreldoc.html The monitoring objectives for the NAMS/SLAMS network are found in: " 40 CFR 58, Appendix D http://www.epa.gov/ttn/amtic/ " 40 CFR 58.2(c) " EPA 454/R-98-004, Part I, Section 3.2 http://www.epa.gov/ttn/amtic/cpreldoc.html

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The conceptual model used to derive these indicators has been used and thoroughly reviewed as part of the Agency's national report on air quality trends for 25 years. Ozone air quality monitoring sites meet the annual trends data completeness requirement if they have at least 50 percent of the daily data available for the ozone season, which varies by state, but typically runs from May through September. The model basically has three elements: 1.) Determine if year is valid for inclusion. Must have greater than or equal to 50% of required days. 2.) Determine if site is valid for trends. Must have greater than or equal to 75% of possible years in the time series. For the 24-year period 1980-2003, trend sites must have at least 18 valid years and must not be missing more than 2 consecutive years of data. 3.) Interpolate for missing years. Simple linear interpolation is used to fill in for missing years in the following way. Missing annual summary statistics for the in-between years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since endpoint rates of change are dampened by the interpolated estimates. References include: U.S. Environmental Protection Agency. The Ozone Report - Measuring Progress through 2003, EPA 454/K-04-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, April 2004. Latest Findings on National Air Quality 2002 Status and Trends, 2003, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The data for these indicators are collected under a single national program of ambient air quality surveillance known as the National Air Monitoring Stations (NAMS)/State or Local Air Monitoring Stations (SLAMS) network. The NAMS/SLAMS network focus is on providing data for assessing public health consequences of criteria pollutants and, therefore, the monitors tend to be concentrated in urban areas with modest coverage in most rural areas. Pollutant specific guidance for establishing NAMS/SLAMS networks is provided in 40 CFR 58, Appendix D.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The network is not focused on sensitive populations like children, the elderly, asthmatics, etc., but samples them proportion to their occurrence in the general populations of the areas monitored.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Yes, annual values are established which represent the levels of the corresponding national ambient air quality standard (NAAQS), and are 0.125 ppm for 1-hour ozone and 0.085 ppm for 8-hour ozone. These levels are indicative of the state of the environment with respect to ambient air concentrations of ozone.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Standard data documentation is available to support these data and can be accessed at: General Air Quality and National Monitoring Network - http://www.epa.gov/ttn/amtic/moninfo.html National Air Quality and Emissions Trends Report, 2003 Special Studies Edition - http://www.epa.gov/air/airtrends/aqtrnd03/

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. The data used to develop these indicators are available through the Air Quality Subsystem of the Aerometric Information Retrieval System (AIRS). Information on AIRS can be obtained at: http://www.epa.gov/ttn/airs/. In addition, data from AIRS can be accessed via the Internet at: http://www.epa.gov/air/data/index.html

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The Ambient Monitoring Technology Information Center (AMTIC) contains information and files on ambient air quality monitoring programs, details on monitoring methods, relevant documents and articles, information on air quality trends and nonattainment areas, and federal regulations related to ambient air quality monitoring. This information can be found at http://www.epa.gov/ttn/amtic/ .

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The QA/QC of the national air monitoring program has several major components: the Data Quality Objective (DQO) process, reference and equivalent methods program, EPA s National Performance Audit Program (NPAP), system audits, and network reviews (Available on the Internet: www.epa.gov/ttn/amtic/npaplist.html) To ensure quality data, the SLAMS are required to meet the following: 1) each site must meet network design and site criteria; 2) each site must provide adequate QA assessment, control, and corrective action functions according to minimum program requirements; 3) all sampling methods and equipment must meet EPA reference or equivalent requirements; 4) acceptable data validation and record keeping procedures must be followed; and 5) data from SLAMS must be summarized and reported annually to EPA. Finally, there are system audits that regularly review the overall air quality data collection activity for any needed changes or corrections. Further information available on the Internet: http://www.epa.gov/cludygxb/programs/namslam.html and through United States EPA's Quality Assurance Handbook (EPA-454/R-98-004 Section 15) There is a Quality Assurance Project Plan from each state or local agency operating a NAMS/SLAMS monitor meeting the AEPA Requirements for Quality Assurance Project Plans@, EPA QA/R-5. The quality assurance plans for specific sites are publicly available by request to the reporting agency or the corresponding EPA Regional Office. The plans are audited at least once every three years as required in 40 CFR 58, Appendix A, Section 2.5. In addition, the data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The air quality statistics presented relate to the pollutant specific NAAQS and comply with the recommendations of the Intra-Agency Task Force on Air Quality Indicators. A composite average of each trend statistic is used in the graphical presentations. All sites were weighted equally in calculating the composite average trend statistic. Missing annual summary statistics for the second through ninth years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since endpoint rates of change are dampened by the interpolated estimates.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. The data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

We are not aware of any sources of error that may affect the findings developed from these data.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The national air monitoring network for the six criteria air pollutants is extensive; however, there are far more monitors in urban areas than in rural areas. Monitoring in urban areas helps to characterize population exposures, because population tends to be concentrated in urban areas. More rural monitoring might help scientists assess transport and ecological effects, although EPA uses additional tools and techniques (e.g., models and spatial analyses) to augment limited monitoring in some areas and to better characterize pressures on ecological condition. EPA is currently conducting a national assessment of the existing ambient monitoring networks and is analyzing, among other issues, the need for and appropriateness of each of the nation s urban monitors.

Indicator: Ambient Concentrations of PM (003)

Particulate matter (PM) is the general term used for a mixture of solid particles and liquid droplets found in the air. Airborne PM comes from many different sources. Primary particles are released directly from emissions sources into the atmosphere, while secondary particles are formed in the air from reactions involving precursor chemicals (e.g., nitrogen oxides, sulfur dioxide). Ambient air monitoring stations throughout the country measure air concentrations of two size ranges of particles: PM2.5 and PM10. PM2.5 consists of "fine particles" with aerodynamic diameters less than or equal to 2.5 µm. PM10 includes both fine particles (PM2.5) and "coarse particles," which are particles with aerodynamic diameters between 2.5 and 10 µm. The heavier PM10 particles tend to exhibit more localized effects, whereas PM2.5 tends to exhibit a more regional effect as the primary and secondary particles that form it are more easily transported. PM2.5 also has a seasonal pattern because some of the secondary particles involved in its formation vary by seasonal emission and/ or transport (EPA 2002B).

Scientific studies show a link between inhalable PM, which includes both fine and coarse particles that can accumulate in the respiratory system, and a series of significant health effects. Some of these effects are associated with exposures to PM, while others are associated with exposures to a combination of PM and other air pollutants. Exposure to coarse particles is primarily associated with the aggravation of respiratory conditions such as asthma. Exposure to fine particles is closely associated with decreased lung function, increased hospital admissions and emergency room visits, increased respiratory symptoms and disease, and premature death. Sensitive groups that appear to be at greatest risk to such PM effects include the elderly, individuals with cardiopulmonary disease such as asthma or congestive heart disease, and children (EPA2002a).

PM also can cause adverse impacts to the environment. Fine particles are the major cause of reduced visibility in parts of the U.S., including many of our National Parks and wilderness areas (see Indicator 006). PM deposition affects vegetation and ecosystems by upsetting delicate nutrient and chemical balances in soils and surface water. For example, deposition of particles containing nitrogen and sulfur may change the nutrient balance and acidity of aquatic environments so that species composition and buffering capacity change (see Indicator 041). Some particles that deposit onto plant leaves can corrode leaf surfaces or interfere with plant metabolism. PM also causes soiling and erosion damage to materials, including monuments, statues, and other objects of cultural importance.

This indicator describes trends in ambient air concentrations of PM, based on measurements from a nationwide network of monitoring stations.

What the Data Show

PM10 concentrations averaged across the 434 monitoring stations in operation between 1988 and 2004 are currently 31% lower than the average 1988 levels, with most of this decrease occurring between 1988 and 1996 (Figure 003-1). The baseline year (1988) was selected because widespread PM10 monitoring did not occur in earlier years. PM10 concentrations for the ten EPA Regions all experienced steady decreases in PM10 levels (Figure 003-2). The greatest decreases were observed in Regions 9 and 10, the two EPA regions that had the highest PM10 levels in the baseline year. While the ambient condition for PM10 is clearly improving, airborne particulate concentrations continue to be a health issue in certain parts of the country. In 2003, 37 counties (21 million people) measured concentrations in excess of the PM10 standards (EPA 2004).

Average PM2.5 concentrations in 2003 were the lowest since nationwide monitoring began in 1999 (Figure 003-3). The baseline year (1999) in this case is the first year when widespread PM2.5 monitoring occurred, and the trend is based on measurements collected at 785 monitoring stations that generated high quality data over that period. Improvements were most significant in portions of the West (Region 9) and the Southeast (Region 4), where average PM2.5 levels in 2003 were 18% lower than those in 1999 (Figure 003-4). However, average PM2.5 levels in the Rocky Mountains (Region 8) and New England (Region 1) were essentially unchanged over the period. In 2003, 72 counties (53 million people) measured concentrations in excess of the PM2.5 standards (EPA 2004).

Indicator Limitations

- There are far more PM10 and PM2.5 monitors in urban areas than in rural areas.

Data Source

US EPA Air Quality System (http://www.epa.gov/air/data/index.html).

Interagency Monitoring of Protected Visual Environments Network and EPA Speciation Network, 2002

References

U.S. Environmental Protection Agency. Air Quality Criteria for Particulate Matter, Third External Review Draft, Volume II, EPA 600-P-99-002bC. Research Triangle Park, NC; US Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, April 2002A.

U.S. Environmental Protection Agency. Latest Findings on National Air Quality – 2002 Status and Trends, EPA 454/K-03-001. 2002b

U.S. Environmental Protection Agency. The Particulate Pollution Report: Current Understanding of Air Quality and Emissions through 2003, EPA 454/R-04-002. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, December 2004.

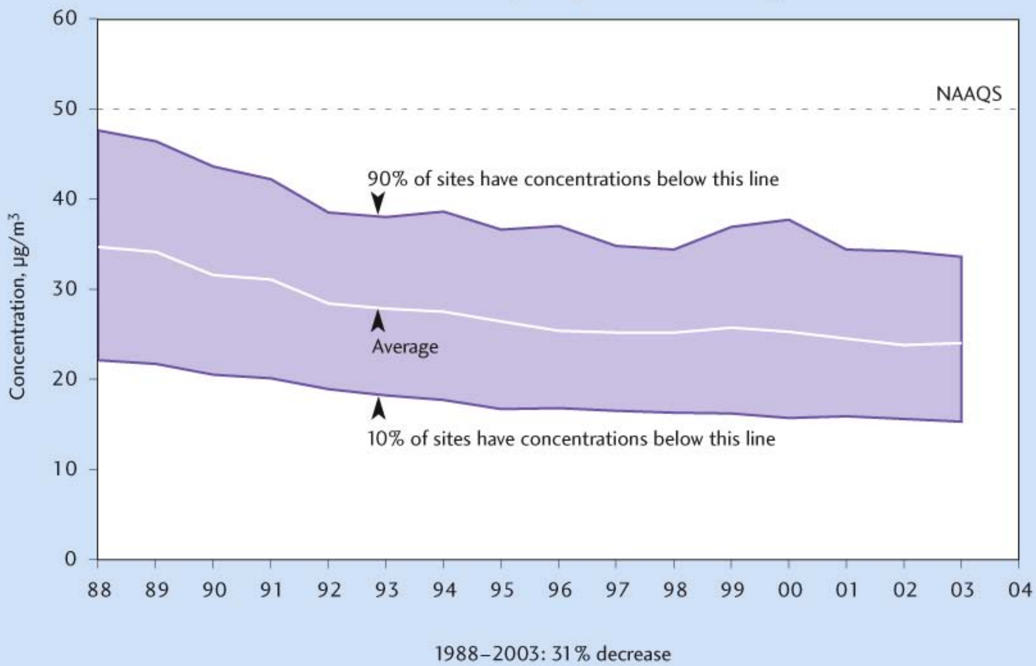
Latest Findings on National Air Quality – 2002 Status and Trends, EPA 454/K-03-001.)

U.S. Environmental Protection Agency. Latest Findings on National Air Quality – 2002 Status and Trends, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

U.S. Environmental Protection Agency. National Air Quality and Emissions Trends Report - 2003 Special Studies Edition, EPA 454/R-03-005. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, September 2003.

Graphics

Figure 003-1: Particulate matter (PM_{10}) air quality, 1988-2004
Based on seasonally weighted annual average

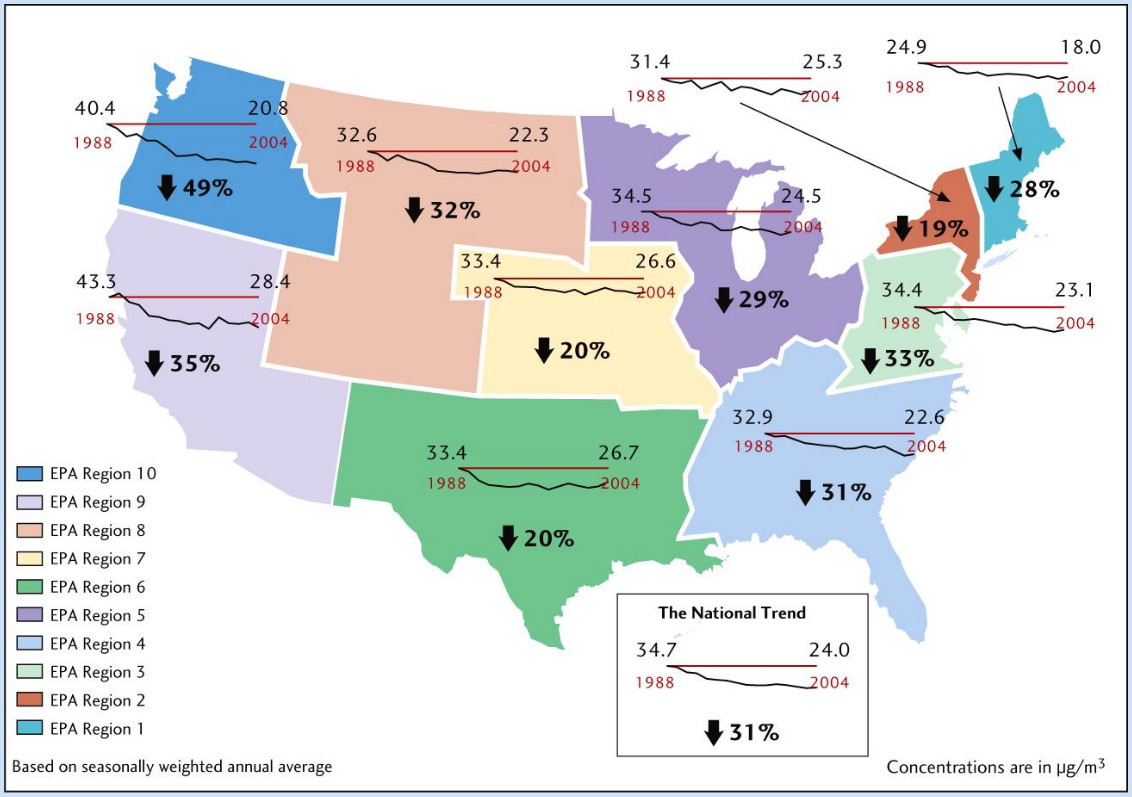


Coverage: 434 monitoring sites nationwide with sufficient data to assess trends.

Source: EPA's Air Quality System.

Note: Figure will be updated with 2004 data, once the data are available.

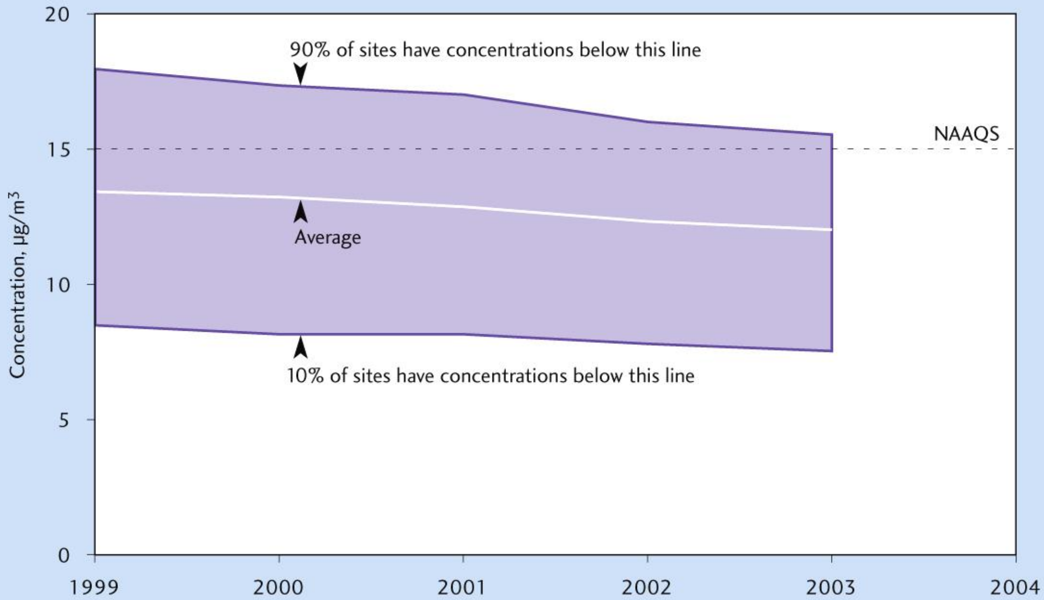
Figure 003-2 : Trends in particulate matter (PM_{10}), 1988-2004, averaged across EPA regions



Source: EPA's Air Quality System.

Note: Figure will be updated with 2004 data, once the data are available.

Figure 003-3: Particulate matter ($PM_{2.5}$) air quality, 1999-2004
Based on seasonally weighted annual average



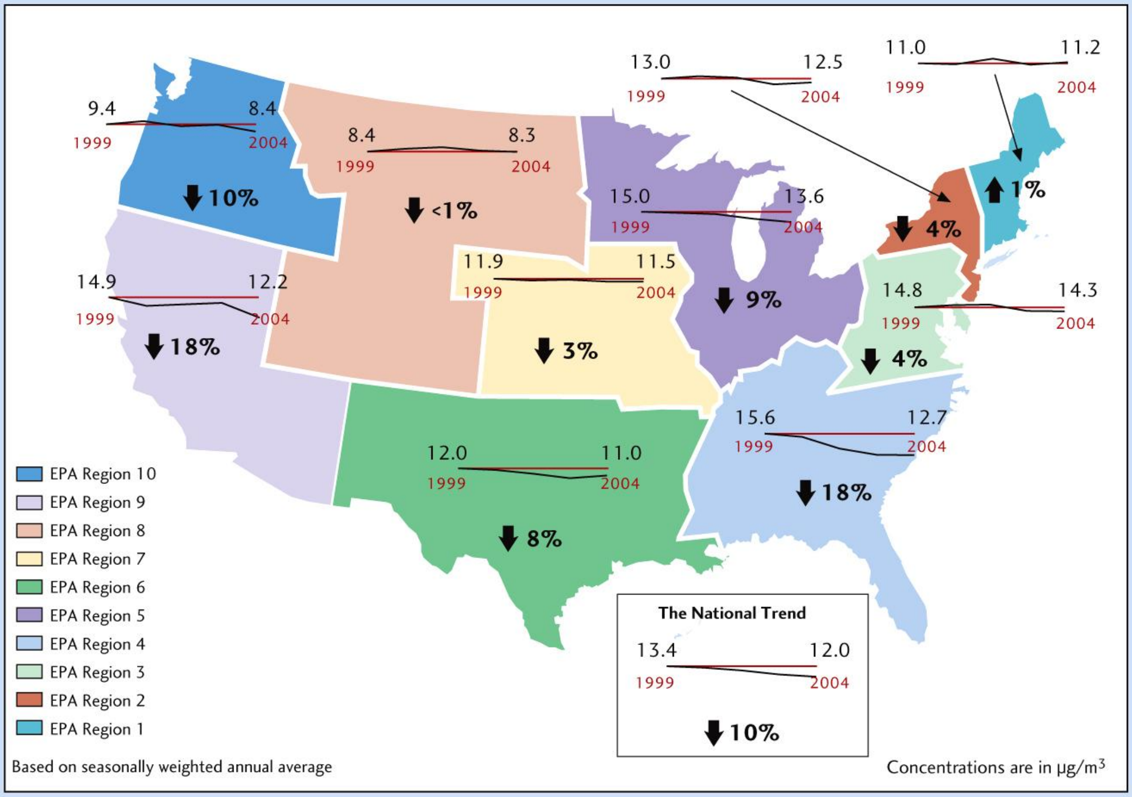
1999–2003: 10% decrease

Coverage: 785 monitoring sties nationwide with sufficient data to assess trends.

Source: EPA's Air Quality System.

Note: Figure will be updated with 2004 data, once the data are available.

Figure 003-4: Trends in particulate matter ($PM_{2.5}$), 1999-2004, averaged across EPA regions



Source: EPA's Air Quality System.

Note: Figure will be updated with 2004 data, once the data are available.

R.O.E. Indicator QA/QC

Data Set Name: AMBIENT PM CONCENTRATIONS
Indicator Number: 003 (89072)
Data Set Source: EPA Air Quality System
Data Collection Date: 1988-2004
Data Collection Frequency: Varies. See 40 CFR Parts 53 & 58 & attached QA/QC
Data Set Description: Ambient PM Concentrations
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The ambient air quality data are based on data retrieved from the Air Quality System (AQS) in August 2004. These are direct measurements of pollutant concentrations at monitoring stations operated by tribes and state and local governments throughout the nation. The monitoring stations are generally located in larger urban areas. EPA and other federal agencies also operate some air quality monitoring sites on a temporary basis as a part of air pollution research studies. The national monitoring network conforms to uniform criteria for monitor siting, instrumentation, and quality assurance. The program under which the data are collected is the NAMS/SLAMS network. 40 CFR 53 - Process for determining reference or equivalent methods for determining criteria air pollutant concentrations in the atmosphere " 40 CFR 58 - Ambient air quality surveillance (monitoring) requirements These results have been peer reviewed. The most recent review was as a part of the National Air Quality and Emissions Trends Report, 2001 EPA 454/K-02-001, September 2002. This report is available at: http://www.epa.gov/airtrends. In addition, the Interagency Monitoring of Protected Visual Environments (IMPROVE) network was established in 1987 to track trends in pollutants such as PM2.5 that contribute to visibility impairment. These sites are located predominantly in rural areas throughout the country and the data is useful for assessing regional differences in PM2.5.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. In 2002, thousands of monitoring sites reported air quality data for one or more of the six National Ambient Air Quality Standards (NAAQS) pollutants to AQS, as shown in Table B-1. The sites consist of National Air Monitoring Stations (NAMS), State and Local Air Monitoring Stations (SLAMS), and other special-purpose monitors. NAMS were established to ensure a long-term national network for urban area-oriented ambient monitoring and to provide a systematic, consistent database for air quality comparisons and trends analysis. SLAMS allow state or local governments to develop networks tailored for their immediate monitoring needs. A description of this network includes: " 40 CFR 50 - National ambient air quality standards (NAAQS) and reference methods for

determining criteria air pollutant concentrations in the atmosphere "
(http://www.epa.gov/ttn/oarpg/t1/fr_notices/pmnaaqs.pdf)

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The conceptual model used to derive these indicators has been used and thoroughly reviewed as part of the Agency's national report on air quality trends for 25 years. Particulate matter air quality monitoring sites meet the annual trends data completeness requirement if they have at least 30 daily measurements per year for PM10 or at least 11 daily measurements for each calendar quarter for PM2.5. The model basically has three elements: 1.) Determine if year is valid for inclusion. Must have greater than or equal to 30 daily measurements per year for PM10. Must have greater than or equal to 11 daily measurements for each calendar quarter for PM2.5. 2.) Determine if site is valid for trends. Must have greater than or equal to 75% of possible years in the time series. The national PM10 monitoring network started in 1988. For the 16-year period 1988-2003, trend sites must have at least 12 valid years and must not be missing more than 2 consecutive years of data. The national PM2.5 monitoring network started in 1999. For the 5-year period 1999-2003, trend sites must have at least 4 valid years. 3.) Interpolate for missing years. Simple linear interpolation is used to fill in for missing years in the following way. Missing annual summary statistics for the in-between years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since endpoint rates of change are dampened by the interpolated estimates. References include: U.S. Environmental Protection Agency. The Ozone Report - Measuring Progress through 2003, EPA 454/K-04-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, April 2004. Latest Findings on National Air Quality 2002 Status and Trends, 2003, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003. The Particle Pollution Report, 2003, EPA 454-R-04-002. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, December 2004.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The national air monitoring network for the six criteria air pollutants is extensive; however, there are far more monitors in urban areas than in rural areas. Monitoring in urban areas helps to characterize population exposures, because population tends to be concentrated in urban areas. More rural monitoring might help scientists assess transport and ecological effects, although EPA uses additional tools and techniques (e.g., models and spatial analyses) to augment limited monitoring in some areas and to better characterize pressures on ecological condition. EPA is currently conducting a national assessment of the existing ambient monitoring networks and is analyzing, among other issues, the need for and appropriateness of each of the nation s urban monitors.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The network is not focused on sensitive populations like children, the elderly, asthmatics, etc., but samples them proportion to their occurrence in the general populations of the areas monitored.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Yes, the levels of the corresponding national ambient air quality standards (NAAQS) for PM2.5 are 15 ug/m3 (annual) and 65 ug/m3 (24-hour). The levels of the corresponding NAAQS for PM10 are 50 ug/m3 (annual) 150 ug/m3 (24-hour). These levels are indicative of the state of the environment with respect to ambient air concentrations of particulate matter. The annual averages are more stable than peak 24-hour metrics and, therefore, are used for tracking long-term trends.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

National Air Quality and Emissions Trends Report, 2003 Special Studies Edition - http://www.epa.gov/air/airtrends/aqtrnd03/ General Air Quality and National Monitoring Network - http://www.epa.gov/ttn/amtic/moninfo.html PM 2.5 Monitoring Information - http://www.epa.gov/ttn/amtic/amticpm.html

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. The data used to develop these indicators are available through the Air Quality Subsystem of the Aerometric Information Retrieval System (AIRS). Information on AIRS can be obtained at: http://www.epa.gov/ttn/airs/. In addition, data from AIRS can be accessed via the Internet at: http://www.epa.gov/air/data/index.html.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The Ambient Monitoring Technology Information Center (AMTIC) contains information and files on ambient air quality monitoring programs, details on monitoring methods, relevant documents and articles, information on air quality trends and nonattainment areas, and federal regulations related to ambient air quality monitoring. This information can be found at http://www.epa.gov/ttn/amtic/

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The QA/QC of the national air monitoring program has several major components: the Data Quality Objective (DQO) process, reference and equivalent methods program, EPA's National Performance Audit Program (NPAP), system audits, and network reviews (Available on the Internet: www.epa.gov/ttn/amtic/npaplist.html) To ensure quality data, the SLAMS are required to meet the following: 1) each site must meet network design and site criteria; 2) each site must provide adequate QA assessment, control, and corrective action functions according to minimum program requirements; 3) all sampling methods and equipment must meet EPA reference or equivalent requirements; 4) acceptable data validation and record keeping procedures must be followed; and 5) data from SLAMS must be summarized and reported annually to EPA. Finally, there are system audits that regularly review the overall air quality data collection activity for any needed changes or corrections. Further information available on the Internet: http://www.epa.gov/cludygxb/programs/namslam.html and through United States EPA's Quality Assurance Handbook (EPA-454/R-98-004 Section 15) There is a Quality Assurance Project Plan from each state or local agency operating a NAMS/SLAMS monitor meeting the AEPA Requirements for Quality Assurance Project Plans@, EPA QA/R-5. The quality assurance plans for specific sites are publicly available by request to the reporting agency or the corresponding EPA Regional Office. The plans are audited at least once every three years as required in 40 CFR 58, Appendix A, Section 2.5. In addition, the data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

The air quality statistics presented relate to the pollutant specific NAAQS and comply with the recommendations of the Intra-Agency Task Force on Air Quality Indicators. A composite average of each trend statistic is used in the graphical presentations. All sites were weighted equally in calculating the composite average trend statistic. Missing annual summary statistics for the second through ninth years for a site are estimated by linear interpolation from the surrounding years. Missing end points are replaced with the nearest valid year of data. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since endpoint rates of change are dampened by the interpolated estimates.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. The data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No, We are not aware of any sources of error that may affect the findings developed from these data.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The national air monitoring network for the six criteria air pollutants is extensive; however, there are far more monitors in urban areas than in rural areas. Monitoring in urban areas helps to characterize population exposures, because population tends to be concentrated in urban areas. More rural monitoring might help scientists assess transport and ecological effects, although EPA uses additional tools and techniques (e.g., models and spatial analyses) to augment limited monitoring in some areas and to better characterize pressures on ecological condition. EPA is currently conducting a national assessment of the existing ambient monitoring networks and is analyzing, among other issues, the need for and appropriateness of each of the nation s urban monitors. The monitoring is conducted mostly in urban areas, although the PM 2.5 data from the IMPROVE network support assessments of rural trends since the late 1980s. Trend data for PM10 are not available before 1988. Prior to 1988, total suspended particulate matter, which includes particles larger than PM10, was monitored to assess compliance with the NAAQS.

Indicator: Atmospheric Concentrations of Greenhouse Gases (349)

The Earth's temperature depends mainly on the amount of sunlight received, the portion reflected back into space, and the extent to which the atmosphere retains heat. Natural forces (volcanoes, changes in the Earth's orbit, etc.) and human activities (emissions of so-called "greenhouse gases", land use change) affect the amount of energy available to the Earth-atmosphere system and, thus, the Earth's temperature, climate, and weather. Human activities have altered the chemical composition of the atmosphere by the emissions and accumulation in the atmosphere of gases that change how much energy is reflected or escapes back into space, and hence, the Earth's climate. Some of the primary gases that retain heat in the atmosphere are water vapor, carbon dioxide, methane, nitrous oxides, and certain manufactured gases such as chlorofluorocarbons, hydrofluorocarbons, sulfur hexafluoride, and others. Many of these synthetic gases are extremely long-lived, remaining in the atmospheric for hundreds or even thousands of years.

This indicator shows the accumulation of these gases in the atmosphere, as increasing concentrations. Recent data are from networks that monitor the concentrations of these gases in the atmosphere. Historical data result from gas measurements made on air trapped in ice cores at the time the ice was formed. Water vapor is not included as a greenhouse gas, because its concentration is not thought to be directly influenced by water vapor emissions from human activities.

What the Data Show *(Note: These figures will be updated with the latest concentration data available, late in 2005.)*

The concentration of CO2 has varied considerably over geological time (Figure 349-1). From at least 900 A.D. to 1800 A.D., CO2 concentrations stayed relatively constant at about 270 – 290 ppm. Over the past 150 years, CO_2 concentrations have increased by 31 percent to present, and by about 18 percent since 1958.

Methane (CH4) concentrations also remained fairly constant from at least 1000 A.D. until about 1730 A.D. (Figure 349-2). CH4 concentrations then rose from about from about 680 ppm to about 774 ppm in 1850, and then rose more rapidly to over 1700 ppm today. Stated another way, essentially no increase occurred from 1000 A.D. to 1730 A.D. It then took approximately 175 years (c.1905) to add 200 ppm to atmospheric CH4 concentrations, 40 years (c.1945) to add the next 200 ppm, 20 years to add the next 200 ppm (c 1965), and 10 years (c 1975) to add the next 200 ppm. The rates of methane increase began to slow by the late 1970s and then to decline, with less than 200 ppm added to atmospheric concentrations between 1978 and the present. Overall, methane concentrations more than doubled in the past 150 years, although rates of increase have slowed almost to zero in recent years.

Nitrous oxides (N2O) concentrations increased slowly from a thousand years ago until around 1800, when concentrations began to rise more rapidly (Figure 349-3), with large interannual variability. After 1800 N_2O concentrations increased by 15 percent (about 0.25%/year +/- 0.05%/year) to concentrations of 314 ppm in 1998 (IPCC 2001). Recent interannual variations in N_2O concentrations may be explained by changes in use of nitrogen-based fertilizer, biogenic soil emissions, or stratospheric losses due to volcanic-induced circulation changes, but significant uncertainty remains about the drivers of trends and variability of N2O.

The concentrations of some of the manufactured gases peaked around 1994 and now are decreasing (CFC-11, CFC-113, CH_3CCl_3 and CCl_4), while others are increasing more slowly (CFC-12), as a result of emissions reductions under the Montreal Protocol and its Amendments (Figure 349-4). Greenhouse halocarbons not controlled by the Protocol (because they do not contribute to stratospheric ozone losses) continue to increase. For example, the concentration of HFC-23 has increased by more than a factor of three between 1978 and 1995.

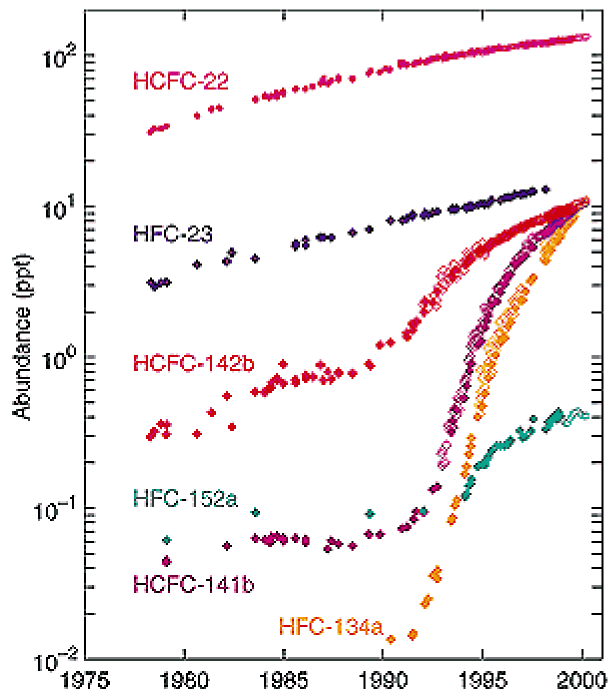


Figure 349-4: *HFC-23 (blue, UEA scale), -152a (green, UEA scale), -134a (orange, NOAA scale), and HCFC-22 (magenta, SIO scale), -142b (red, NOAA scale), and -141b (purple, NOAA scale) abundances (ppt) at Cape Grim, Tasmania for the period 1978 to 1999. Different symbols are data from different measurement networks: SIO (filled circles), NOAA-CMDL (open diamonds, Montzka et al., 1994, 1996a,b, 1999), UEA (filled diamonds, Oram et al., 1995, 1996, 1998, 1999) and AGAGE (open circles, only for 1998 to 2000, all gases but HFC-23, Miller et al., 1998; Sturrock et al., 1999; Prinn et al., 2000). Southern Hemisphere values (Cape Grim) are slightly lower than global averages. Source: IPCC Third Assessment Report: The Scientific Basis (2001)*

Indicator Limitations

- Ozone (O_3) is an important greenhouse gas present in both the stratosphere and troposphere. Trends in atmospheric concentrations of these are discussed in sections ___ and ___ of this report. Unlike the other gases in this indicator, ozone has a very short atmospheric life and is not well-mixed globally; large inter-temporal and geographical variability occurs. The effectiveness of ozone as a greenhouse gas is very dependent on the altitude of the concentrations, with the greatest radiative forcing occurring for concentrations at about 7 kilometers up. Depletion of stratospheric ozone tends to cool the Earth, partially offsetting elevated levels in the troposphere. Confidence in the measurement of ozone and of its contributions to climate change is much lower than for the long-lived greenhouse gases, such as carbon dioxide.

- Ice- core measurements are not taken in real time, which introduces some error into the date of the sample. Where snow accumulation is high, as in the air enclosed in the three ice cores from Law Dome, Antarctica, diffusion of the air is very limited, and allows the samples unparalleled age resolution. Etheridge et al. (1996) reported the uncertainty of the Law Dome ice core CH_4 concentrations to be about 10 ppb, while the precision of analysis of the Law Dome ice core air samples for CO2 was 0.2 ppm (http://cdiac.esd.ornl.gov/trends/co2/lawdome.html). For the Vostok ice cores, Barnola et al. (1991) reported that the age difference between air and ice may be ~6000 years during the coldest periods instead of ~4000 years, as previously assumed – small relative to the ages ranging into the hundreds of thousands of years. Dating accuracy for the ice cores ranged up to ± 20 years (often less), depending on the method used and the time period of the sample. For CH_4 from the Greenland ice sheets, the difference in air content and the ice age ranges from about 8 years for ice at small depths up to 200 years for deep ice. Comparisons across ice cores generally show good agreement, suggesting that the measurement errors are insignificant. (See, for example, http://cdiac.esd.ornl.gov/trends/co2/vostok.htm) More information on the accuracy of measurements of ice samples and other measurement methods can be found at: http://cdiac.esd.ornl.gov/by_new/bysubjec.html#atmospheric

Data Sources

All data sets can be accessed through: Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. at: http://cdiac.esd.ornl.gov/trends/trends.htm

References

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Etheridge, D.M., L.P. Steele, R.L. Langenfelds, R.J. Francey, J.-M. Barnola, and V.I. Morgan. 1996. Natural and anthropogenic changes in atmospheric CO_2 over the last 1000 years from air in Antarctic ice and firn. Journal of Geophysical Research 101:4115-4128.

Intergovernmental Panel on Climate Change (IPCC). 2001. Report of the Science Working Group.

National Research Council of the NAS. 2004. Radiative Forcing of Climate Change: Expanding the Concept and Addressing Uncertainties, Prepublication version, Dec.16, 2006.

Summaries of methods and discussions of data sets of atmospheric concentrations of greenhouse gases can be found in: Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. at: http://cdiac.esd.ornl.gov/trends/trends.htm

Graphics

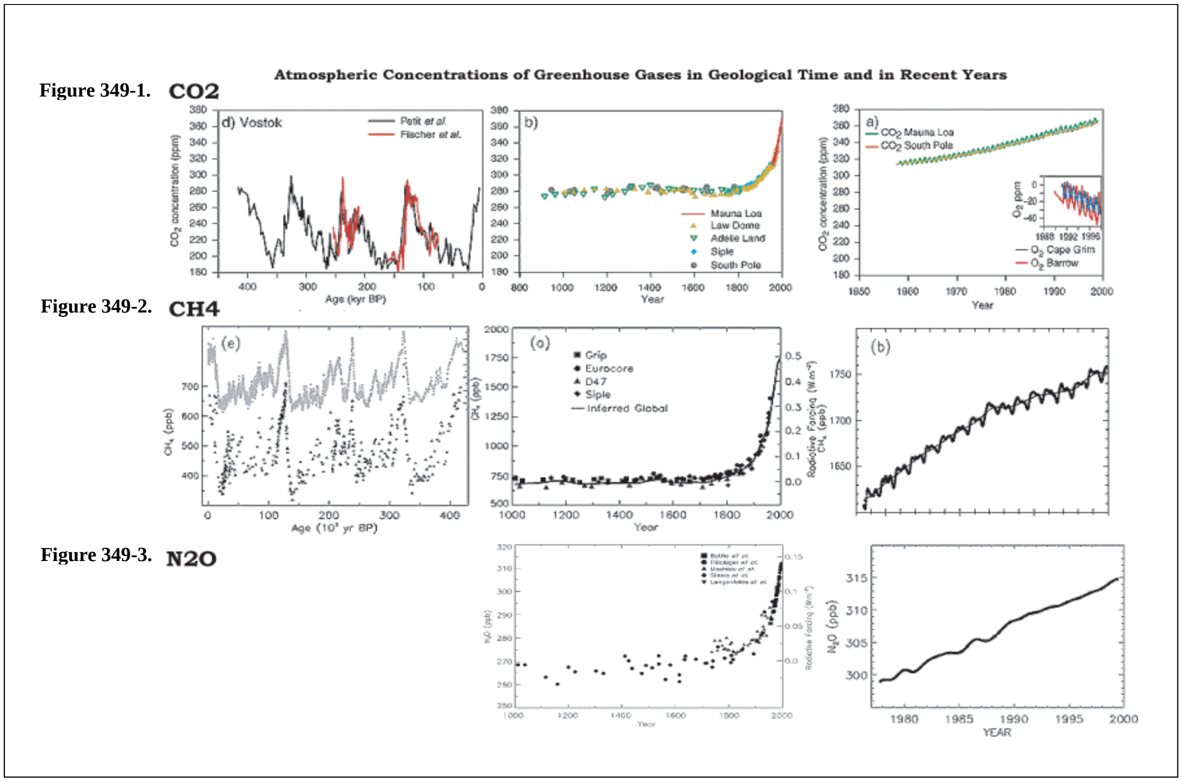


Figure 349-1. CO2

Figure 349-2. CH4

Figure 349-3. N2O

R.O.E. Indicator QA/QC

Data Set Name: ATMOSPHERIC CONCENTRATIONS OF GREENHOUSE GASES
Indicator Number: 349 (114470)
Data Set Source:
Data Collection Date:
Data Collection Frequency:
Data Set Description: Atmospheric Concentrations of Greenhouse Gases
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Summaries of methods and discussions of them can be found in: Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. at:

http://cdiac.esd.ornl.gov/trends/trends.htm Also, more detailed documentation of methods, uncertainties and some results can be found in the following references. For CO2: Barnola, J.-M., D. Raynaud, A. Neftel, and H. Oeschger. 1983. Comparison of CO2 measurements by two laboratories on air from bubbles in polar ice. Nature 303:410-13. Bacastow, R.B., C.D. Keeling, and T.P. Whorf. 1985. Seasonal amplitude increase in atmospheric CO2 concentration at Mauna Loa, Hawaii, 1959-1982. Journal of Geophysical Research 90(D6):10529-40. Etheridge, D.M., and C.W. Wookey. 1989. Ice core drilling at a high accumulation area of Law Dome, Antarctica. 1987. In Ice Core Drilling, edited by C. Rado and D. Beaudoing, pp. 86-96. Proceedings of the Third International Workshop on Ice Core Drilling Technology, Grenoble, France, October 10-14, 1988, CNRS, Grenoble. Etheridge, D.M., L.P. Steele, R.L. Langenfelds, R.J. Francey, J.-M. Barnola, and V.I. Morgan. 1996. Natural and anthropogenic changes in atmospheric CO2 over the last 1000 years from air in Antarctic ice and firn. Journal of Geophysical Research 101:4115-4128. Friedli, H., H. Lötscher, H. Oeschger, U. Siegenthaler, and B. Stauffer. 1986. Ice core record of 13C/12C ratio of atmospheric CO2 in the past two centuries. Nature 324:237-38. Guenther, P.R., A. Bollenbacher, C.D. Keeling, and D. Moss. 2002 Technical Report: Infrared Analyses of NOAA Primary CO2-in-Air Reference Gas Standards at SIO, 1991-1999. Guenther, P.R., G. Emanuele, and C.D. Keeling. 2002. Alternative Formulation of 1985-1999 Calibrations after Re-calibration of 4cc Chanber Volume of Mercury Manometer. Addendium to: Scripps Reference Gas Calibration System for Carbon-Dioxide-in Nitrogen and Carbon Dioxide-in-Air Standards: Revision of 1999, February 2002. See Diagram of the constant-volume mercury-column manometer. Herbert, G.A., E.R. Green, J.M. Harris, G.L. Koenig, S.J. Roughton, and K.W. Thaut, Control and monitoring instrumentation for the continuous measurement of atmospheric CO2 and meteorological variables, J. Atmos. Oceanic Technol., 3, 414-421, 1986. Keeling, C.D., R.B. Bacastow, and T.P. Whorf. 1982. Measurements of the concentration of carbon dioxide at Mauna Loa Observatory, Hawaii. In W.C. Clark (ed.), Carbon Dioxide Review: 1982. Oxford University Press, New York. Keeling, C.D., P.R. Guenther, G. Emanuele III, A. Bollenbacher, and D.J. Moss. 2002. Scripps Reference Gas Calibration System for Carbon Dioxide-in-Nitrogen and Carbon Dioxide-in-Air Standards: Revision of 1999 (with Addendum). SIO Reference Series No. 01-11. Lorius, C., J. Jouzel, C. Ritz, L. Merlivat, N.I. Barkov, Y.S. Korotkevich, and V.M. Kotlyakov. 1985. A 150,000-year climatic record from Antarctic ice. Nature 316:591-96. Morgan, V.I., C.W. Wookey, J. Li, T.D. van Ommen, W. Skinner, and M.F. Fitzpatrick. 1997. Site information and initial results from deep ice drilling on Law Dome. J. Glaciol. 43:3-10. Neftel, A., H. Oeschger, J. Schwander, B. Stauffer, and R. Zumbrunn. 1982. Ice core measurements give atmospheric CO2 content during the past 40,000 yr. Nature 295:220-23. Neftel, A., E. Moor, H. Oeschger, and B. Stauffer. 1985. Evidence from polar ice cores for the increase in atmospheric CO2 in the past two centuries. Nature 315:45-47. Petit, J.R., I. Basile, A. Leruyuet, D. Raynaud, C. Lorius, J. Jouzel, M. Stievenard, V.Y. Lipenkov, N.I. Barkov, B.B. Kudryashov, M. Davis, E. Saltzman, and V. Kotlyakov. 1997. Four climate cycles in Vostok ice core. Nature 387: 359-360. Petit, J.R., J. Jouzel, D. Raynaud, N.I. Barkov, J.-M. Barnola, I. Basile, M. Benders, J. Chappellaz, M. Davis, G. Delayque, M. Delmotte, V.M. Kotlyakov, M. Legrand, V.Y. Li

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Most of the greenhouse gases presented in this indicator are considered to be well-mixed in the global atmosphere, due in large part to their long residence time in the atmosphere. Relatively small variations across different locations do occur, and hence the value in monitoring the concentrations at multiple locations, as in these indicator figures.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. See the references provided above.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The sampling and monitoring design is very appropriate for answering the relevant indicator for the gases covered, because these gases are relatively evenly distributed globally.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The sampling design does not represent sensitive populations or ecosystems in particular. However, the global measurements should be adequate for understanding the impacts on such populations or ecosystems, if such were identified.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

No. Reference points are typically given as the mean over some period of measurement. Sometimes, a benchmark used is around 1850, to represent the atmosphere and climate system before significant anthropogenic influence is hypothesized to have occurred globally or regionally. No specific thresholds for damage have been scientifically established.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Summaries of methods and discussions of them can be found in: Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. at: http://cdiac.esd.ornl.gov/trends/trends.htm Also, more detailed documentation of methods, uncertainties and some results can be found in the following references. For CO2: Barnola, J.-M., D. Raynaud, A. Neftel, and H. Oeschger. 1983. Comparison of CO2 measurements by two laboratories on air from bubbles in polar ice. Nature 303:410-13. Bacastow, R.B., C.D. Keeling, and T.P. Whorf. 1985. Seasonal amplitude increase in atmospheric CO2 concentration at Mauna Loa, Hawaii, 1959-1982. Journal of Geophysical Research 90(D6):10529-40. Etheridge, D.M., and C.W. Wookey. 1989. Ice core drilling at a high accumulation area of Law Dome, Antarctica. 1987. In Ice Core Drilling, edited by C. Rado and D. Beaudoing, pp. 86-96. Proceedings of the Third International Workshop on Ice Core Drilling Technology, Grenoble, France, October 10-14, 1988, CNRS, Grenoble. Etheridge, D.M., L.P. Steele, R.L. Langenfelds, R.J. Francey, J.-M. Barnola, and V.I. Morgan. 1996. Natural and anthropogenic changes in atmospheric CO2 over the last 1000 years from air in Antarctic ice and firn. Journal of Geophysical Research 101:4115-4128. Friedli, H., H. Lötscher, H. Oeschger, U. Siegenthaler, and B. Stauffer. 1986. Ice core record of 13C/12C ratio of atmospheric CO2 in the past two centuries. Nature 324:237-38. Guenther, P.R., A. Bollenbacher, C.D. Keeling, and D. Moss. 2002 Technical Report: Infrared Analyses of NOAA Primary CO2-in-Air Reference Gas Standards at SIO, 1991-1999. Guenther, P.R., G. Emanuele, and C.D. Keeling. 2002. Alternative Formulation of 1985-1999 Calibrations after Re-calibration of 4cc Chanber Volume of Mercury Manometer. Addendium to: Scripps Reference Gas Calibration System for Carbon-Dioxide-in Nitrogen and Carbon Dioxide-in-Air Standards: Revision of 1999, February 2002. See Diagram of the constant-volume mercury-column manometer. Herbert, G.A., E.R. Green, J.M. Harris, G.L. Koenig, S.J. Roughton, and K.W. Thaut, Control and monitoring instrumentation for the continuous measurement of atmospheric CO2 and meteorological variables, J. Atmos. Oceanic Technol., 3, 414-421, 1986. Keeling, C.D., R.B. Bacastow, and T.P. Whorf. 1982. Measurements of the concentration of carbon dioxide at Mauna Loa Observatory, Hawaii. In W.C. Clark (ed.), Carbon Dioxide Review: 1982. Oxford University Press, New York. Keeling, C.D., P.R. Guenther, G. Emanuele III, A. Bollenbacher, and D.J. Moss. 2002. Scripps Reference Gas Calibration System for Carbon Dioxide-in-Nitrogen and Carbon Dioxide-in-Air Standards: Revision of 1999 (with Addendum). SIO Reference Series No. 01-11. Lorius, C., J. Jouzel, C. Ritz, L. Merlivat, N.I. Barkov, Y.S. Korotkevich, and V.M. Kotlyakov. 1985. A 150,000-year climatic record from Antarctic ice. Nature 316:591-96. Morgan, V.I., C.W. Wookey, J. Li, T.D. van Ommen, W. Skinner, and M.F. Fitzpatrick. 1997. Site information and initial results from deep ice drilling on Law Dome. J. Glaciol. 43:3-10. Neftel, A., H. Oeschger, J. Schwander, B. Stauffer, and R. Zumbrunn. 1982. Ice core measurements give atmospheric CO2 content during the past 40,000 yr. Nature 295:220-23. Neftel, A., E. Moor, H. Oeschger, and B. Stauffer. 1985. Evidence from polar ice cores for the increase in atmospheric CO2 in the past two centuries. Nature 315:45-47. Petit, J.R., I. Basile, A. Leruyuet, D. Raynaud, C. Lorius, J. Jouzel, M. Stievenard, V.Y. Lipenkov, N.I. Barkov, B.B. Kudryashov, M. Davis, E. Saltzman, and V. Kotlyakov. 1997. Four climate cycles in Vostok ice core. Nature 387: 359-360. Petit, J.R., J. Jouzel, D. Raynaud, N.I. Barkov, J.-M. Barnola, I. Basile, M. Benders, J. Chappellaz, M. Davis, G. Delayque, M. Delmotte, V.M. Kotlyakov, M. Legrand, V.Y. Lipe

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. Among other locations, the data sets can be accessed over the internet with appropriate summaries, metadata and graphics, at: http://cdiac.esd.ornl.gov/trends/trends.htm There are no known confidentiality issues.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. See references above. Also, there is a large degree of replication of findings across different studies.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

They are accessible. See references provided above.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. Because the gases covered by this indicator have long residence times in the atmosphere, they are considered to be well-mixed. Although there are minor variations from sampling location to location, the overwhelming consistency among sampling locations indicates that extrapolation from these locations to the global atmosphere is reliable.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. See the references provided.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Uncertainty does not impact the conclusions, and variability is represented in the data.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The limitations of this indicator are minimal. There is relatively little scientific controversy over the magnitude of growth of atmospheric concentrations of CO2, CH4 or N2O during the Industrial Period. Moreover, the estimated concentrations from ice core data have been replicated and corroborated from a growing number of sites. The contemporary data are based on direct sampling, The record of direct sampling of CO2 concentrations (at Mauna Loa, Hawaii and at the South Pole) since 1957 is one of the longest and most consistent time series that atmospheric science has produced. Because all three gases are relatively well mixed globally over the time scales of concern, spatial sampling error is a very small uncertainty. The overall trend of post-industrial increase in concentrations, and its magnitude relative to concentrations in the past 100 years, overwhelms the small local, daily, seasonal and inter-annual variability.

Indicator: Atmospheric Deposition of Mercury (038)

Mercury is found naturally in the environment and is also emitted into the air from industrial processes, like coal combustion and waste incineration (see “Mercury Emissions” indicator). Wet atmospheric deposition of mercury (mercury that falls to the Earth’s surface in the form of rain or snow) is an important environmental issue, particularly in aquatic settings. When mercury enters water bodies, whether from direct deposition or runoff, microorganisms can convert mercury into methylmercury, a highly toxic chemical (Wiener et al., 2002). The rate of this chemical conversion depends on environmental conditions such as the pH of a water body. For example, lakes heavily influenced by acid deposition often form more methylmercury than do similar lakes that are not acidified (Watras et al., 1994). Once formed in the water, small aquatic plants (phytoplankton) can absorb methylmercury. Methylmercury then enters small aquatic animals (zooplankton) that consume the plants. Through this process, the methylmercury continues to work its way up the food chain becoming more concentrated as it goes. For this reason, fish species higher in the food chain, such as sharks and swordfish, tend to have much higher methylmercury concentrations than fish species lower in the food chain.

Methylmercury in fish tissue presents a health risk to humans who eat fish from waters impacted by atmospheric deposition and other environmental releases (see the “Blood Mercury Level” indicator). Methylmercury also can have adverse behavioral and reproductive impacts on fish and both birds and mammals that eat significant amounts of fish (Wiener et al., 2002).

This indicator reflects the amount of mercury deposited to the United States in wet precipitation (rain or snow). The data were collected as part of the National Atmospheric Deposition Program (NADP) Mercury Deposition Network (MDN). The network began with 13 monitoring sites in 1995 and now has over 85 sites in operation. Most existing MDN sites are located in eastern North America from Minnesota to the Canadian Maritime Provinces and along the U.S. Atlantic and Gulf coasts. Precipitation samples are collected weekly and aggregated to provide annual average concentrations and annual wet deposition. MDN sites are located to measure broad geographical patterns of deposition that are not markedly influenced by local emissions. Annual wet deposition of mercury is calculated by multiplying concentrations in rainfall by the total precipitation amounts and summing them for the calendar year.

What the Data Show

Figure 038-1 shows the average mercury concentrations in precipitation measured across several regions of the U.S. in 2003 using shaded contours. The dots and numbers on the map correspond to the annual average concentration at each MDN monitoring site. Regional estimates of concentrations in precipitation can be made for the eastern United States, but there are too few monitoring stations located in the western United States to make such estimates there. As the figure shows, the highest mercury concentrations in precipitation were observed in the south. Two southwestern monitoring stations where there is very little rainfall had average concentrations of 27.0 and 16.4 ng/L and at four stations in central and southern Florida had average concentrations 16.1-16.4 ng/L. High concentrations (16.7 ng/L) were also found at one monitoring site in southeastern Wisconsin. In general, concentrations in the Northeastern and Mid-Atlantic states tended to be lower than those in the Midwestern and Southeastern United States.

Figure 038-2 shows data for annual wet deposition of mercury across several regions of the U.S. in 2003 using shaded contours. Wet deposition is a better measure than concentration of the amount of mercury that goes into the environment through precipitation. The dots and numbers on the map correspond to the annual deposition amount at each MDN monitoring site. Regional estimates of deposition amount can be made for the eastern United States, but there are too few monitoring stations located in the western United States to make such estimates there. The highest levels of wet mercury deposition were found in the South along the Gulf coast and extending up to the Mid-Atlantic and the Ohio River Valley. Lower wet deposition levels were observed in Minnesota, Wisconsin, New York, New England, and the Western sites.

Indicator Limitations

- Although monitoring stations are placed in many areas impacted by major mercury sources, the spatial coverage provided by MDN is limited in the western and central United States.
- Data are not available to characterize dry deposition of mercury, or the amount of mercury that falls to the Earth during periods of no precipitation as gases or particles. Dry deposition is believed to make up a substantial portion of the total amount deposited through atmospheric deposition.
- The precise relationship between the total mercury measured at MDN sites and the amount of methylmercury in the environment is currently unknown.

Data Sources

National Atmospheric Deposition Program (NADP): http://nadp.sws.uiuc.edu/. This site includes a link to the Mercury Deposition Network (MDN) website.

References

Guallar, E., Inmaculada Sanz-Gallardo, M., van't Veer, P., Bode, P., Aro, A., Gómez-Aracena, J., Kark, J.D., Riemersma, R.A., Martín-Moreno, J.M., Kok, F.J. 2002. Mercury, Fish Oils, and the Risk of Myocardial Infarction. *New England Journal of Medicine* 347(22): 1747-1754.

U.S. EPA. 2004. Web site: "Mercury." http://www.epa.gov/mercury.

Watras C.J., Bloom N.S., Hudson R.J.M., Gherini S., Munson R., Claas S.A., Morrison K.A., Hurley J., Wiener J.G., Fitzgerald W.F., Mason R., Vandal G., Powell D., Rada R., Rislove L., Winfrey M., Elder J., Krabbenhoft D.P., Andren A.W., Babiarz C., Porcella D.B., Huckabee J.W. 1994. Sources and fates of mercury and methylmercury in Wisconsin lakes. In: Watras CJ, HUckabee JW, editors. *Mercury Pollution: Integration and Synthesis*. Boca Raton, FL, USA:Lewis Publishers, p 153-177.

Weiner, J.G., Krabbenhoft, D.P., Heinz, G.H., Scheuhammer, A.M. 2002. Chapter 16: Ecotoxicology of Methylmercury. In: Hoffman DJ, Rattner BA, Burton Jr. GA, Cairns Jr. J, editors. *Handbook of Ecotoxicology, 2nd edition*. Florida, USA: CRC Press. P 407-461.

Graphics

Figure 038-1: Total Mercury Concentration, 2003

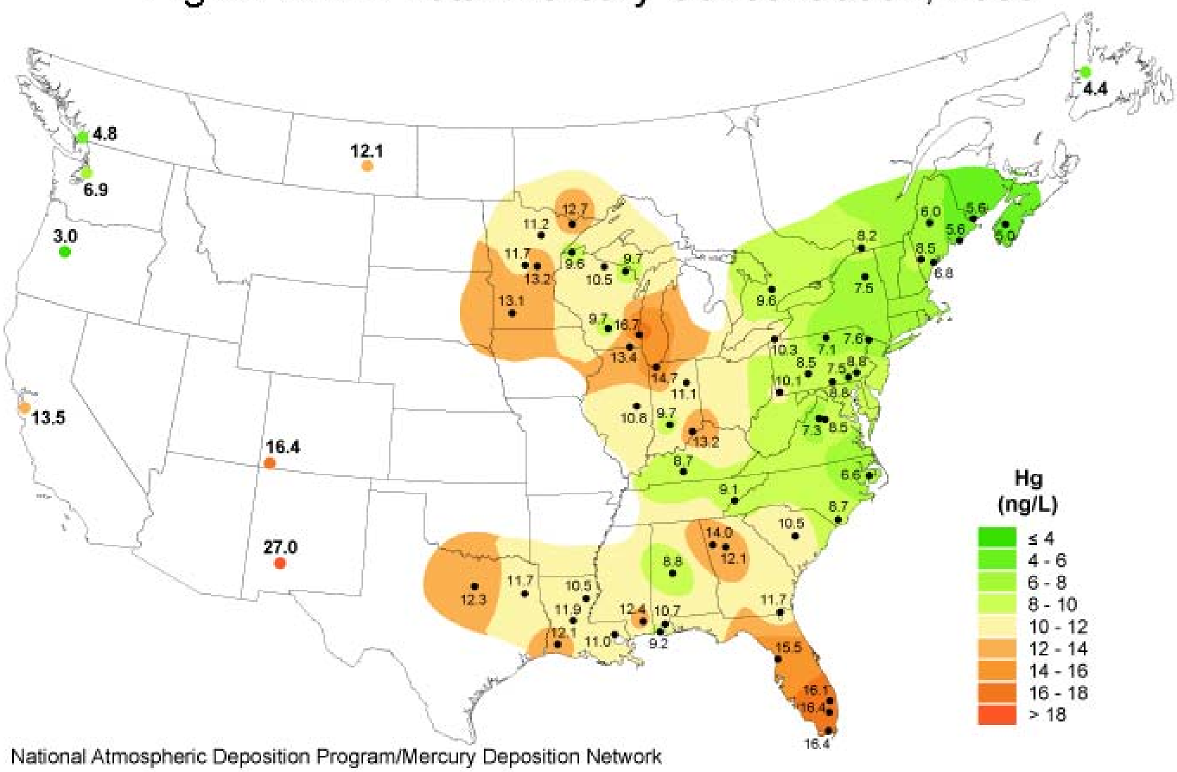
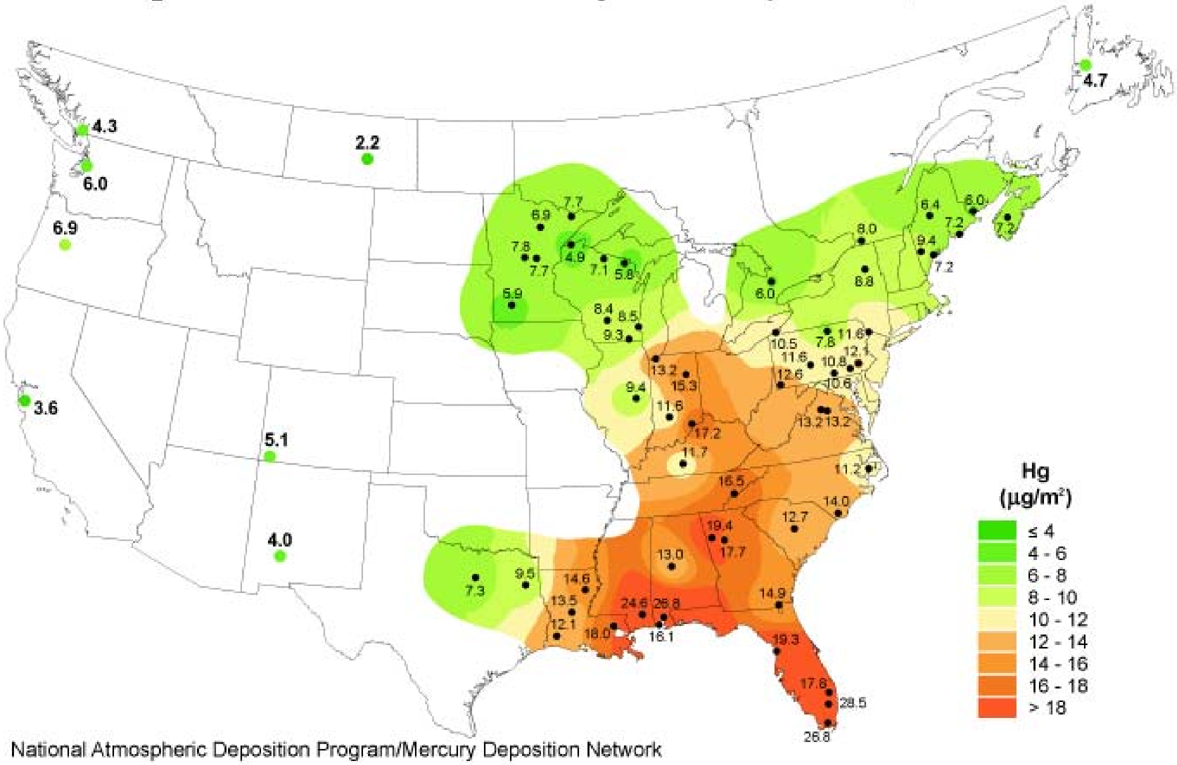


Figure 038-2: Total Mercury Wet Deposition, 2003



R.O.E. Indicator QA/QC

Data Set Name: ATMOSPHERIC DEPOSITION OF MERCURY
Indicator Number: 038 (89136)
Data Set Source: NADP http://nadp.sws.uiuc.edu/
Data Collection Date: ongoing 1995-present
Data Collection Frequency: weekly
Data Set Description: Atmospheric Deposition of Mercury
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes, MDN uses standardized methods for data collection and analyses based on similar scientifically and technically valid methods used for the long-term NADP National

Trends Network. Weekly precipitation samples are collected in a modified Aerochem Metrics model 301 collector. The "wet-side" sampling glassware is removed from the collector every Tuesday and mailed to the Hg Analytical Laboratory (HAL) at Frontier Geosciences in Seattle, WA for analysis by cold vapor atomic fluorescence. The methods and units of uncertainty of measurement are detailed in the MDN and NADP QA plan available at http://nadp.sws.uiuc.edu/QA/. Vermette, S., Lindberg, S., Bloom, N., 1995. Field tests for a regional mercury deposition network sampling design and preliminary test results. Atmospheric Environment 29, 1247-1251. Lindberg, S., Vermette, S., 1995. Workshop on sampling mercury in precipitation for the National Atmospheric Deposition Program. Atmospheric Environment 29, 1219-1220.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes, as documented in the NADP/MDN QA plan http://nadp.sws.uiuc.edu/QA/), the MDN monitoring program is designed to ensure samples are regionally representative and not unduly influenced by individual local sources. MDN recognizes that the representativeness of a given site location, or of the distribution of a group of sites, is best determined in the context of the planned application of the data. There are objectives for monitoring locations as well as for the samples collected for chemistry. These objectives are (1) to obtain and analyze individual samples which are qualitatively and quantitatively representative of the precipitation that fell (sample representativeness), and (2) to obtain network data that represent broad-scale geographical patterns in concentrations and deposition (spatial representativeness). The following journal articles and presentations describe the network design, including the sampling and analytical protocols, used in the MDN: Lindberg, S. and Vermette, S. 1995. Workshop on Sampling Mercury in Precipitation for the National Atmospheric Deposition Program. Atmospheric Environment. 29, 1219-1220. Vermette, S., Lindberg, S., and Bloom, N. 1995. Field Tests for a Regional Mercury Deposition Network - Sampling Design and Preliminary Test Results. Atmospheric Environment. 29, 1247-1251. Welker, M. and Vermette, S.J., 1996. Mercury Deposition Network: QA/QC Protocols. Paper 96-RP129.01, Proceedings of the 89th Annual Meeting of the Air and Waste Management Association, A&WMA, Pittsburgh, PA. Swain, E.B., Engstrom, D.R., Brigham, M.E., Henning, T.A., Brezonik, P.L., 1992. Increasing rates of atmospheric mercury deposition in midcontinental North America. Science 257, 784-787. Sweet, C.W. and Prestbo, E. 1999. Wet Deposition of Mercury in the U.S. and Canada. Presented at "Mercury in the Environment Specialty Conference", September 15-17, 1999, Minneapolis, MN. Proceedings published by Air and Waste Management Association, Pittsburgh, PA.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes, the methods used to calculate wet Hg deposition from NADP/MDN data are scientifically and technically valid. Wet deposition of mercury depends on both the concentration in rain and the total rainfall amount. Mercury wet deposition is calculated by multiplying rain gage precipitation amount (mm) by total mercury concentrations (ng/L) reported by the central laboratory. MDN methods of determining wet deposition values have undergone extensive peer review. Assessments of changes in NADP methods are developed primarily through the academic and scientific community and reviewed through the technical literature process. For more information on sampling procedures and calculations, refer to the NADP/MDN Quality Assurance Plan http://nadp.sws.uiuc.edu/QA/ In addition, a number of researchers have estimated that direct wet deposition accounts for between 50-90% of the mercury entering surface waters. Sorensen, J.A., Glass, G.E., Schmidt, K.W.. Huber, J.K., Rapp, G.R. 1990. Airborne mercury deposition and watershed characteristics in relation to mercury concentrations in water, sediments, plankton, and fish of eighty northern Minnesota lakes. Environmental Science and Technology 24, 1716-1727. Scherbatskoy, T., Burke, J.M., Rea, A.W., Keeler, G.J., 1997. Atmospheric mercury deposition and cycling in the Lake Champlain Basin of Vermont. In Atmospheric Deposition of Contaminants to the Great Lakes and Coastal Waters, J.E. Baker (Ed.), SETAC Press, Pensacola, FL, pp. 245-257. Lamborg, C.H., Fitzgerald, W.F., Vandal, G.M., Rolfhus, K.R., 1995. Atmospheric mercury in northern Wisconsin: sources and species. Water, Air, & Soil Pollution 80, 189-198. Mason, R.P., Lawson, N.M., Sullivan, K.A., 1997. Atmospheric deposition to the Chesapeake Bay – regional and local sources. Atmospheric Environment 31, 3531-3540. Landis, M.S., Keeler, G.J., 2002. Atmospheric mercury deposition to Lake Michigan during the Lake Michigan mass balance study. Environmental Science and Technology 36, 4518-4524. Mason, R.P., Lawson, N.M., Lawrence, A.L., Lee, J.G., Leaner, J.J., Sheu, G.R., 1999. Mercury in the Chesapeake Bay. Marine Chemistry 665, 114-119.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

MDN is the nation's only long-term, consistent survey of mercury wet-deposition concentrations and fluxes to show regional and national patterns of mercury wet deposition. At the time of NADP's 2004 Scientific Symposium & Annual Technical Committee Meeting (September 21-24) there were eighty-four active MDN monitoring sites. Precipitation samples are collected weekly using standard procedures in a modified Aerochem Metrics model 301 collector to preserve mercury. The "wet-side" sampling glassware is removed from the collector every Tuesday and mailed to the Hg Analytical Laboratory (HAL) at Frontier Geosciences in Seattle, WA for analysis by cold vapor atomic fluorescence. The MDN provides data for total mercury, but also includes methylmercury if desired by a site sponsor. Data is most often aggregated to provide seasonal and annual averages.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

As documented in the MDN QA plan http://nadp.sws.uiuc.edu/QA/), MDN uses long established NADP local and regional siting criteria in an attempt to obtain samples that are regionally representative (i.e., represent major physiographic, agricultural, aquatic and forested areas within states, regions or Eco-regions). Data collected are intended to be indicative of broad geographical patterns of deposition and are not markedly influenced by local emissions. Mercury deposition from the atmosphere is the primary pathway by which it enters sensitive aquatic systems where conversion to methyl mercury (MMHg) in fish can give rise to harmful human health and environmental impacts. The data is used to develop an information base on spatial and seasonal trends in mercury deposited to surface waters, forested watersheds, and other sensitive receptors. Regional criteria will be relaxed in some instances in order to research Hg deposition in biologically or ecologically important areas. Most of the current MDN sites are located in eastern North America from Minnesota to the Canadian Maritime Provinces and along the U.S. Atlantic and Gulf coasts. These regions generally have the most sensitive lakes and highest number of fish advisories.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

No, however, deposition levels are a valuable resource for determining Total Maximum Daily Load (TMDL) estimates. The MDN database will be particularly useful to evaluate the effectiveness of any state or federally mandated controls on mercury emissions.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The sampling and analytical procedures are documented in the MDN and NADP Quality Assurance plan. Quality assurance information is available on the web at http://nadp.sws.uiuc.edu/QA

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

NADP/MDN Data are available via the web at http://nadp.sws.uiuc.edu/mdn/ for the transition network (1995) and for 1996 through the second quarter of 2003.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes, refer to the NADP and MDN QA plan for details on the monitoring plan and descriptions of the survey design

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Analysis of precipitation samples for total- and methylmercury is performed by Frontier Geosciences, Inc., Seattle WA, USA. Frontier Geosciences provides the environmental sciences community with uncompromisingly high-quality contract research, project design and management, and analytical chemistry services concerned with the sources, fate and effects of trace metals. The QA Plan for the laboratory can be downloaded at http://nadp.sws.uiuc.edu/QA/ The procedures for quality assurance and quality control are documented and accessible in the NADP and MDN QA plan at http://nadp.sws.uiuc.edu/QA.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes, appropriate statistical methods have been used for spatial interpolation of wet deposition and calculating volume-weighted mercury concentration annual means. For more information, refer to the NADP/MDN Quality Assurance Plan available at http://nadp.sws.uiuc.edu/QA/.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes, the objectives and goals for data completeness, precision, bias, and comparability are addressed in the NADP/MDN QA plan at http://nadp.sws.uiuc.edu/QA/.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

The MDN network is designed to minimize sources of error or uncertainty in sample collection by utilizing uniform sampling equipment and following standardized operating procedures at all individual sites. Variability in site location and limited geographic coverage, particularly in the western United States do impact a broader national surveys of mercury deposition.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Sites are concentrated in the East in those States with and there is limited geographic coverage of monitoring sties in the middle part of the country and in the West. The data does not allow for a comprehensive picture of the mercury problem in North America.

Indicator: Carbon Monoxide Emissions (330)

Carbon monoxide (CO) is a colorless and odorless gas, formed when carbon in fuel is not burned completely. Mobile sources account for the majority of CO emissions (EPA 2003, pg. 16). These sources include both onroad vehicles (e.g., cars, trucks, motorcycles) and nonroad vehicles (e.g., farm equipment, construction equipment, aircraft, and marine vessels). Consequently, high concentrations of CO generally occur in areas with heavy traffic congestion. In cities, as much as 95 percent of all CO emissions may come from automobile exhaust (EPA 2003, pg 16). Other sources of CO emissions include industrial processes, non-transportation fuel combustion, and natural sources, such as wildfires. Fuel-burning appliances also are a significant source of CO releases in indoor environments. Undetected releases of carbon monoxide in indoor settings can present serious health risks to building occupants. Indicator 331 describes health hazards associated with inhaling CO.

This indicator shows trends in CO emissions data tracked by the National Emissions Inventory (NEI). The NEI is a composite of data from many different data sources, including industry and numerous state, tribal, and local agencies. Different data sources use different data collection methods, and many of the emissions data are based on estimates rather than actual measurements. Emissions are tracked for stationary point and non-point sources as well as onroad and non-road mobile sources. NEI data have been collected since 1990 and cover all 50 states and their counties, D.C., the U.S. territories of Puerto Rico and Virgin Islands, and some of the territories of federally-recognized American Indian nations. Data are presented only for 1990 and the years from 1996 forward because although data are available for 1991 – 1995, they have not been updated and comparisons of these data with those from other inventory years could lead to incorrect trends assumptions. Inventory years 1990 and from 1996 forward are up to date.

What the Data Show

Nationwide CO emissions have decreased 33 percent between 1990 and 2002, the most recent year for which aggregate NEI emissions estimates are available (Figure 330-1). Emission estimates for 1990 have been updated to enhance consistency with inventories for 1996-2002 and are believed sufficient to establish baseline conditions for trend assessments. Almost the entire emissions reduction is attributed to decreased emissions from onroad mobile sources. In 2002, mobile sources (both onroad and nonroad sources combined) accounted for 90% of the nation's total CO emissions. The CO emissions reductions are reflected in corresponding reductions in ambient concentrations (see Indicator 331).

Trends in CO emissions in the EPA Regions have been consistent with the nationwide trend over the last 13 years (Figure 330-2). All ten Regions showed decreases of between 22 and 44 percent during this period.

Indicator Limitations

- Comparable CO emissions estimates through the NEI are available only for 1990 and 1996–2002. Data are not available for other years. Data for 1991-1995 are not provided due to differences in emission estimation methodologies from other inventory years which could lead to improper trend assessments.
- CO emissions from "miscellaneous sources," including wildfires, are not included in the total emissions. Yearly fluctuations in wildfire emissions have the potential to mask trends in anthropogenic emissions and therefore have been excluded from the trends graphics. Details on emissions from miscellaneous sources can be found at http://www.epa.gov/ttn/chief/eiinformation.html.

- The emissions data for CO are largely based on estimates that employ emissions factors generated from empirical and engineering studies, rather than on actual measurements of CO emissions. Although these estimates are generated using well-established approaches, the estimates have inherent uncertainties.
- Not all states and local agencies provide the same data or level of detail for a given year.

Data Sources

U.S. Environmental Protection Agency. National Emissions Inventory - http://www.epa.gov/ttn/chief/net/neidata.html

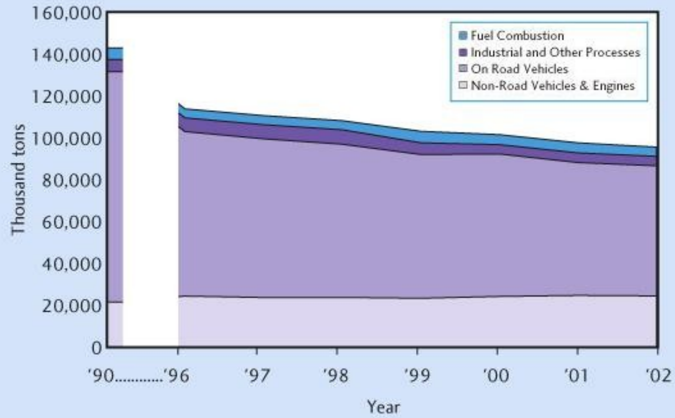
References

U.S. Environmental Protection Agency. Latest Findings on National Air Quality – 2002 Status and Trends, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

U.S. Environmental Protection Agency. National Air Quality and Emissions Trends Report - 2003 Special Studies Edition, EPA 454/R-03-005. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, September 2003.

Graphics

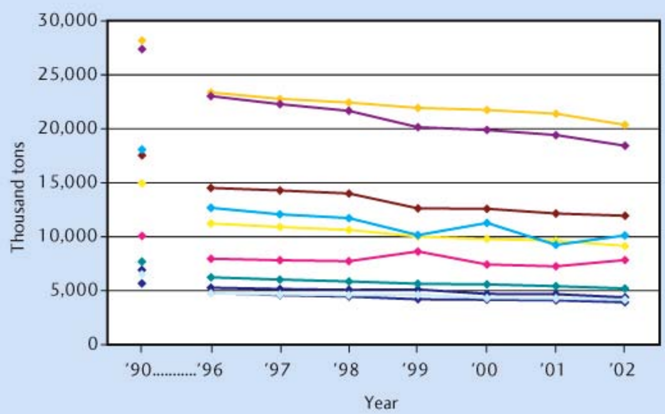
Figure 330-1: National CO emissions, 1990 and 1996-2002



Source: National Emissions Inventory (NEI).

Note: data are presented for 1990 and 1996-2002, as datasets from these inventory years are all fully up-to-date. Data are available for inventory years 1991–1995, but these data have not been updated to allow comparison with data from 1990 and 1996–2002.

Figure 330-2: CO emissions by EPA region, 1990 and 1996-2002



Source: National Emissions Inventory (NEI).

Note: data are presented for 1990 and 1996-2002, as datasets from these inventory years are all fully up-to-date. Data are available for inventory years 1991–1995, but these data have not been updated to allow comparison with data from 1990 and 1996–2002.

R.O.E. Indicator QA/QC

Data Set Name: CO EMISSIONS
Indicator Number: 330 (89166)
Data Set Source: EPA Air Quality System
Data Collection Date: ongoing: since at least 1983-present
Data Collection Frequency: Varies. See 40 CFR Parts 53 & 58 & attached QA/QC
Data Set Description: CO Emissions
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. While the NEI is a composite of data from many different data sources and methods, most of which are estimates instead of actual measurements with associated precision and accuracy, the methods are widely accepted as technically valid. These methods are considered largely sufficient in their application to derive the indicator data and conclusions presented to the typical user of the ROE. The NEI contains annual emissions (units = tons/year) of the criteria pollutants and the hazardous air pollutants (HAPs) noted in the Clean Air Act Amendments of 1990 (CAAA). The methods used to develop the NEI pollutant data vary by source sector and involve multiple data sources. A general description of methods by source sector is included below. Source emissions can be measured using monitoring equipment or estimated by using emission factors and emission process activity levels. Mathematical models may be used to characterize and simulate emissions that are influenced by several variables. For most source types, estimation techniques are the most practical. The NEI emissions are grouped into four main source sectors: Point sources and NonPoint sources (these are also referred to as stationary sources) and Onroad Mobile and Nonroad mobile sources (these are referred to as mobile sources). The Point source sector contains data on individual industrial, commercial and institutional facilities and is further divided into two subsectors: Electric Generating Units (EGUs) and NonEGUs. For the NEI sector data that is collected from state and local agencies - they either gather the data from their facilities or estimate the emissions themselves, using average and industry-specific emission factors. Some of the techniques they may use to generate their point and nonpoint estimates are referenced in a guidebook of methods which is endorsed by the EPA and the state and local agencies (STAPPA/ALAPCO). The guidebook of methods is located on http://www.epa.gov/ttn/chief/eiip/techreport/. Depending on the source sector and the pollutants of interest, the EPA uses other data sources in addition to the data received by the state and local agencies. Those other data sources, where applicable, are generally described below by sector, and identified specifically in the EPA’s Preparation Plan for the 2002 NEI, located on http://www.epa.gov/ttn/chief/net/2002inventory.html. In addition to identifying the data sources, the NEI 2002 Preparation Plan also describes the EPA's current method of quality checking the different data sources, and blending and merging among them, as well as augmenting data in order to complete the data set over space and time for specific source sectors and pollutants. The EPA Preparation Plan for the 1999 NEI (http://www.epa.gov/ttn/chief/net/nei_plan_feb2001.pdf) describes the data sources and process used to compile the 1999 HAP data which is included in the indicator. There is a triennial development effort and focus on compiling data for the NEI which results in the most complete national emissions inventory data every third year. For the criteria emissions in the NEI, data is also developed for the years in between the 3-year inventory cycles. For some sectors and pollutants, the methods used may be the same as those applied for the 3-year inventory, or the data may be extrapolated from the most recent third year inventory using economic projections or more simply as a mathematical interpolation between previous and subsequent years of record. While the NEI is a composite of data from many different data sources and methods, most of which are estimates instead of actual measurements with associated precision and accuracy, the methods are widely accepted as technically valid. These methods are considered largely sufficient in their application to derive the indicator data and conclusions presented to the typical user of the ROE.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

There is not a sampling design per se for the overall NEI data development project, at least not in the typical terms of a statistical sampling design. The data methods are predominantly based on estimation techniques rather than measurement techniques with associated precision and accuracy and standard error. For most sector data, emission factors are used with average emission process rates and average activity indicators to estimate typical emissions expected from similar processes in different geographical areas. Emission factors typically are based on emission testing or other sampling observations of sources and are generally developed and revised as need arises and more data becomes available. Highway vehicle emissions factors, however, are based on relatively recent research-driven sampling approaches that are documented in information collection plans implemented by the EPA's Office and Transportation and Air Quality Planning (http://www.epa.gov/otaq/ap42.htm). For onroad mobile sources, estimates are made by month or by season to account for typical temperatures and fuel properties. Estimates of vehicle miles traveled are based on the United States Department of Transportation (US DOT) Highway Performance Monitoring System, which makes use of a formal sample panel of roadway segments. Like onroad mobile sources, emissions from some other processes are estimated for time periods less than annual. As an example, pollutant emissions for seasonal processes are estimated for only a portion of the year in which they occur (i.e., winter burning season). The NEI attempts to capture the full universe of large point source facilities, which are closely monitored and located individually by the state and local agencies. Most Point EGU emissions are individually measured with continuous monitoring devices. These data are summarized to annual average emissions for all 50 states and their counties, D.C., the U.S. territories of Puerto Rico and Virgin Islands, and as available, for some of the territories of federally-recognized American Indian nations, and are widely used and accepted as an indicator of national and regional emission trends over time.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The annual emissions are directly estimated in most cases, or are simply totaled from monthly or seasonal estimates - there is no transformation.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The NEI is designed to explicitly answer the question posed in the ROE. This indicator estimates emissions from all anthropogenic sources of a primary air pollutant.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The emission estimates that comprise the NEI are non-specific for sensitive populations or ecosystems. Rather, the data are specific for types of emission processes and as such, are representative of how much and where those process emissions occur by county for the nonpoint sources and by individual facility location for the point sources.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator(s) directly addresses changes in air pollutant emissions from year-to-year and the contributions of various types of emissions sources, by county, and for every state. Air pollutant emissions are a reliable gauge of impact on the environment and when considered along with air quality transport and transformation issues, are the foundation for air quality analysis, including health indicators. Emission reductions generally indicate positive impact on air quality. Average annual pollutant emission trends over time may also reference a specific year or years in the time series, during which emission reductions were realized due to previous year implementation of federal, regional, or local control and compliance programs. There are no thresholds or ranges of values associated with safe levels of emissions for this indicator.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The NEI is a composite of many data sources, much of which is provided by state and local agencies and comes to EPA with little or no documentation on the specific methods used to generate the estimates. An emission inventory guidebook of methods, which is endorsed by the EPA and the state and local agencies (STAPPA/ALAPCO), is generally used by state and local agencies as reference for acceptable methods. The guidebook of methods is located on http://www.epa.gov/ttn/chief/eiip/techreport/. For emissions that are reported by the states as direct measurements from monitoring devices, the analytical procedures are referenced on http://www.epa.gov/ttn/emc/. Documentation of the procedures that EPA used to compile the NEI data for some of the more recent years in the time series is located on http://www.epa.gov/ttn/chief/net/neidata.html and is more organized and descriptive than documentation for previous year data. Documentation for the earlier years noted in the time series is located on http://www.epa.gov/ttn/chief/trends/procedures/neiproc99.pdf. Some of the methods noted have subsequently been revised for specific processes and years as EPA has gone back to update and apply improved methods. The documentation sources noted above will also describe use of emission factors. Documentation on process specific emission factors and how they were derived is located on http://www.epa.gov/ttn/chief/ap42/index.html.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The national annual NEI criteria emission trends summaries, as presented in the indicator, are publicly available on http://www.epa.gov/airtrends/econ-emissions.html. The national annual NEI hazardous air pollutant (HAP) data for year 1999, as presented in the indicator, are publicly available on http://www.epa.gov/air/data/index.html. Data format information typically resides at the same location as the data itself.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The EPA's documentation (see that noted in T3Q1) of how the NEI data estimates are generated will facilitate reproduction of some emission process estimates. As the EPA's documentation has evolved and improved over the years, it is expected that the more recent data years are documented in a more organized and transparent manner and would best enable reproducibility of emission estimates. Where EPA's documentation for specific years indicates that data was incorporated as that received from the state and local agencies, there is no additional documentation available by which to reproduce the state-derived values.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Much of the data that is used to compile the NEI is gathered indirectly from multiple and numerous sources, as referenced in the estimation methods information under T1Q1. These indirect data sources are presumed to have their own QA practices. Where state-supplied emissions estimates are used for some sectors and pollutants, it is presumed that states have QA plans in most cases but EPA does not systematically obtain information on QA practices from the states. The EPA contractors who use data sources and EPA-developed emissions factors to make emissions estimates operate under general contract-wide quality assurance plans, which can be made available on request. In addition, the EPA's more recent QC practices performed during the blending and merging of data from numerous sources, are described in the 2002 NEI Preparation Plan located on http://www.epa.gov/ttn/chief/net/2002inventory.html.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

No statistical generalization is performed to generate the national annual emissions trends presented in the indicator. The annual pollutant totals are developed at the plant or county level and then simply totaled and summarized at the regional and national levels.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No. At present, statistical uncertainty measures are not available for the underlying data that comprise the indicator. Most of the QA routines that are currently performed by EPA are sector data comparisons between different years or geographic areas, rather than on individual data variables. Much of the associated data variables for a specific sector are implied or not highly characterized, and therefore do not lend themselves well at present to quantitative uncertainty analysis.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Yes, OAQPS has developed standardized procedures for quality assuring the NEI as discussed in the "2002 NEI Preparation Plan" (http://www.epa.gov/ttn/chief/net/2002neiplan_081004final.pdf). The procedures include use of software to facilitate and standardize review of the data by EPA regional offices and state, local and tribal agencies. During the review process, industries often closely review their emission estimates to ensure they have been correctly incorporated in the NEI. In addition, OAQPS is able to use techniques which contrast data from various sources and from several inventory years to understand variability and identify areas in need of additional review. Where several data sources are available, assessments of data quality are conducted by OAQPS to ensure use of the highest quality emissions data when developing the NEI. The sum of the review procedures used for developing the NEI is believed to yield data of sufficient quality to support the conclusions which typical users will derive from the indicators. However, for the most rigorous applications, the NEI may be used in conjunction with ambient monitoring data and air quality and source receptor models to better characterize air quality problems and thus reduce uncertainties.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The indicator represents aggregated data. Most of the data is the result of a calculation that combines an emission rate per unit of input or output and a measure of that input or output, rather than a direct measurement of emissions. All states and counties are represented in the NEI, however not all states and local agencies may provide the same data or level of detail for a given year. State and local agencies may prioritize their data development efforts on emissions in county and metropolitan areas that are nonattainment for specific ambient air quality standards, i.e., ozone or PM2.5 NAAQS. The result may be more complete and quality assured data submissions to the NEI for these areas. Where data is absent or incomplete, EPA performs some data extrapolation from previous year data or other data sources. Inference follows many processes, depending on source type, etc. To the extent possible, facility-specific or county-specific information is used. In some cases, all counties in a state are assumed to have common properties influencing emissions, for example daily low and high temperatures. Best available or at most plausible substitutes are used where needed. For example, gasoline fuel properties are not available for all counties, known fuel properties in nearby counties subject to similar regulations on gasoline are used instead. Various and not fully consistent methodologies have been used to develop the emission estimates in the NEI. This is to be expected considering the variety of organizations that have contributed the estimates.

Indicator: Concentrations of Ozone-depleting Substances (017)

Ozone is a pollutant at the earth's surface but is very important in the stratosphere, where a layer of ozone helps shield Earth from the sun's ultraviolet (UV) radiation. UV-rays can cause skin cancer, cataracts, and other human health and ecological problems (EPA, 1996). Over recent decades, certain chemicals of human origin released at ground-level have migrated through the atmosphere and mixed into the stratosphere, where they have caused depletion of stratospheric ozone, especially over the polar regions. These chemicals, collectively known as ozone-depleting substances, include chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and others. Worldwide production of CFCs and other ozone-depleting substances is being progressively eliminated under the provisions of the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer, an international agreement ratified by more than 180 countries. Over time, reducing the atmospheric loading of ozone-depleting substances is expected to result in global increases in stratospheric ozone.

This indicator reflects concentrations of effective equivalent chlorine (EECl) in the lower atmosphere. EECl is derived by measuring concentrations of 10 chlorine- and bromine-containing gases in the lower atmosphere and calculating chlorine equivalents based on the ability of each gas to catalyze the destruction of ozone relative to the ability of chlorine to do so. Individual chlorine equivalent concentrations are then summed into the total EECl concentration and reported in parts per trillion by volume. While monitoring at some sites began as early as 1977, this indicator is based on monitoring since 1992 at 5-7 remote locations in Alert, North West Territories, Canada; Barrow, Alaska; Niwot Ridge, Colorado; Mauna Loa, Hawaii; American Samoa; Cape Grim, Tasmania, Australia; and the South Pole (NOAA 2003).

What the Data Show

The total abundance of ozone-depleting compounds in the lower atmosphere, expressed as chlorine equivalents, has decreased approximately 6% globally since its peak in 1994 (Figure 017-1). Of the individual compounds, total chlorine is declining, while bromine from industrial halons is still increasing, but at a slower rate than was occurring previously (WMO 2002). Observations in the stratosphere indicate that the total chlorine abundance is at or near a peak, while bromine abundances are probably still increasing (WMO 2002).

Indicator Limitations

- Persistent chemicals not monitored in this indicator (such as methyl halides and lesser halocarbons) contribute an additional 900 ppt to the EECl in today's atmosphere.
- The calculation of EECl depends on the understanding to the interactions and atmospheric residence times of many different gases; incorrect knowledge about these factors could affect trends in the EECl.

Data Sources

The data source for this indicator was NOAA's Climate Monitoring and Diagnostics Laboratory: ftp://ftp.cmdl.noaa.gov/hats/Total_Cl_Br/2004b%20update%20total%20EECl.xls

References

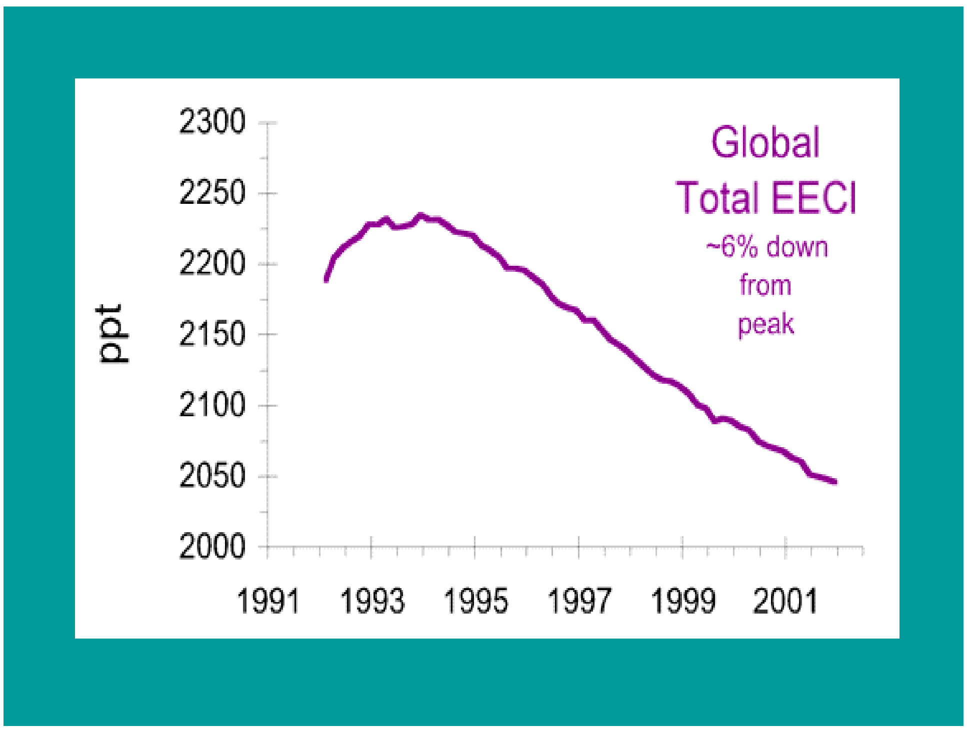
NOAA. 2003. *Climate Monitoring and Diagnostics Laboratory - Summary Report No. 27.* National Oceanographic and Atmospheric Administration, Boulder Colorado. http://www.cmdl.noaa.gov/publications/annrpt27/

World Meteorological Organization (WMO). Scientific Assessment of Ozone Depletion: 2002. Geneva, Switzerland. March 2003.

EPA, 1996. Air Quality Criteria for Ozone and Related Photochemical Oxidants, EPA 600-P-93-004F-cF. Research Triangle Park, NC; US Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, July 1996.

Graphics

Figure 017-1



R.O.E. Indicator QA/QC

Data Set Name: CONCENTRATIONS OF OZONE-DEPLETING SUBSTANCES
Indicator Number: 017 (89074)
Data Set Source: NOAA http://www.cmdl.noaa.gov/hats/graphs/graphs.html
Data Collection Date: UNKNOWN
Data Collection Frequency: unknown
Data Set Description: Concentrations of Ozone-depleting Substances
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes, the data serve as an important basis for the periodic Scientific Assessment of Ozone Depletion published by the World Meteorological Organization and the United Nations Environment Program pursuant to Article 6 of the Montreal Protocol, and the data are peer reviewed both in the scientific literature and in conjunction with the assessments: http://www.wmo.ch/web/arep/reports/ozone_2002/01_title.pdf. A good description of the measurement protocols can be found at: http://www.cmdl.noaa.gov/publications/annrpt27/hats5.pdf. An earlier version of this indicator was published in Montza, et al. 1999, Present and future trends in the atmospheric burden of ozone-depleting halogens, Nature 398, 690.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

The Climate Monitoring and Diagnostics Laboratory (CMDL) Halocarbons and other Atmospheric Trace Species (HATS) group of the National Oceanic and Atmospheric Administration has been analyzing air samples collected in flasks since 1977. Originally set up under the auspices of the Geophysical Monitoring for Climatic Change (GMCC) division of NOAA's Air Resources Laboratory (NOAA/ARL), this program involved the analysis of flask samples from Alert, North West Territories, Canada; Barrow, Alaska, USA; Niwot Ridge, Colorado, USA; Mauna Loa, Hawaii, USA; American Samoa; Cape Grim, Tasmania, Australia; and the South Pole. A description of the HATS Flask Sampling Plan can be found at http://www.cmdl.noaa.gov/noah/flask/flasks.html.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. It has been used to support the Scientific Assessment of Ozone Depletion published by the World Meteorological Organization and the United Nations Environment Program pursuant to Article 6 of the Montreal Protocol, and the data are peer reviewed both in the

scientific literature and in conjunction with the assessments:
http://www.wmo.ch/web/arep/reports/ozone_2002/01_title.pdf.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The indicator helps to answer the question, "What are the trends in outdoor air quality and effects on human health and ecological systems?" Because ozone depleting substances are well mixed in the troposphere away from immediate sources, the seven remote sampling sites provide a good indication of the tropospheric mixing ratios.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Not Applicable.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

No.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

A description of the HATS Flask Sampling Plan can be found at
http://www.cmdl.noaa.gov/noah/flask/flasks.html and at
http://www.cmdl.noaa.gov/publications/annrpt27/hats5.pdf.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Links to the files containing datasets of CMDL measurements can be downloaded at the CMDL anonymous FTP area - http://www.cmdl.noaa.gov/infodata/ftpdata.html.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The NOAA Halocarbons and other Atmospheric Trace Species (HATS) group measures and interprets the distributions and trends of these species in the troposphere, stratosphere, and ocean with the best analytical instrumentation available. Continuing programs within HATS are based upon in situ and flask measurements of the atmosphere from the 4 CMDL baseline observatories and 10 cooperative stations. A list of the geographic locations can be found in the paper Halocarbons and other Atmospheric Trace Species. A copy of this paper can be downloaded from
http://www.cmdl.noaa.gov/publications/annrpt26/5_1.pdf.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Accurate measurements of trace constituents in the atmosphere ability to accurately prepare compressed gas calibration standards. Standards for various halocarbons including chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs), methyl halides, halons, chlorinated solvents, and other gases are prepared gravimetrically as primary standards in our laboratory. The concentrations of most of these standards are at part per trillion (ppt or pmol/mol) levels. These standards are then used to calibrate secondary and tertiary gas mixtures that are used within NOAA as well as other federal, state, and private laboratories world-wide. The secondary and tertiary standards normally contain dried, natural air that is collected using a pumping system located at Niwot Ridge, CO. QA procedures can be viewed at http://www.cmdl.noaa.gov/hats/standard/standard.html.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. Hemispheric mixing ratios are estimated after weightingresults by sampling latitude, and these results are then averaged to estimatetropospheric, global means.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

For a description of factors affecting scientific understanding of atmospheric chlorine loading, see the Scientific Assessment of Ozone Depletion: 2002 at http://www.unep.org/ozone/pdfs/Scientific_assess_depletion/06-Chapter1.pdf.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No. Also, research programs in key regions, utilizing an array of platforms including aircraft, balloons, ocean vessels and towers, complement the land-based information. A description of the Airborne Chromotograph for Atmospheric Trace Species (ACATS) can be found at http://www.cmdl.noaa.gov/hats/airborne/acats/.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The precision of this indicator depends on understanding the chemistry and behavior of the many different gases involved. For example, accurate estimates of the atmospheric lifetime of a gas are essential to assigning it the proper weight relative to other gases. As scientific understanding of atmospheric chemistry improves, calculations continue to be refined.

Indicator: Number and Percent of Days with AQI Values >100 (001)

The Air Quality Index (AQI) provides information on pollutant concentrations of ground level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. Formerly known as the Pollutant Standard Index (PSI), this nationally uniform air quality index is used by state and local agencies for reporting daily air quality and air quality related health advisories to the public.

In 1999, the AQI was updated to reflect the latest science on air pollution health effects and to make it more appropriate for use in contemporary news media (EPA 2003, pg 53). It also serves as a basis for community-based programs that encourage the public to take action to reduce air pollution on days when levels are projected to be of concern. The index has been adopted by many other countries (e.g., Mexico, Singapore, and Taiwan) to provide the public with information on air quality.

The AQI is based on pollutant concentration data measured by the State and Local Air Monitoring Stations (SLAMS). The AQI is monitored in city groupings known as metropolitan statistical areas (MSAs) which are defined by the Office of Management and Budget. For each pollutant in the index, the concentration is converted into index values between 0 and 500, "normalized" so that an index value of 100 represents the short term, health-based standard for that pollutant as established by EPA (EPA 1999). The higher the index value, the greater the level of air pollution and health risk. An index value of 500 reflects a risk of imminent and substantial endangerment to public health. The level of the pollutant with the highest index value is reported as the AQI level for that day. An AQI value greater than 100 means that at least one criteria pollutant has reached levels at which people in sensitive groups are likely to experience health effects.

This indicator is based on the percentage of days across all large MSA's (500,000 people or more) during the sampling season that record an AQI greater than 100 at one or more monitoring sites in the MSA. The air quality data consist of daily (24-hour) measurements for PM10 and PM 2.5 and continuous (1-hour) measurements for CO, NO2, O3, and SO2. The data come from a subset of ambient monitoring sites that meet the trends requirements in Appendix B of the National Air Quality and Emissions Trends Report, 2003 (EPA 2003).

What the Data Show

The number of days with AQI greater than 100 in 93 large Metropolitan Statistical Areas nationwide was 1,649 in 1990 and 1,207 in 2003 (Figure 001-1). The percentage of days with AQI greater than 100 in 2003 is 27% lower than that for 1990. Of the five criteria pollutants in the AQI, only four (CO, O3, PM10, and SO2) usually exhibit values higher than 100; since 1993, ozone has been responsible for between 96 and 98% of these days.

Trends in AQI in the EPA Regions have been consistent with the nationwide trend over the last 13 years (Figure 001-2). In five of the EPA regions (2, 4, 6, 9, and 10), the percentage of days with AQI greater than 100 generally decreased between 1990 and 2003; in three EPA regions (5, 7, and 8), the percentage of days with AQI greater than 100 generally increased during this time period. In EPA Regions 1 and 3, the percentage of days with AQI greater than 100 in 1990 show no general trend, although in Region 3 the percentage of days with AQI greater than 100 in 2004 was lower than the percentage of days in 1990.

Indicator Limitations

- The AQI does not address hazardous air pollutants (HAPs).
- Air quality may vary across a single MSA. In assigning a single number for each pollutant in each MSA, the AQI does not reflect this potential variation.

- The data for this indicator does not reflect MSA's smaller than 500,000 or rural areas.
- The AQI does not show which pollutant(s) are causing the days with an AQI of more than 100, or distinguish between days >100 and days with much higher AQIs.
- This composite AQI indicator does not show which specific MSAs, or how many MSAs, have problems–a specific number of days could reflect a few areas with persistent problems or many areas with occasional problems.

Data Sources

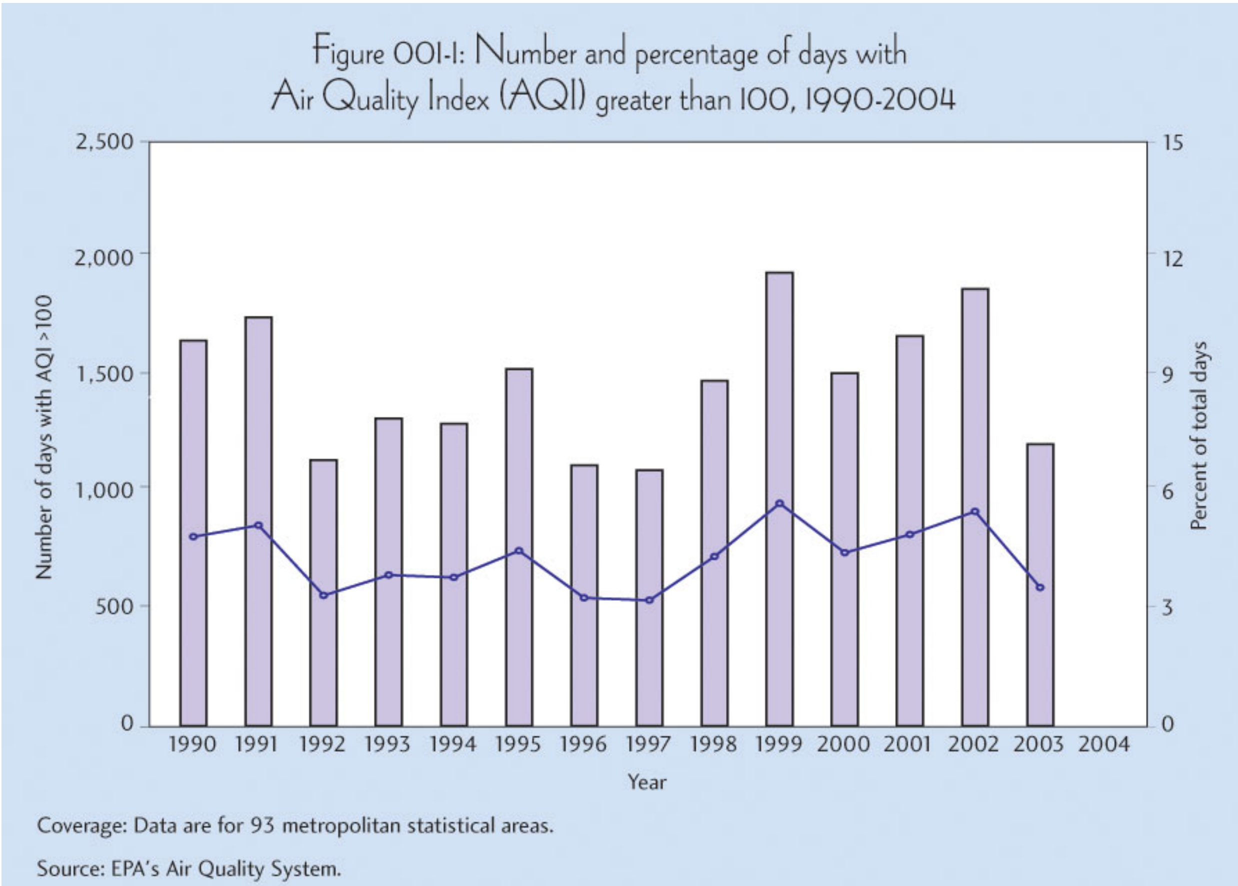
The data source for this indicator is "Air Trends: Metropolitan area trends," Table A-16, National Air Quality and Emissions Trends Report, 2003. (See Appendix A)

References

U.S. Environmental Protection Agency. National Air Quality and Emissions Trends Report - 2003 Special Studies Edition, EPA 454/R-03-005. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, September 2003.

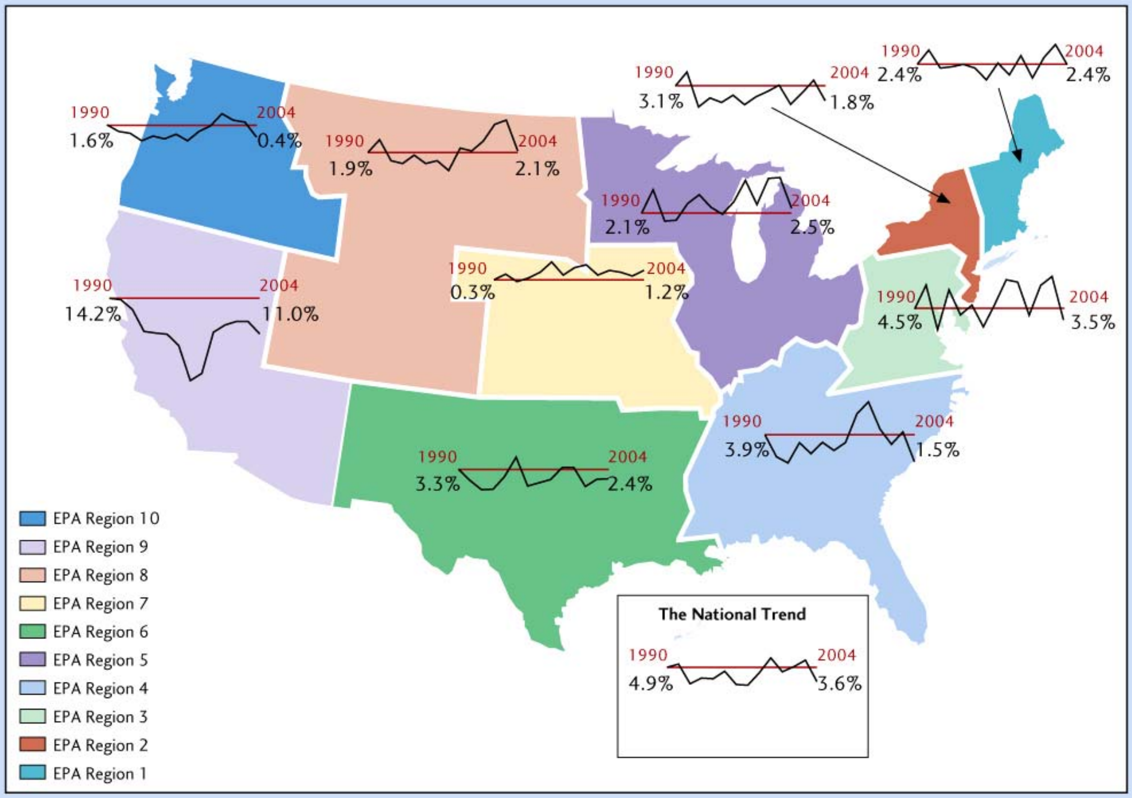
U.S. Environmental Protection Agency. Air Quality Index Reporting, 40 CFR Part 58, August 1999.. http://www.epa.gov/ttn/oarpg/t1/fr_notices/airqual.pdf

Graphics



Note: Figure will be updated with 2004 data, once the data are available.

Figure 001-2: Percentage of days with Air Quality Index (AQI) greater than 100, 1990-2004



Source: EPA's Air Quality System.

Note: Figure will be updated with 2004 data, once the data are available.

R.O.E. Indicator QA/QC

Data Set Name: DAYS THAT MSAS HAVE AQI VALUES GREATER THAN 100
Indicator Number: 001 (89068)
Data Set Source: EPA Air Quality Subsystem
Data Collection Date: UNKNOWN
Data Collection Frequency: Varies. See 40 CFR Parts 53 & 58 & attached QA/QC
Data Set Description: Days that MSAs have AQI values greater than 100
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

The AQI integrates information on pollutant concentrations across an entire monitoring network into a single number that represents the worst daily air quality experienced in an urban area. For each of the pollutants, concentrations are converted into index values between 0 and 500. The index is normalized across each pollutant so that, generally, an index value of 100 is set at the level of the short-term, health-based standard for that pollutant. An index value of 500 is set at the significant harm level, which represents imminent and substantial endangerment to public health. The higher the index value, the greater the level of air pollution and health risk. The Guideline for Reporting of Daily Air Quality Air Quality Index (AQI), EPA-454/R-99-010, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 1999. contains the equations used to calculate the AQI. This document can be downloaded at http://www.epa.gov/ttn/oarpg/t1/memoranda/rg701.pdf

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. In 2002, thousands of monitoring sites reported air quality data for one or more of the six National Ambient Air Quality Standards (NAAQS) pollutants to AQS. The sites consist of National Air Monitoring Stations (NAMS), State and Local Air Monitoring Stations (SLAMS), and other special-purpose monitors. NAMS were established to ensure a long-term national network for urban area-oriented ambient monitoring and to provide a systematic, consistent database for air quality comparisons and trends analysis. SLAMS allow state or local governments to develop networks tailored for their immediate monitoring needs The monitoring objectives for the NAMS/SLAMS network are found in: " 40 CFR 58, Appendix D http://www.epa.gov/ttn/amtic/ " 40 CFR 58.2(c) " EPA 454/R-98-004, Part I, Section 3.2 http://www.epa.gov/ttn/amtic/cpreldoc.html In the case of PM, many areas use non-Federal Reference Method monitors (continuous PM monitors such as TEOM monitors) for the purpose of reporting the AQI. Before using these monitors, state must establish a linear relationship between concentrations from a Federal Reference or Equivalent Method and a non-reference method monitor for the purpose of reporting PM values in the AQI. EPA s Air Quality Index (AQI), monitors air quality in selected city groupings known as metropolitan statistical areas (MSAs). MSAs are defined by the Office of Management and Budget and generally include one or more entire counties, except in New England where cities and towns are the basic geographic units. MSAs have been selected as the reporting unit because they are the basis for listings of attainment and nonattainment status for National Ambient Air Quality Standards (NAAQS).

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. EPA compiles and processes outdoor air quality data to generate the AQI. The AQI is an index for reporting daily air quality for a given location and is a key tool in EPA s efforts to make air quality data accessible and useful to the general public. It indicates how clean or how polluted the outside air is. Based on monitoring data, the AQI gives a daily score of 1 to 500 for each pollutant monitored in each MSA. An AQI of 100 means the outdoor air concentration is generally no higher than the respective NAAQS. For example, an AQI of 50 means good air quality, whereas an AQI of 300 means poor air quality. The AQI for particulate matter is a special case, in that day counts are derived slightly differently. AQI levels for particulate matter are best estimated from daily particulate matter monitors, and, therefore, the nation s air programs are installing more continuous particulate matter monitors. However, when using EPA s Federal Reference Method (FRM) data, the non-daily sampling schedules for particulate matter (e.g., one sample per 3 days) can affect the observed day counts. Therefore, EPA is evaluating methods for adjusting the counts for particulate matter days with an AQI over 100. The easiest method to adjust particulate matter counts, and that currently being used, is based on a simple ratio of the number of days in a quarter to the number of days with at least one sample in an MSA. The ratio is multiplied times the actual number of days in the quarter with the AQI above 100 for particulate matter to get an adjusted quarterly count, which can then be used to calculate an annual number. For example, if there are 90 days in a quarter and 15 sampling days in that quarter, the ratio of 90:15, or 6, is used to adjust the count of days with an AQI over 100 for particulate matter. Thus, if there are 2 days with sample values resulting in an AQI greater than 100, the count is adjusted to 12 days with an AQI greater than 100. EPA maintains a Web site that fully explains the derivation of the AQI and its interpretation and use at http://www.epa.gov/airnow/aqibroch/aqi.html#1

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The air quality data consist of daily (24-hour) measurements for PM10 and PM 2.5 and continuous (1-hour) measurements for CO, NO2, O3, and SO2.1 The daily measurements for particulate matter are taken from monitoring instruments that produce one 24-hour measurement and typically operate on a systematic sampling schedule of once every 6 days, or 61 samples per year. In other words, these instruments generate one 24-hour sample every 6 days. EPA has determined that these 61 daily samples adequately represent outdoor air quality throughout the year. Monitoring instruments for CO, NO2, O3, and SO2 operate continuously and produce a measurement every hour for a possible total of 8,760 hourly measurements in a year.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The data for this indicator are associated with large MSAs only (500,000 people or more); therefore, the data tend to reflect urban air quality. Also, This composite AQI indicator does not show which areas, or how many areas, have problems a specific number of days could reflect a few areas with persistent problems or many areas with occasional problems The network does not explicitly target sensitive populations such as asthmatics, the elderly, or children.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

The index is normalized across each pollutant so that, generally, an index value of 100 is set at the level of the shortterm, health-based standard for that pollutant. An index value of 500 is set at the significant harm level, which represents imminent and substantial endangerment to public health. To make the AQI as easy to understand as possible, EPA has divided the AQI scale into six general categories that correspond to a different level of health concern: " Good (0 50): Air quality is considered satisfactory, and air pollution poses little or no risk. " Moderate (51 100): Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of individuals. For example, people who are unusually sensitive to ozone may experience respiratory symptoms. " Unhealthy for Sensitive Groups (101 150): Certain groups of people may be particularly sensitive to the harmful effects of certain air pollutants. This means they are likely to be affected at lower levels than is the general public. For example, people with respiratory disease are at greater risk from exposure to ozone, while people with respiratory disease or heart disease are at greater risk from particulate matter. When the AQI is in this range, members of sensitive groups may experience health effects, but the general public is not likely to be affected. " Unhealthy (151 200): Everyone may begin to experience health effects. Members of sensitive groups may experience more serious health effects. " Very Unhealthy (201 300): Air quality in this range triggers a health alert, meaning everyone may experience more serious health effects. " Hazardous (over 300): Air quality in this range triggers health warnings of emergency conditions. The entire population is more likely to be affected.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

National Air Quality and Emissions Trends Report, 2003 Special Studies Edition - http://www.epa.gov/air/airtrends/aqtrnd03/ General Air Quality and National Monitoring Network - http://www.epa.gov/ttn/amtic/moninfo.html PM 2.5 Monitoring Information - http://www.epa.gov/ttn/amtic/amticpm.html

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Table A-17 and A-18 in Appendix A of the National Air Quality and Emissions Trends Report, 2003 contains the AQI indicator data. This data can be downloaded from the internet at http://www.epa.gov/air/airtrends/aqtrnd03/appenda.pdf

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes, The pollutant concentration data is from the State and Local Air Monitoring Stations (SLAMS) operating under the rules set forth in Part 58 of 40 CFR. In the case of PM, many areas use non-Federal Reference Method monitors (continuous PM monitors such as TEOM monitors) for the purpose of reporting the AQI. Before using these monitors, state must establish a linear relationship between concentrations from a Federal Reference or Equivalent Method and a non-reference method monitor for the purpose of reporting PM values in the AQI. EPA s Air Quality Index (AQI), monitors air quality in selected city groupings known as metropolitan statistical areas (MSAs). MSAs are defined by the Office of Management and Budget and generally include one or more entire counties, except in New England where cities and towns are the basic geographic units.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

AQI information is presented for those air quality data that meet EPA s data quality requirements. (For more information on EPA s data quality requirements, see Appendix B Metropolitan Area Trends of the Trends Report at http://www.epa.gov/airtrends/metro.html) Also, there is a Quality Assurance Project Plan from each state or local agency operating a NAMS/SLAMS monitor meeting the AEPA Requirements for Quality Assurance Project Plans@, EPA QA/R-5. The quality assurance plans for specific sites are publicly available by request to the reporting agency or the corresponding EPA Regional Office. The plans are audited at least once every three years as required in 40 CFR 58, Appendix A, Section 2.5. In addition, the data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes, EPA compiles and processes outdoor air quality data to generate the AQI. The AQI is an index for reporting daily air quality for a given location and is a key tool in EPA s efforts to make air quality data accessible and useful to the general public. It indicates how clean or how polluted the outside air is. Based on monitoring data, the AQI gives a daily score of 1 to 500 for each pollutant monitored in each MSA. An AQI of 100 means the outdoor air concentration is generally no higher than the respective NAAQS. For example, an AQI of 50 means good air quality, whereas an AQI of 300 means poor air quality. The AQI for particulate matter is a special case, in that day counts are derived slightly differently. AQI levels for particulate matter are best estimated from daily particulate matter monitors, and, therefore, the nation s air programs are installing more continuous particulate matter monitors. However, when using EPA s Federal Reference Method (FRM) data, the non-daily sampling schedules for particulate matter (e.g., one sample per 3 days) can affect the observed day counts. Therefore, EPA is evaluating methods for adjusting the counts for particulate matter days with an AQI over 100. The easiest method to adjust particulate matter counts, and that currently being used, is based on a simple ratio of the number of days in a quarter to the number of days with at least one sample in an MSA. The ratio is multiplied times the actual number of days in the quarter with the AQI above 100 for particulate matter to get an adjusted quarterly count, which can then be used to calculate an annual number. For example, if there are 90 days in a quarter and 15 sampling days in that quarter, the ratio of 90:15, or 6, is used to adjust the count of days with an AQI over 100 for particulate matter. Thus, if there are 2 days with sample values resulting in an AQI greater than 100, the count is adjusted to 12 days with an AQI greater than 100. EPA maintains a Web site that fully explains the derivation of the AQI and its interpretation and use at http://www.epa.gov/airnow/aqibroch/aqi.html#1

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Air quality may vary across a single MSA. In assigning a single symbol for each pollutant in each MSA, the AQI does reflect this potential variation.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

AQI is designed to address CO, NO2, O3, particulate matter (PM10 and PM2.5), and SO2. Also, the indicator as a national trend does not contain information about exceedances of the AQI for more than one pollutant during any particular day. EPA acknowledges that the general public is not always familiar with MSAs. For example, users living in small towns may not realize they are part of an MSA named for a nearby larger town. Furthermore, not all areas in the country are in MSAs. Those MSAs with small populations, those with air quality that is so good that AQI reporting is not currently required, and those with too little monitoring data would not be included. Also, the general public is not always familiar with MSAs. For example, users living in small towns may not realize they are part of an MSA named for a nearby larger town. Furthermore, not all areas in the country are in MSAs, and not all MSAs would be included in this display. Those MSAs with small populations, those with air quality that is so good that AQI reporting is not currently required, and those with too little monitoring data would not be included. Also, the general public is not always familiar with MSAs. For example, users living in small towns may not realize they are part of an MSA named for a nearby larger town. Furthermore, not all areas in the country are in MSAs, and not all MSAs would be included in this display. Those MSAs with small populations, those with air quality that is so good that AQI reporting is not currently required, and those with too little monitoring data would not be included. Also, the general public is not always familiar with MSAs. For example, users living in small towns may not realize they are part of an MSA named for a nearby larger town. Furthermore, not all areas in the country are in MSAs, and not all MSAs would be included in this display. Those MSAs with small populations, those with air quality that is so good that AQI reporting is not currently required, and those with too little monitoring data would not be included. Also, the general public is not always familiar with MSAs. For example, users living in small towns may not realize they are part of an MSA named for a nearby larger town. Furthermore, not all areas in the country are in MSAs, and not all MSAs would be included in this display. Those MSAs with small populations, those with air quality that is so good that AQI reporting is not currently required, and those with too little monitoring data would not be included.

Indicator: Lead Emissions (009)

In the past, automotive sources were the major contributor of lead emissions to the atmosphere. After leaded motor vehicle fuels were phased out during the 1970s and 1980s, the contribution of air emissions of lead from the transportation sector, and particularly the automotive sector, greatly declined. Today, industrial processes, primarily metals processing, are the major source of lead emissions to the atmosphere. The highest air concentrations of lead are usually found in the vicinity of smelters and battery manufacturers. Exposure to lead occurs mainly through inhalation of air and ingestion of lead in food, water, soil, or dust. Indicator 005 describes health hazards associated with lead exposures (EPA2003, p. 17).

This indicator presents lead emissions data tracked by the National Emissions Inventory (NEI). The NEI is a composite of data from many different data sources, including industry and numerous state, tribal, and local agencies. Different data sources use different data collection methods, and many of the emissions data are based on estimates rather than actual measurements. Emissions are tracked for stationary point and non-point sources as well as onroad and non-road mobile sources. NEI data have been collected since 1990 and cover all 50 states and their counties, D.C., the U.S. territories of Puerto Rico and Virgin Islands, and some of the territories of federally-recognized American Indian nations.

What the Data Show

Between 1990 and 1999 estimated nationwide emissions decreased by approximately 1,600 tons, mostly due to reductions reported for the metals processing and waste management industries (Figure 009-1)

Emissions reductions over the longer term are far greater: some estimates place the reductions between 1970 and 1999 at nearly 220,000 tons, with the overwhelming majority of this reduction attributed to the phase-out of leaded motor vehicle fuels [EPA, 2003, pg. 13]. Sharp decreases in nationwide air concentrations of lead between 1980 and 1990 paralleled the emissions reductions (see Indicator 005).

Indicator Limitations

- Although lead emissions trends have been generated using well-established estimation methods, the data reflect estimates based on empirical and engineering models and not actual measurement of lead emissions.
- EPA has not estimated trends in lead emissions since 1999, because uncertainties in past emissions estimates for fuel combustion and industrial sources are greater than the current year-to-year variation in emissions [EPA 2003, pg 14]
- Not all states and local agencies-provide the same data or level of detail for a given year.

Data Sources

U.S. Environmental Protection Agency. National Emissions Inventory - http://www.epa.gov/ttn/chief/net/neidata.html

References

U.S. Environmental Protection Agency. Latest Findings on National Air Quality – 2002 Status and Trends, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.
http://www.epa.gov/airtrends/2002_airtrends_final.pdf

U.S. Environmental Protection Agency. National Air Quality and Emissions Trends Report - 2003 Special Studies Edition, EPA 454/R-03-005. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, September 2003. http://www.epa.gov/air/airtrends/aqtrnd03/toc.html

Graphics

Figure 009-1: National lead emissions, 1990-1999

Source: Air Emissions Trends—Continued Progress Through 2003 (http://www.epa.gov/airtrends/econ-emissions.html).

R.O.E. Indicator QA/QC

Data Set Name: LEAD EMISSIONS
Indicator Number: 009 (89078)
Data Set Source: EPA National Emissions Inventory
Data Collection Date: ongoing: from at least 1980-present
Data Collection Frequency: Varies from annually to triennially
Data Set Description: Lead Emissions
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

The NEI contains annual emissions (units = tons/year) of the criteria pollutants and the hazardous air pollutants (HAPs) noted in the Clean Air Act Amendments of 1990 (CAAA). The methods used to develop the NEI pollutant data vary by source sector and involve multiple data sources. A general description of methods by source sector is included below. Source emissions can be measured using monitoring equipment or estimated by using emission factors and emission process activity levels. Mathematical models may be used to characterize and simulate emissions that are influenced by several variables. For most source types, estimation techniques are the most practical. The NEI emissions are grouped into four main source sectors: Point sources and NonPoint sources - these are also referred to as stationary sources; and Onroad Mobile and Nonroad mobile sources - these are referred to as mobile sources. The Point source sector contains data on individual industrial, commercial and institutional facilities and is further divided into two subsectors - Electric Generating Units (EGUs) and NonEGUs. For the NEI sector data that is collected from state and local agencies - they either gather the data from their facilities or estimate the emissions themselves, using average and industry-specific emission factors. Some of the techniques they may use to generate their point and nonpoint estimates are referenced in a guidebook of methods which is endorsed by the EPA and the state and local agencies (STAPPA/ALAPCO). The guidebook of methods is located on http://www.epa.gov/ttn/chief/eiip/techreport/. Depending on the source sector and the pollutants of interest, the EPA uses other data sources in addition to the data received by the state and local agencies. Those other data sources, where applicable, are generally described below by sector, and identified specifically in the EPA's Preparation Plan for the 2002 NEI, located on http://www.epa.gov/ttn/chief/net/2002inventory.html. In addition to identifying the data sources, the NEI 2002 Preparation Plan also describes the EPA's current method of quality checking the different data sources, and blending and merging among them, as well as augmenting data in order to complete the data set over space and time for specific source sectors and pollutants. The EPA Preparation Plan for the 1999 NEI (http://www.epa.gov/ttn/chief/net/nei_plan_feb2001.pdf) describes the data sources and process used to compile the 1999 HAP data which is included in the indicator. There is a triennial development effort and focus on compiling data for the NEI which results in the most complete national emissions inventory data every third year. For the criteria emissions in the NEI, data is also developed for the years in between the 3-year inventory cycles. For some sectors and pollutants, the methods used may be the same as those applied for the 3-year inventory, or the data may be extrapolated from the most recent third year inventory using economic projections or more simply as a mathematical interpolation between previous and subsequent years of record. While the NEI is a composite of data from many different data sources and methods, most of which are estimates instead of actual measurements with associated precision and accuracy, the methods are widely accepted as technically valid. These methods are considered largely sufficient in their application to derive the indicator data and conclusions presented to the typical user of the ROE.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

There is not a sampling design per se for the overall NEI data development project, at least not in the typical terms of a statistical sampling design. The data methods are predominantly based on estimation techniques rather than measurement techniques with associated precision and accuracy and standard error. For most sector data, emission factors are used with average emission process rates and average activity indicators to estimate typical emissions expected from similar processes in different geographical areas. Emission factors typically are based on emission testing or other sampling observations of sources and are generally developed and revised as need arises and more data becomes available. Highway vehicle emissions factors however, are based on relatively recent research-driven sampling approaches that are documented in information collection plans implemented by the EPA's Office and Transportation and Air Quality Planning (OTAQ - http://www.epa.gov/otaq). For onroad mobile sources, estimates are made by month or by season to account for typical temperatures and fuel properties. Estimates of vehicle miles traveled are based on the United States Department of Transportation (US DOT) Highway Performance Monitoring System, which makes use of a formal sample panel of roadway segments. Like onroad mobile sources, emissions from some other processes are estimated for time periods less than annual. As an example, pollutant emissions for seasonal processes are estimated for only a portion of the year in which they occur (i.e., winter burning season). The NEI attempts to capture the full universe of large point source facilities, which are closely monitored and located individually by the state and local agencies. Most Point EGU emissions are individually measured with continuous monitoring devices. These data are summarized to annual average emissions for all 50 states and their counties, D.C., the U.S. territories of Puerto Rico and Virgin Islands, and as available, for some of the territories of federally-recognized American Indian nations, and are widely used and accepted as an indicator of national and regional emission trends over time.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

See T1Q2 above. The annual emissions are directly estimated in most cases, or are simply totaled from monthly or seasonal estimates - there is no transformation.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Refer to the information provided under T1Q2.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The emission estimates that comprise the NEI are non-specific for particular segments of population and ecosystem. Rather, the data are specific for types of emission processes and as such, are representative of how much and where those process emissions occur by county for the nonpoint sources and by individual facility location for the point sources.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator(s) directly addresses changes in air pollutant emissions from year-to-year and the contributions of various types of emissions sources, by county, and for every state. Air pollutant emissions are a reliable gauge of impact on the environment and when considered along with air quality transport and transformation issues, are the foundation for air quality analysis, including health indicators. Emission reductions generally indicate positive impact on air quality. Average annual pollutant emission trends over time may also reference a specific year or years in the time series, during which emission reductions were realized due to previous year implementation of federal, regional, or local control and compliance programs.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The NEI is a composite of many data sources, much of which is provided by state and local agencies and comes to EPA with little or no documentation on the specific methods used to generate the estimates. An emission inventory guidebook of methods, which is endorsed by the EPA and the state and local agencies (STAPPA/ALAPCO), is generally used by state and local agencies as reference for acceptable methods. The guidebook of methods is located on http://www.epa.gov/ttn/chief/eiip/techreport/. For emissions that are reported by the states as direct measurements from monitoring devices, the analytical procedures are referenced on http://www.epa.gov/ttn/emc/. Documentation of the procedures that EPA used to compile the NEI data for some of the more recent years in the time series is located on http://www.epa.gov/ttn/chief/net/neidata.html and is more organized and descriptive than documentation for previous year data. Documentation for the earlier years noted in the time series is located on http://www.epa.gov/ttn/chief/trends/procedures/neiproc99.pdf. Some of the methods noted have subsequently been revised for specific processes and years as EPA has gone back to update and apply improved methods. The documentation sources noted above will also describe use of emission factors. Documentation on process specific emission factors and how they were derived is located on http://www.epa.gov/ttn/chief/ap42/index.html.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The national annual NEI criteria emission trends summaries, as presented in the indicator, are publicly available on http://www.epa.gov/airtrends/econ-emissions.html. The national annual NEI hazardous air pollutant (HAP) data for year 1999, as presented in the indicator, are publicly available on http://www.epa.gov/air/data/index.html. Data format information typically resides at the same location as the data itself.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The EPA's documentation (see that noted in T3Q1) of how the NEI data estimates are generated will facilitate reproduction of some emission process estimates. As the EPA's documentation has evolved and improved over the years, it is expected that the more recent data years are documented in a more organized and transparent manner and would best enable reproducibility of emission estimates. Where EPA's documentation for specific years indicates that data was incorporated as that received from the state and local agencies, there is no additional documentation available by which to reproduce the state-derived values.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Much of the data that is used to compile the NEI is gathered indirectly from multiple and numerous sources, as referenced in the estimation methods information under T1Q1. These indirect data sources are presumed to have their own QA practices. Where state-supplied emissions estimates are used for some sectors and pollutants, it is presumed that states have QA plans in most cases but EPA does not systematically obtain information on QA practices from the states. The EPA contractors who use data sources and EPA-developed emissions factors to make emissions estimates operate under general contract-wide quality assurance plans , which can be made available on request. In addition, the EPA's more recent QC practices performed during the blending and merging of data from numerous sources, are described in the 2002NEI Preparation Plan located on http://www.epa.gov/ttn/chief/net/2002inventory.html.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

No statistical generalization is performed to generate the national annual emissions trends presented in the indicator. The annual pollutant totals are developed at the plant or county level and then simply totaled and summarized at the regional and national levels.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No. At present, statistical uncertainty measures are not available for the underlying data that comprise the indicator. Most of the QA routines that are currently performed by EPA are sector data comparisons between different years or geographic areas, rather than on individual data variables. Much of the associated data variables for a specific sector are implied or not highly characterized, and therefore do not lend themselves well at present to quantitative uncertainty analysis.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Yes, OAQPS has developed standardized procedures for quality assuring the NEI as discussed in the "2002 NEI Preparation Plan" (http://www.epa.gov/ttn/chief/net/2002neiplan_081004final.pdf). The procedures include use of software to facilitate and standardize review of the data by EPA regional offices and state, local and tribal agencies. During the review process, industries often closely review their emission estimates to ensure they have been correctly incorporated in the NEI. In addition, OAQPS is able to use techniques which contrast data from various sources and from several inventory years to understand variability and identify areas in need of additional review. Where several data sources are available, assessments of data quality are conducted by OAQPS to ensure use of the highest quality emissions data when developing the NEI. The sum of the review procedures used for developing the NEI is believed to yield data of sufficient quality to support the conclusions which typical users will derive from the indicators. However, for the most rigorous applications, the NEI may be used in conjunction with ambient monitoring data and air quality and source receptor models to better characterize air quality problems and thus reduce uncertainties.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The indicator represents aggregated data. Most of the data is the result of a calculation that combines an emission rate per unit of input or output and a measure of that input or output, rather than a direct measurement of emissions. All states and counties are represented in the NEI, however not all states and local agencies may provide the same data or level of detail for a given year. State and local agencies may prioritize their data development efforts on emissions in county and metropolitan areas that are nonattainment for specific ambient air quality standards, i.e., ozone or PM2.5 NAAQS. The result may be more complete and quality assured data submissions to the NEI for these areas. Where data is absent or incomplete, EPA performs some data extrapolation from previous year data or other data sources. Inference follows many processes, depending on source type, etc. To the extent possible, facility-specific or county-specific information is used. In some cases, all counties in a state are assumed to have common properties influencing emissions, for example daily low and high temperatures. Best available or at most plausible substitutes are used where needed. For example, gasoline fuel properties are not available for all counties, known fuel properties in nearby counties subject to similar regulations on gasoline are used instead. Various and not fully consistent methodologies have been used to develop the emission estimates in the NEI. This is to be expected considering the variety of organizations that have contributed the estimates.

Indicator: Mercury Emissions (316)

Mercury is an element that is naturally found in the environment. However, many industrial processes, such as coal combustion, waste incineration, and certain chemical manufacturing operations, have increased the amounts of mercury released to the air. Because mercury does not degrade in the environment, most mercury that is emitted to the atmosphere will eventually deposit to the ground or onto water bodies.

Through a series of chemical transformations and environmental transport processes, which Indicator 038 describes in much greater detail, the airborne mercury that deposits to the Earth's surface can eventually accumulate in fish tissue, most profoundly in those fish species near the top of the food chain (e.g., shark, swordfish). People who eat mercury-contaminated fish are at risk for various health effects. Health risks are greatest for the developing fetus, as high mercury exposures among pregnant women can cause impaired neurological development in the fetus. (Mercury Study Report to Congress Volumes I to VII, EPA 452-R-96-001b) For further information on how mercury cycles in the environment and additional human health risks, refer to [the Mercury Thread].

This indicator presents mercury emissions data tracked by the National Emissions Inventory (NEI). The NEI is a composite of data from many different data sources, including industry and numerous state, tribal, and local agencies. Different data sources use different data collection methods, and many of the emissions data are based on estimates rather than actual measurements. Emissions are tracked for stationary point and non-point sources as well as onroad and non-road mobile sources. NEI data have been collected since 1990 and cover all 50 states and their counties, D.C., the U.S. territories of Puerto Rico and Virgin Islands, and some of the territories of federally-recognized American Indian nations. Data for mercury emissions are currently available only for the years 1990 and 1999.

What the Data Show (NEI data for 2002 will be added to this indicator once they are available in final form).

Figure 316-1 shows how estimated nationwide air emissions of mercury have changed from 1990 to 1999, according to the NEI. During this time frame, annual nationwide emissions decreased from 210 tons to 113 tons—a total decrease of 46% that is attributed primarily to decreased emissions from medical waste incinerators and municipal solid waste combustors.

Indicator Limitations

- The emissions data in this indicator are primarily based on estimates, not direct measurements. Although these estimates have inherent uncertainties, the data have been generated using well-established estimation methods.
- The trend shown is based on nationwide aggregate data. Emissions trends on local scales will depend largely on changes at the nearest emissions sources.
- Not all states and local agencies provide the same data or level of detail for a given year.

Data Sources

U.S. Environmental Protection Agency. National Emissions Inventory - http://www.epa.gov/ttn/chief/net/neidata.html

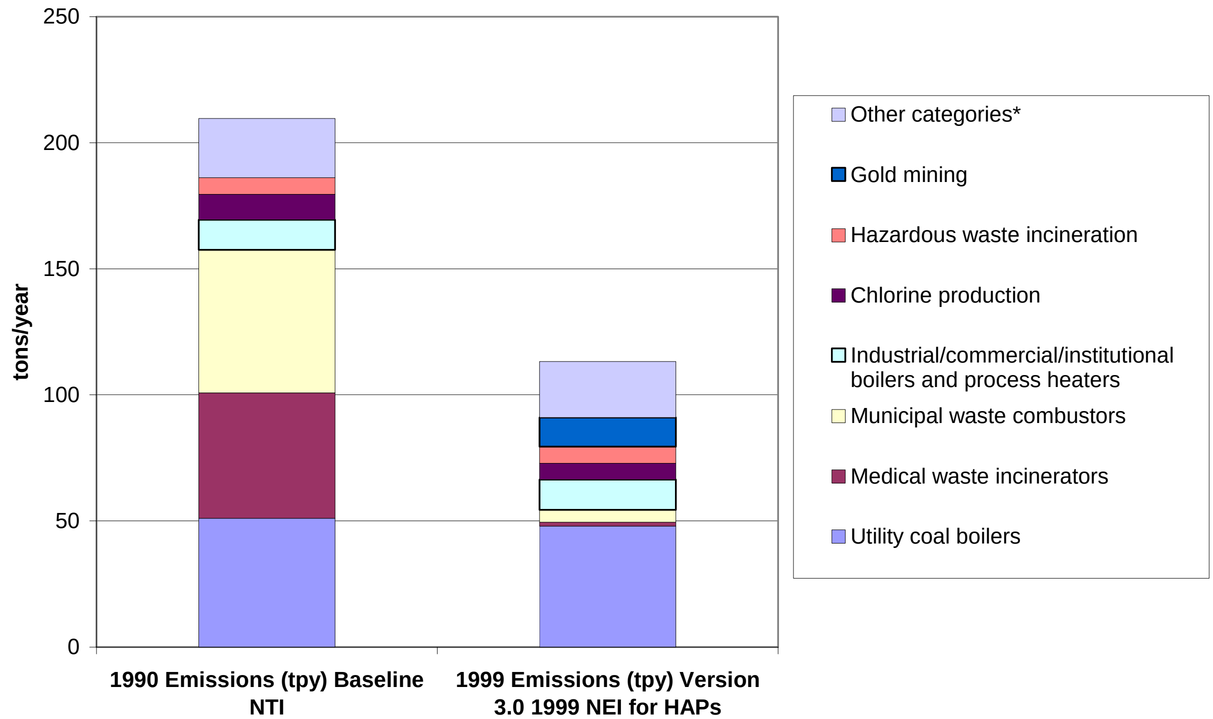
U.S. Environmental Protection Agency. 1999 National Emission Inventory Documentation and Data - Final Version 3.0. (http://www.epa.gov/ttn/chief/net/1999inventory.html)

References

U.S. Environmental Protection Agency. Mercury Study Report to Congress Volumes I to VII, EPA 452-R-96-001b. Washington, DC: Office of Air Quality Planning and Standards, 1996. http://www.epa.gov/mercury/report.htm.

Graphics

Figure 316-1. Mercury emissions, 1990 & 1999



R.O.E. Indicator QA/QC

Data Set Name: MERCURY EMISSIONS
Indicator Number: 316 (89077)
Data Set Source: EPA National Emissions Inventory
Data Collection Date: ongoing: 1990-present
Data Collection Frequency: varies from annually to triennially
Data Set Description: Mercury Emissions
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. While the NEI is a composite of data from many different data sources and methods, most of which are estimates instead of actual measurements with associated precision and accuracy, the methods are widely accepted as technically valid. These methods are considered largely sufficient in their application to derive the indicator data and conclusions presented to the typical user of the ROE. The NEI contains annual emissions (units = tons/year) of the criteria pollutants and the hazardous air pollutants (HAPs) noted in the Clean Air Act Amendments of 1990 (CAAA). The methods used to develop the NEI pollutant data vary by source sector and involve multiple data sources. A general description of methods by source sector is included below. Source emissions can be measured using monitoring equipment or estimated by using emission factors and emission process activity levels. Mathematical models may be used to characterize and simulate emissions that are influenced by several variables. For most source types, estimation techniques are the most practical. The NEI emissions are grouped into four main source sectors: Point sources and NonPoint sources (these are also referred to as stationary sources) and Onroad Mobile and Nonroad mobile sources (these are referred to as mobile sources). The Point source sector contains data on individual industrial, commercial and institutional facilities and is further divided into two subsectors: Electric Generating Units (EGUs) and NonEGUs. For the NEI sector data that is collected from state and local agencies - they either gather the data from their facilities or estimate the emissions themselves, using average and industry-specific emission factors. Some of the techniques they may use to generate their point and nonpoint estimates are referenced in a guidebook of methods which is endorsed by the EPA and the state and local agencies (STAPPA/ALAPCO). The guidebook of methods is located on http://www.epa.gov/ttn/chief/eiip/techreport/. Depending on the source sector and the pollutants of interest, the EPA uses other data sources in addition to the data received by the state and local agencies. Those other data sources, where applicable, are generally described below by sector, and identified specifically in the EPA   s Preparation Plan for the 2002 NEI, located on http://www.epa.gov/ttn/chief/net/2002inventory.html. In addition to identifying the data sources, the NEI 2002 Preparation Plan also describes the EPA's current method of quality checking the different data sources, and blending and merging among them, as well as augmenting data in order to complete the data set over space and time for specific source sectors and pollutants. The EPA Preparation Plan for the 1999 NEI (http://www.epa.gov/ttn/chief/net/nei_plan_feb2001.pdf) describes the data sources and process used to compile the 1999 HAP data which is included in the indicator. There is a triennial development effort and focus on compiling data for the NEI which results in the most complete national emissions inventory data every third year. For the criteria emissions in the NEI, data is also developed for the years in between the 3-year inventory cycles. For some sectors and pollutants, the methods used may be the same as those applied for the 3-year inventory, or the data may be extrapolated from the most recent third year inventory using economic projections or more simply as a mathematical interpolation between previous and subsequent years of record. While the NEI is a composite of data from many different data sources and methods, most of which are estimates instead of actual measurements with associated precision and accuracy, the methods are widely accepted as technically valid. These methods are considered largely sufficient in their application to derive the indicator data and conclusions presented to the typical user of the ROE.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

There is not a sampling design per se for the overall NEI data development project, at least not in the typical terms of a statistical sampling design. The data methods are predominantly based on estimation techniques rather than measurement techniques with associated precision and accuracy and standard error. For most sector data, emission factors are used with average emission process rates and average activity indicators to estimate typical emissions expected from similar processes in different geographical areas. Emission factors typically are based on emission testing or other sampling observations of sources and are generally developed and revised as need arises and more data becomes available. Highway vehicle emissions factors, however, are based on relatively recent research-driven sampling approaches that are documented in information collection plans implemented by the EPA's Office and Transportation and Air Quality Planning (http://www.epa.gov/otaq/ap42.htm). For onroad mobile sources, estimates are made by month or by season to account for typical temperatures and fuel properties. Estimates of vehicle miles traveled are based on the United States Department of Transportation (US DOT) Highway Performance Monitoring System, which makes use of a formal sample panel of roadway segments. Like onroad mobile sources, emissions from some other processes are estimated for time periods less than annual. As an example, pollutant emissions for seasonal processes are estimated for only a portion of the year in which they occur (i.e., winter burning season). The NEI attempts to capture the full universe of large point source facilities, which are closely monitored and located individually by the state and local agencies. Most Point EGU emissions are individually measured with continuous monitoring devices. These data are summarized to annual average emissions for all 50 states and their counties, D.C., the U.S. territories of Puerto Rico and Virgin Islands, and as available, for some of the territories of federally-recognized American Indian nations, and are widely used and accepted as an indicator of national and regional emission trends over time.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The annual emissions are directly estimated in most cases, or are simply totaled from monthly or seasonal estimates - there is no transformation.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The NEI is designed to explicitly answer the question posed in the ROE. This indicator estimates emissions from all anthropogenic sources of a primary air pollutant.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The emission estimates that comprise the NEI are non-specific for sensitive populations or ecosystems. Rather, the data are specific for types of emission processes and as such, are representative of how much and where those process emissions occur by county for the nonpoint sources and by individual facility location for the point sources.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator(s) directly addresses changes in air pollutant emissions from year-to-year and the contributions of various types of emissions sources, by county, and for every state. Air pollutant emissions are a reliable gauge of impact on the environment and when considered along with air quality transport and transformation issues, are the foundation for air quality analysis, including health indicators. Emission reductions generally indicate positive impact on air quality. Average annual pollutant emission trends over time may also reference a specific year or years in the time series, during which emission reductions were realized due to previous year implementation of federal, regional, or local control and compliance programs. There are no thresholds or ranges of values associated with safe levels of emissions for this indicator.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The NEI is a composite of many data sources, much of which is provided by state and local agencies and comes to EPA with little or no documentation on the specific methods used to generate the estimates. An emission inventory guidebook of methods, which is endorsed by the EPA and the state and local agencies (STAPPA/ALAPCO), is generally used by state and local agencies as reference for acceptable methods. The guidebook of methods is located on http://www.epa.gov/ttn/chief/eiip/techreport/. For emissions that are reported by the states as direct measurements from monitoring devices, the analytical procedures are referenced on http://www.epa.gov/ttn/emc/. Documentation of the procedures that EPA used to compile the NEI data for some of the more recent years in the time series is located on http://www.epa.gov/ttn/chief/net/neidata.html and is more organized and descriptive than documentation for previous year data. Documentation for the earlier years noted in the time series is located on http://www.epa.gov/ttn/chief/trends/procedures/neiproc99.pdf. Some of the methods noted have subsequently been revised for specific processes and years as EPA has gone back to update and apply improved methods. The documentation sources noted above will also describe use of emission factors. Documentation on process specific emission factors and how they were derived is located on http://www.epa.gov/ttn/chief/ap42/index.html.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The national annual NEI criteria emission trends summaries, as presented in the indicator, are publicly available on http://www.epa.gov/airtrends/econ-emissions.html. The national annual NEI hazardous air pollutant (HAP) data for year 1999, as presented in the indicator, are publicly available on http://www.epa.gov/air/data/index.html. Data format information typically resides at the same location as the data itself.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The EPA's documentation (see that noted in T3Q1) of how the NEI data estimates are generated will facilitate reproduction of some emission process estimates. As the EPA's documentation has evolved and improved over the years, it is expected that the more recent data years are documented in a more organized and transparent manner and would best enable reproducibility of emission estimates. Where EPA's documentation for specific years indicates that data was incorporated as that received from the state and local agencies, there is no additional documentation available by which to reproduce the state-derived values.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Much of the data that is used to compile the NEI is gathered indirectly from multiple and numerous sources, as referenced in the estimation methods information under T1Q1. These indirect data sources are presumed to have their own QA practices. Where state-supplied emissions estimates are used for some sectors and pollutants, it is presumed that states have QA plans in most cases but EPA does not systematically obtain information on QA practices from the states. The EPA contractors who use data sources and EPA-developed emissions factors to make emissions estimates operate under general contract-wide quality assurance plans, which can be made available on request. In addition, the EPA's more recent QC practices performed during the blending and merging of data from numerous sources, are described in the 2002 NEI Preparation Plan located on http://www.epa.gov/ttn/chief/net/2002inventory.html.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

No statistical generalization is performed to generate the national annual emissions trends presented in the indicator. The annual pollutant totals are developed at the plant or county level and then simply totaled and summarized at the regional and national levels.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No. At present, statistical uncertainty measures are not available for the underlying data that comprise the indicator. Most of the QA routines that are currently performed by EPA are sector data comparisons between different years or geographic areas, rather than on individual data variables. Much of the associated data variables for a specific sector are implied or not highly characterized, and therefore do not lend themselves well at present to quantitative uncertainty analysis.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Yes, OAQPS has developed standardized procedures for quality assuring the NEI as discussed in the "2002 NEI Preparation Plan" (http://www.epa.gov/ttn/chief/net/2002neiplan_081004final.pdf). The procedures include use of software to facilitate and standardize review of the data by EPA regional offices and state, local and tribal agencies. During the review process, industries often closely review their emission estimates to ensure they have been correctly incorporated in the NEI. In addition, OAQPS is able to use techniques which contrast data from various sources and from several inventory years to understand variability and identify areas in need of additional review. Where several data sources are available, assessments of data quality are conducted by OAQPS to ensure use of the highest quality emissions data when developing the NEI. The sum of the review procedures used for developing the NEI is believed to yield data of sufficient quality to support the conclusions which typical users will derive from the indicators. However, for the most rigorous applications, the NEI may be used in conjunction with ambient monitoring data and air quality and source receptor models to better characterize air quality problems and thus reduce uncertainties.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The indicator represents aggregated data. Most of the data is the result of a calculation that combines an emission rate per unit of input or output and a measure of that input or output, rather than a direct measurement of emissions. All states and counties are represented in the NEI, however not all states and local agencies may provide the same data or level of detail for a given year. State and local agencies may prioritize their data development efforts on emissions in county and metropolitan areas that are nonattainment for specific ambient air quality standards, i.e., ozone or PM2.5 NAAQS. The result may be more complete and quality assured data submissions to the NEI for these areas. Where data is absent or incomplete, EPA performs some data extrapolation from previous year data or other data sources. Inference follows many processes, depending on source type, etc. To the extent possible, facility-specific or county-specific information is used. In some cases, all counties in a state are assumed to have common properties influencing emissions, for example daily low and high temperatures. Best available or at most plausible substitutes are used where needed. For example, gasoline fuel properties are not available for all counties, known fuel properties in nearby counties subject to similar regulations on gasoline are used instead. Various and not fully consistent methodologies have been used to develop the emission estimates in the NEI. This is to be expected considering the variety of organizations that have contributed the estimates.

Indicator: Nitrogen Oxides Emissions (008a)

Nitrogen oxides (NO_x) is the term used to describe the sum of nitric oxide (NO), nitrogen dioxide (NO_2), and other oxides of nitrogen. Most airborne NO_x come from combustion-related emissions sources of human origin, primarily fossil fuel combustion in electrical utilities, high temperature operations at other industrial sources, and operation of motor vehicles. However, natural sources, like biological decay processes and lightning, also contribute to airborne NO_x. Fuel-burning appliances, like home heaters and gas stoves, produce substantial amounts of NO_x in indoor settings (EPA, 2003).

NO_x play a major role in several important environmental and human health issues such as:

- Both short-term and long-term exposures to elevated air concentrations of NO_2 can cause various acute and chronic respiratory effects (EPA, 1993).
- Airborne NO_x and VOCs react in the presence of sunlight to form ozone. Elevated ozone concentrations continue to be a serious air pollution problem in much of the U.S. (see Indicator "Ambient Ozone Concentrations").
- NO_x and other pollutants react in the air to form compounds that contribute to acid deposition, which can damage forests and cause lakes and streams to acidify (see Indicator "Acid Deposition").
- Deposition of NO_x affects how nitrogen cycles through ecosystems. Excessive nitrogen loadings can upset the chemical balance of nutrients in water bodies, especially in coastal estuaries (see Indicator Lake and Stream Acidity).
- NO_x plays a role in several other environmental issues, including formation of particulate matter (see Indicator "Ambient PM Concentrations"), visibility impairment (see Indicator "Visibility"), and global climate change (see Indicators "U.S. Greenhouse Gas Emissions" and "Ambient Concentrations of Greenhouse Gases").

This indicator presents NO_x emissions data tracked by the National Emissions Inventory (NEI). The NEI is a composite of data from many different data sources, including industry and numerous state, tribal, and local agencies. Different data sources use different data collection methods, and many of the emissions data are based on estimates rather than actual measurements. Emissions are tracked for stationary point and non-point sources as well as onroad and non-road mobile sources. NEI data have been collected since 1990 and cover all 50 states and their counties, D.C., the U.S. territories of Puerto Rico and Virgin Islands, and some of the territories of federally-recognized American Indian nations. Data are presented only for 1990 and the years from 1996 forward because although data are available for 1991 – 1995, they have not been updated and comparisons of these data with those from other inventory years could lead to incorrect trends assumptions. Inventory years 1990 and from 1996 forward are up to date.

What the Data Show

Exhibit 008a-1 displays NOx emissions by five source categories: 1) "fuel combustion Title IV" which includes emissions from coal, gas and oil-fired power plants, 2) "fuel combustion other" which includes emissions from industrial, commercial and institutional sources as well as residential heaters and boilers, 3) "industrial and other processes" which includes chemical production, petroleum refining, and metals production, 4) "on road vehicles" which includes cars, trucks, buses, and motorcycles and 5) "non-road vehicles and engines" such as farm and construction equipment, lawnmowers, chainsaws, boats/ships, snowmobiles, aircraft, and others. According to the NEI data, estimated nationwide emissions of NO_x decreased by 18% between 1990 and 2002 (from 25,158,000 to 20,746,000 tons). This downward trend results primarily from emissions reductions at electrical utilities and among onroad mobile sources.

Although total nationwide NO_x emissions decreased during this period, emissions from some sources such as nonroad engines have increased since 1990.

NOx emissions among all ten EPA Regions decreased between 1990 and 2002, consistent with the overall national trend (Figure 008a-2).

Indicator Limitations

- Though NO_x emissions from most electric utilities are measured directly using continuous monitoring devices, NO_x emissions data for most other source types are estimates. These estimates are generated using well-established approaches, but still have inherent uncertainties.
- The methodology for estimating emissions is continually reviewed and is subject to revision. Trend data prior to any revisions must be considered in the context of those changes.
- Not all states and local agencies provide the same data or level of detail for a given year.

Data Sources

U.S. Environmental Protection Agency. National Emissions Inventory - http://www.epa.gov/ttn/chief/net/neidata.html

References

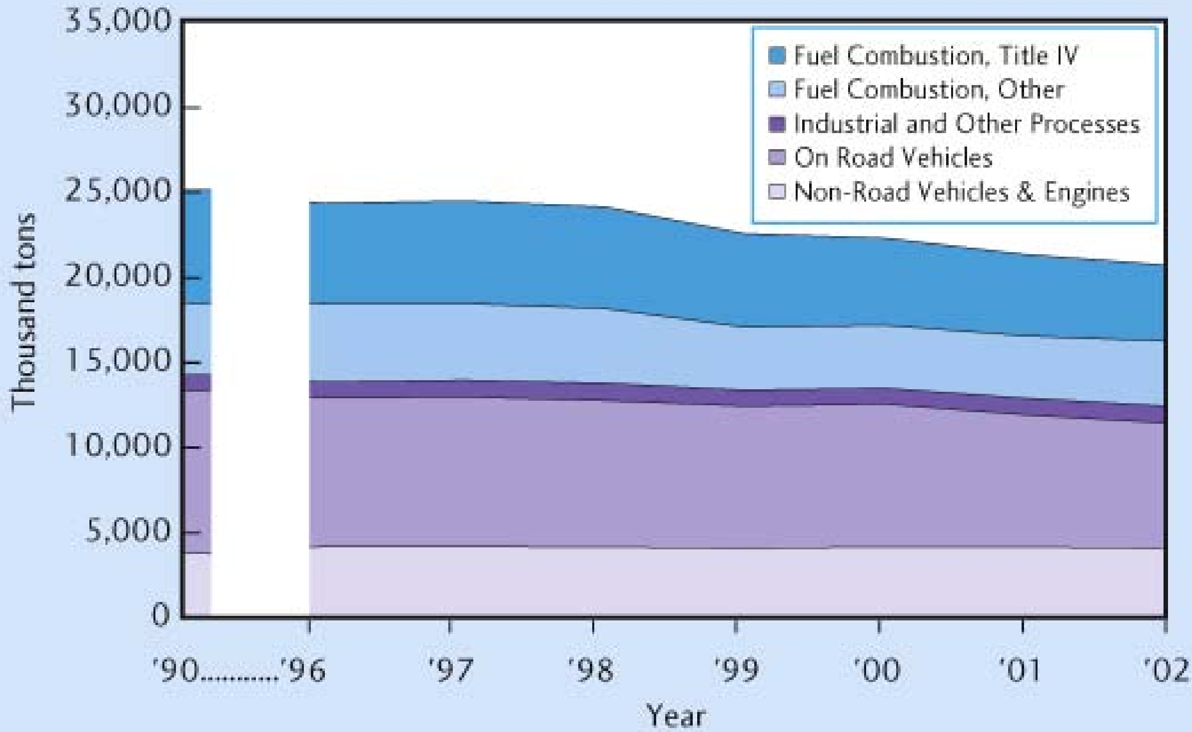
EPA, 2003. National Air Quality and Emissions Trends Report - 2003 Special Studies Edition, EPA 454/R-03-005. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, September 2003.

EPA, 1993. Air Quality Criteria for Oxides of Nitrogen, EPA 600-8-91-049aF-cF. Research Triangle Park, NC; US Environmental Protection Agency, Office of Research and Development, Environmental Criteria and Assessment Office, August 1993.

United States Code. Clean Air Act, as amended in 1990, Title IV: Acid Deposition Control. 42 U.S.C. 7651.

Graphics

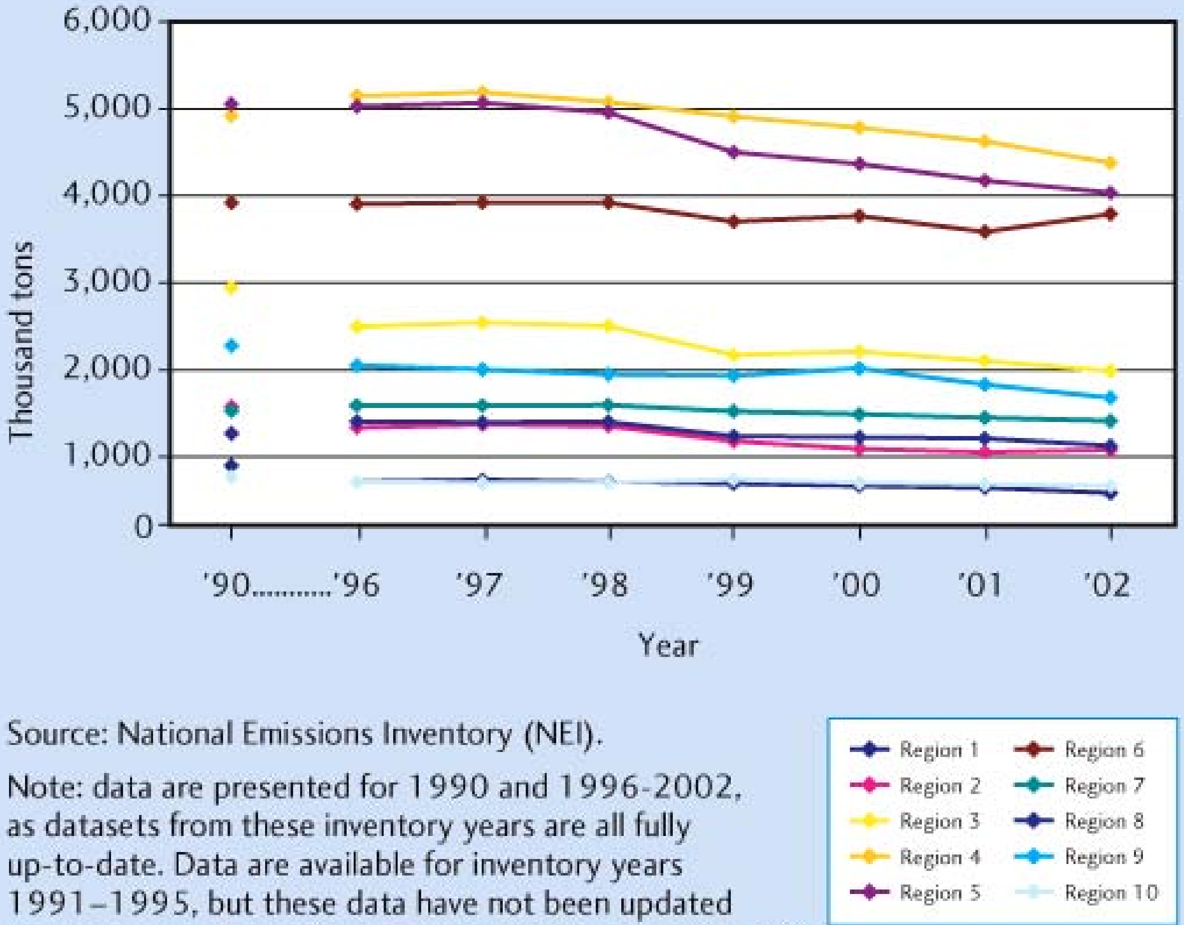
Figure 008a-1: National NO_x emissions, 1990 and 1996-2002



Source: National Emissions Inventory (NEI).

Note: data are presented for 1990 and 1996-2002, as datasets from these inventory years are all fully up-to-date. Data are available for inventory years 1991-1995, but these data have not been updated to allow comparison with data from 1990 and 1996-2002.

Figure 008a-2: NO_x emissions by EPA region, 1990 and 1996-2002



Source: National Emissions Inventory (NEI).

Note: data are presented for 1990 and 1996-2002, as datasets from these inventory years are all fully up-to-date. Data are available for inventory years 1991–1995, but these data have not been updated to allow comparison with data from 1990 and 1996–2002.

R.O.E. Indicator QA/QC

Data Set Name: NOX EMISSIONS
Indicator Number: 008a (89076)
Data Set Source: National Air Quality and Emissions Trends Report - 2003 Special Studies Edition
Data Collection Date: 1990 and 2002
Data Collection Frequency: annual
Data Set Description: NOx Emissions
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

The NEI contains annual emissions (units = tons/year) of the criteria pollutants and the hazardous air pollutants (HAPs) noted in the Clean Air Act Amendments of 1990 (CAAA). The methods used to develop the NEI pollutant data vary by source sector and involve multiple data sources. A general description of methods by source sector is included below. Source emissions can be measured using monitoring equipment or estimated by using emission factors and emission process activity levels. Mathematical models may be used to characterize and simulate emissions that are influenced by several variables. For most source types, estimation techniques are the most practical. The NEI emissions are grouped into four main source sectors: Point sources and NonPoint sources - these are also referred to as stationary sources; and Onroad Mobile and Nonroad mobile sources - these are referred to as mobile sources. The Point source sector contains data on individual industrial, commercial and institutional facilities and is further divided into two subsectors - Electric Generating Units (EGUs) and NonEGUs. For the NEI sector data that is collected from state and local agencies - they either gather the data from their facilities or estimate the emissions themselves, using average and industry-specific emission factors. Some of the techniques they may use to generate their point and nonpoint estimates are referenced in a guidebook of methods which is endorsed by the EPA and the state and local agencies (STAPPA/ALAPCO). The guidebook of methods is located on http://www.epa.gov/ttn/chief/eiip/techreport/. Depending on the source sector and the pollutants of interest, the EPA uses other data sources in addition to the data received by the state and local agencies. Those other data sources, where applicable, are generally described below by sector, and identified specifically in the EPA s Preparation Plan for the 2002 NEI, located on http://www.epa.gov/ttn/chief/net/2002inventory.html. In addition to identifying the data sources, the NEI 2002 Preparation Plan also describes the EPA's current method of quality checking the different data sources, and blending and merging among them, as well as augmenting data in order to complete the data set over space and time for specific source sectors and pollutants. The EPA Preparation Plan for the 1999 NEI (http://www.epa.gov/ttn/chief/net/nei_plan_feb2001.pdf) describes the data sources and process used to compile the 1999 HAP data which is included in the indicator. There is a triennial development effort and focus on compiling data for the NEI which results in the most complete national emissions inventory data every third year. For the criteria emissions in the NEI, data is also developed for the years in between the 3-year inventory cycles. For some sectors and pollutants, the methods used may be the same as those applied for the 3-year inventory, or the data may be extrapolated from the most recent third year inventory using economic projections or more simply as a mathematical interpolation between previous and subsequent years of record. While the NEI is a composite of data from many different data sources and methods, most of which are estimates instead of actual measurements with associated precision and accuracy, the methods are widely accepted as technically valid. These methods are considered largely sufficient in their application to derive the indicator data and conclusions presented to the typical user of the ROE.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

There is not a sampling design per see for the overall NEI data development project, at least not in the typical terms of a statistical sampling design. The data methods are predominantly based on estimation techniques rather than measurement techniques with associated precision and accuracy and standard error. For most sector data, emission factors are used with average emission process rates and average activity indicators to estimate typical emissions expected from similar processes in different geographical areas. Emission factors typically are based on emission testing or other sampling observations of sources and are generally developed and revised as need arises and more data becomes available. Highway vehicle emissions factors however, are based on relatively recent research-driven sampling approaches that are documented in information collection plans implemented by the EPA's Office and Transportation and Air Quality Planning (OTAQ - http://www.epa.gov/otaq). For onroad mobile sources, estimates are made by month or by season to account for typical temperatures and fuel properties. Estimates of vehicle miles traveled are based on the United States Department of Transportation (US DOT) Highway Performance Monitoring System, which makes use of a formal sample panel of roadway segments. Like onroad mobile sources, emissions from some other processes are estimated for time periods less than annual. As an example, pollutant emissions for seasonal processes are estimated for only a portion of the year in which they occur (i.e., winter burning season). The NEI attempts to capture the full universe of large point source facilities, which are closely monitored and located individually by the state and local agencies. Most Point EGU emissions are individually measured with continuous monitoring devices. These data are summarized to annual average emissions for all 50 states and their counties, D.C., the U.S. territories of Puerto Rico and Virgin Islands, and as available, for some of the territories of federally-recognized American Indian nations, and are widely used and accepted as an indicator of national and regional emission trends over time.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

See T1Q2 above. The annual emissions are directly estimated in most cases, or are simply totaled from monthly or seasonal estimates - there is no transformation.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Refer to the information provided under T1Q2.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The emission estimates that comprise the NEI are non-specific for particular segments of population and ecosystem. Rather, the data are specific for types of emission processes and as such, are representative of how much and where those process emissions occur by county for the nonpoint sources and by individual facility location for the point sources.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator(s) directly addresses changes in air pollutant emissions from year-to-year and the contributions of various types of emissions sources, by county, and for every state. Air pollutant emissions are a reliable gauge of impact on the environment and when considered along with air quality transport and transformation issues, are the foundation for air quality analysis, including health indicators. Emission reductions generally indicate positive impact on air quality. Average annual pollutant emission trends over time may also reference a specific year or years in the time series, during which emission reductions were realized due to previous year implementation of federal, regional, or local control and compliance programs.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The NEI is a composite of many data sources, much of which is provided by state and local agencies and comes to EPA with little or no documentation on the specific methods used to generate the estimates. An emission inventory guidebook of methods, which is endorsed by the EPA and the state and local agencies (STAPPA/ALAPCO), is generally used by state and local agencies as reference for acceptable methods. The guidebook of methods is located on http://www.epa.gov/ttn/chief/eiip/techreport/. For emissions that are reported by the states as direct measurements from monitoring devices, the analytical procedures are referenced on http://www.epa.gov/ttn/emc/. Documentation of the procedures that EPA used to compile the NEI data for some of the more recent years in the time series is located on http://www.epa.gov/ttn/chief/net/neidata.html and is more organized and descriptive than documentation for previous year data. Documentation for the earlier years noted in the time series is located on http://www.epa.gov/ttn/chief/trends/procedures/neiproc99.pdf. Some of the methods noted have subsequently been revised for specific processes and years as EPA has gone back to update and apply improved methods. The documentation sources noted above will also describe use of emission factors. Documentation on process specific emission factors and how they were derived is located on http://www.epa.gov/ttn/chief/ap42/index.html.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The national annual NEI criteria emission trends summaries, as presented in the indicator, are publicly available on http://www.epa.gov/airtrends/econ-emissions.html. The national annual NEI hazardous air pollutant (HAP) data for year 1999, as presented in the indicator, are publicly available on http://www.epa.gov/air/data/index.html. Data format information typically resides at the same location as the data itself.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The EPA’s documentation (see that noted in T3Q1) of how the NEI data estimates are generated will facilitate reproduction of some emission process estimates. As the EPA s documentation has evolved and improved over the years, it is expected that the more recent data years are documented in a more organized and transparent manner and would best enable reproducibility of emission estimates. Where EPA’s documentation for specific years indicates that data was incorporated as that received from the state and local agencies, there is no additional documentation available by which to reproduce the state-derived values.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Much of the data that is used to compile the NEI is gathered indirectly from multiple and numerous sources, as referenced in the estimation methods information under T1Q1. These indirect data sources are presumed to have their own QA practices. For example, estimates of SO2 and NOx from most electric generating units (Point EGUs) are based on the continuous emissions monitors required by EPA's Acid Rain (Title 4) compliance program. This EPA program has its own QA/QC requirements and procedures. Information on those procedures may be accessed on http://www.epa.gov/airmarkets/reporting/index.html. Estimates of other pollutants from electric generating units are made by EPA based on fuel consumption data collected from the sources by the Department of Energy (DOE), presumably under a QA plan. Where state-supplied emissions estimates are used for some sectors and pollutants, it is presumed that states have QA plans in most cases but EPA does not systematically obtain information on QA practices from the states. The EPA contractors who use data sources and EPA-developed emissions factors to make emissions estimates operate under general contract-wide quality assurance plans , which can be made available on request. In addition, the EPA's more recent QC practices performed during the blending and merging of data from numerous sources, are described in the 2002NEI Preparation Plan located on http://www.epa.gov/ttn/chief/net/2002inventory.html.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

No statistical generalization is performed to generate the national annual emissions trends presented in the indicator. The annual pollutant totals are developed at the plant or county level and then simply totaled and summarized at the regional and national levels.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No. At present, statistical uncertainty measures are not available for the underlying data that comprise the indicator. Most of the QA routines that are currently performed by EPA are sector data comparisons between different years or geographic areas, rather than on individual data variables. Much of the associated data variables for a specific sector are implied or not highly characterized, and therefore do not lend themselves well at present to quantitative uncertainty analysis.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Yes, OAQPS has developed standardized procedures for quality assuring the NEI as discussed in the "2002 NEI Preparation Plan" (http://www.epa.gov/ttn/chief/net/2002neiplan_081004final.pdf). The procedures include use of software to facilitate and standardize review of the data by EPA regional offices and state, local and tribal agencies. During the review process, industries often closely review their emission estimates to ensure they have been correctly incorporated in the NEI. In addition, OAQPS is able to use techniques which contrast data from various sources and from several inventory years to understand variability and identify areas in need of additional review. Where several data sources are available, assessments of data quality are conducted by OAQPS to ensure use of the highest quality emissions data when developing the NEI. The sum of the review procedures used for developing the NEI is believed to yield data of sufficient quality to support the conclusions which typical users will derive from the indicators. However, for the most rigorous applications, the NEI may be used in conjunction with ambient monitoring data and air quality and source receptor models to better characterize air quality problems and thus reduce uncertainties.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The indicator represents aggregated data. Most of the data is the result of a calculation that combines an emission rate per unit of input or output and a measure of that input or output, rather than a direct measurement of emissions. All states and counties are represented in the NEI, however not all states and local agencies may provide the same data or level of detail for a given year. State and local agencies may prioritize their data development efforts on emissions in county and metropolitan areas that are nonattainment for specific ambient air quality standards, i.e., ozone or PM2.5 NAAQS. The result may be more complete and quality assured data submissions to the NEI for these areas. Where data is absent or incomplete, EPA performs some data extrapolation from previous year data or other data sources. Inference follows many processes, depending on source type, etc. To the extent possible, facility-specific or county-specific information is used. In some cases, all counties in a state are assumed to have common properties influencing emissions, for example daily low and high temperatures. Best available or at most plausible substitutes are used where needed. For example, gasoline fuel properties are not available for all counties, known fuel properties in nearby counties subject to similar regulations on gasoline are used instead. Various and not fully consistent methodologies have been used to develop the emission estimates in the NEI. This is to be expected considering the variety of organizations that have contributed the estimates.

Indicator: Ozone and PM Concentrations for U.S. Counties in the U.S./Mexico Border Region (280R)

The Border between the United States (U.S.) and Mexico spans approximately 2,000 miles, from the Pacific Ocean to the Gulf of Mexico. The area is subjected to a unique blend of increased industrial development (especially on the Mexico side of the border), intense pressures because of the shifting and growing population related to this development, and an arid climate that can exacerbate many air quality problems. Ozone and particulate matter are air pollutants of particular concern.

Ground-level ozone is harmful to both human health and the environment (see Indicator 004). Although some industrial sources release ozone directly into the environment, most ground-level ozone forms from chemical reactions involving nitrogen oxides (NOx), volatile organic compounds (VOCs), and sunlight. Ozone levels are typically highest during the afternoon hours of the summer months, when the influence of direct sunlight is the greatest (EPA, 2003). Inhalation exposure to ozone has been linked to numerous respiratory health effects, including decreases in lung function, airway inflammation, and cough and pain when taking a deep a breath. Ozone exposure can aggravate lung diseases such as asthma, leading to increased medication use and increased hospital admissions and emergency room visits. Though people with respiratory problems are most vulnerable to ozone, even healthy people who are active outdoors can suffer from ozone-related health effects. Elevated concentrations of ozone can also affect vegetation and ecosystems, as Indicator 115 describes further (EPA, 1996).

Particulate matter (PM) is the general term used for a mixture of solid particles and liquid droplets found in the air (see Indicator 008). Primary PM is released directly from emissions sources into the atmosphere, while secondary PM is formed in the air from reactions involving precursor chemicals (e.g., nitrogen oxides, sulfur dioxide). Ambient air monitoring stations measure air concentrations of two size ranges of particles: PM2.5 (fine particles with aerodynamic diameter less than or equal to 2.5 micrometers (µm)) and PM10 (both fine particles (PM2.5) and coarse particles with aerodynamic diameters between 2.5 and 10 µm). Exposure to coarse particles is primarily associated with the aggravation of respiratory conditions such as asthma. Exposure to fine particles is closely associated with the most serious health effects, including decreased lung function, increased hospital admissions and emergency room visits, increased respiratory symptoms and disease, and premature death. Sensitive groups that appear to be at greatest risk to such PM effects include the elderly, individuals with cardiopulmonary disease such as asthma or congestive heart disease, and children (EPA, 2002). Fine particles also are the major cause of reduced visibility in parts of the U.S., including many of our National Parks and wilderness areas (see Indicator 006), and PM deposition affects vegetation and ecosystems by upsetting delicate nutrient and chemical balances in soils and surface water. PM also causes soiling and erosion damage to materials, including monuments, statues, and other objects of cultural importance.

This indicator shows trends in the mean design values for ozone and particulate matter in the U.S. counties at the U.S./Mexico Border area from 1986-2004 in comparison to U.S. national trends. (Figures 296R-1 and 296R-2) This indicator establishes a base line for measuring against future air quality levels. This indicator is based on all monitoring stations that operated on the US side of the border during this time period. Trends in the limited number of stations for which there are continuous data for the period are shown for comparison.

What the Data Show

Counties on the U.S. side of the US/Mexico Border have experienced increasing emissions from the Mexican side of the border and rapid population growth on both sides of the border. However, despite the additional pressures, these counties show a downward trend in ozone, PM2.5, and PM10, similar to the trends in the rest of the U.S. (Figures 296R-1a,b,c and 296R-2a,b,c). The exception is the trend in PM10 in the Region 9 border counties (Figure 296R1-b). PM10 in the Region 9 border counties gradually increased over the period between 1992-1994 and 1999-2001, while PM10 trended downward over the same period in the nation as a whole. PM10 concentrations in the border counties have been higher than the national averages, notably so in the Region 9 Border counties. Also, localized along the Region 6 border, there are some monitors that show elevated PM 10 concentrations (Figure 296R-2b).

Comparison of the means of all border county air monitors with the means of the smaller number of sites in each region with continuous data over the entire period covered by the indicator shows that the shape of the trend curves are very similar, even though the means for the continuous monitoring sites tend to be higher (the exception is PM2.5 in Region 6). This suggests that the better characterization of the border region as the number of monitoring sites increases does not significantly bias the trends in the border counties.

Indicator Limitations

- Many counties along the U.S./Mexico Border do not have ambient air quality monitors; these counties are not characterized by this indicator; adequately characterized data are currently available for U.S. counties only.
- Short-term trends in PM2.5 concentrations are often highly dependent on meteorological conditions. This complicates efforts to interpret data for any given year; trends over the longer term are far less likely to be influenced by unusual meteorological conditions.
- The long-term ozone and PM-10 trends are derived from more and more monitors over the course of time from 1986-2004.
- Low mean air pollutant concentrations may mask higher values in some areas along the border and in the nation.

Data Sources

EPA Air Quality System (AQS) http://www.epa.gov/ttnairs1/airsaqs/index.htm

References

U.S. Environmental Protection Agency. 1996. Air Quality Criteria for Ozone and Related Photochemical Oxidants, EPA 600-P-93-004F-cF. Research Triangle Park, NC; US Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, July 1996.

U.S. Environmental Protection Agency. 2003. Border 2012: U.S.-Mexico Environmental Program. EPA-160-R-03-001. April 4, 2003.

U.S. Environmental Protection Agency. 2002. Air Quality Criteria for Particulate Matter, Third External Review Draft, Volume II, EPA 600-P-99-002bC. Research Triangle Park, NC; US Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment.

Graphics

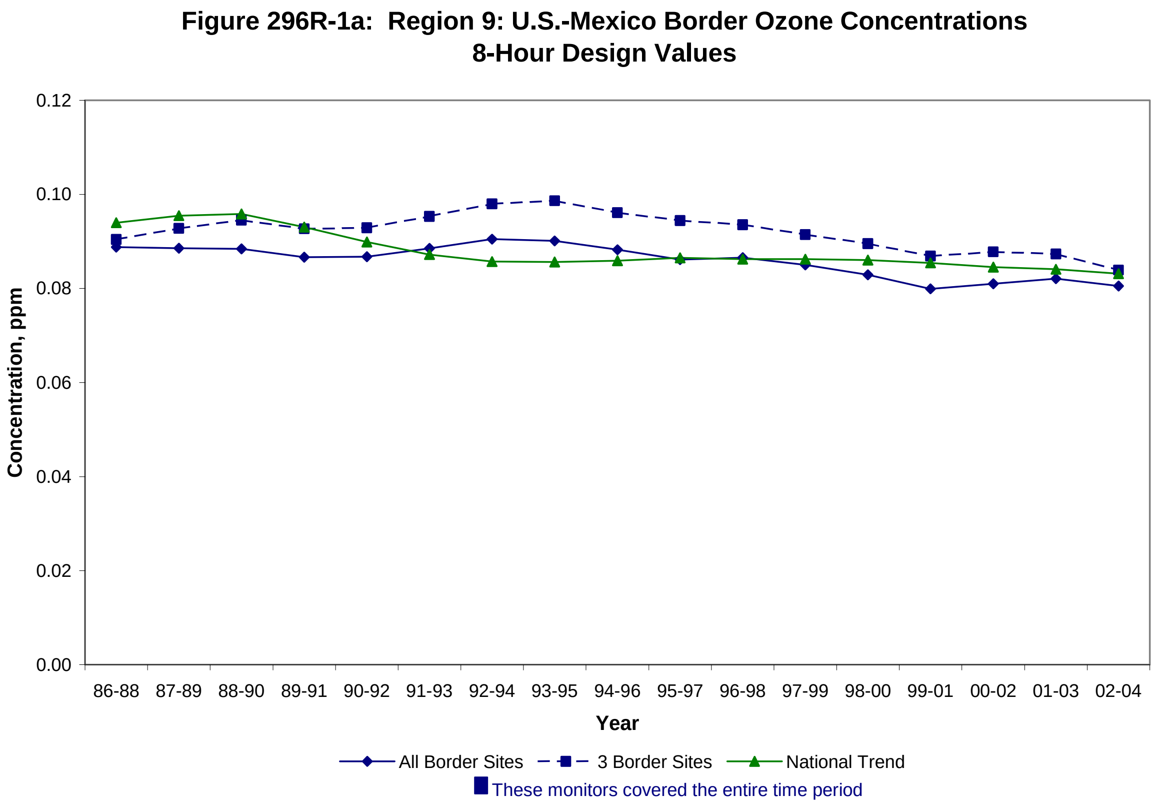


Figure 296R-1a: Region 9: U.S.-Mexico Border Ozone Concentrations
8-Hour Design Values
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Concentration, ppm
86-88
87-89
88-90
89-91
90-92
91-93
92-94
93-95
94-96
95-97
96-98
97-99
98-00
99-01
00-02
01-03
02-04
Year
All Border Sites
3 Border Sites
National Trend
These monitors covered the entire time period

Figure 296R-1b: Region 9: U.S.-Mexico PM10 Concentrations Design Values

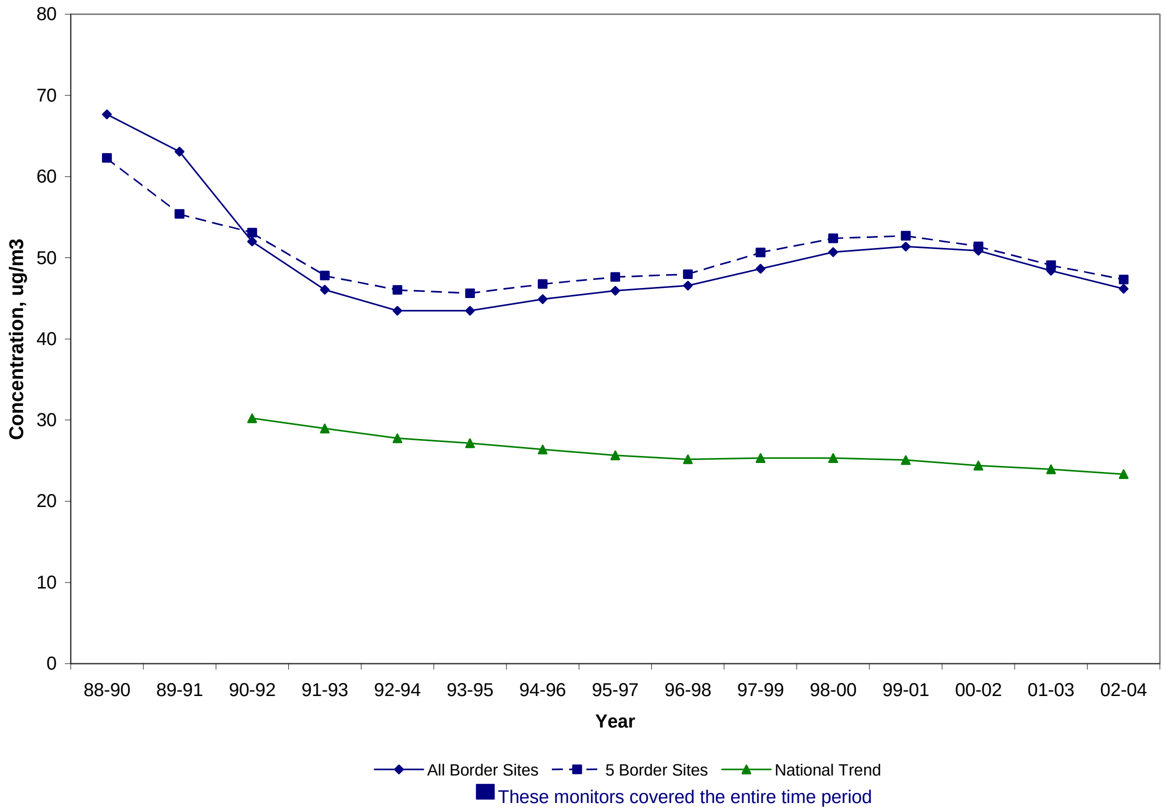


Figure 296R-1c: Region 9: U.S.-Mexico Border PM2.5 Concentrations Design Values

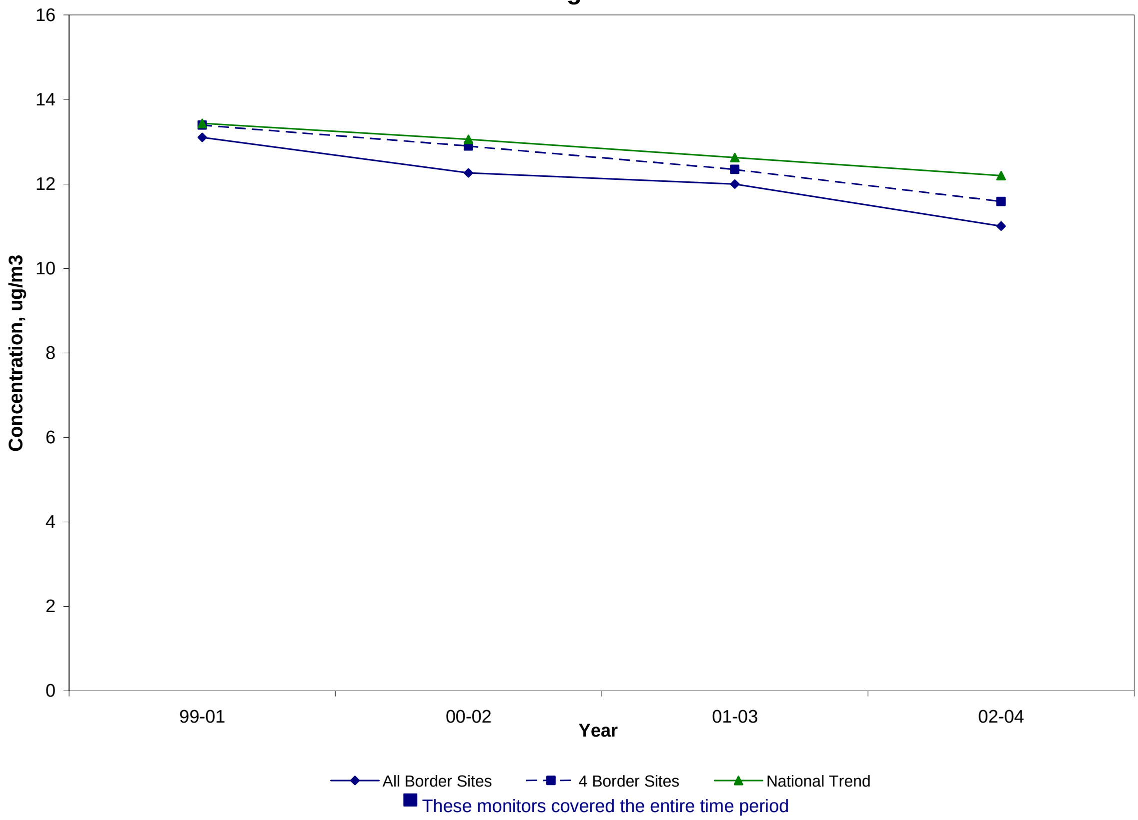


Figure 296R-2a: Region 6: U.S.-Mexico Border Ozone Concentrations
8-Hour Design Values

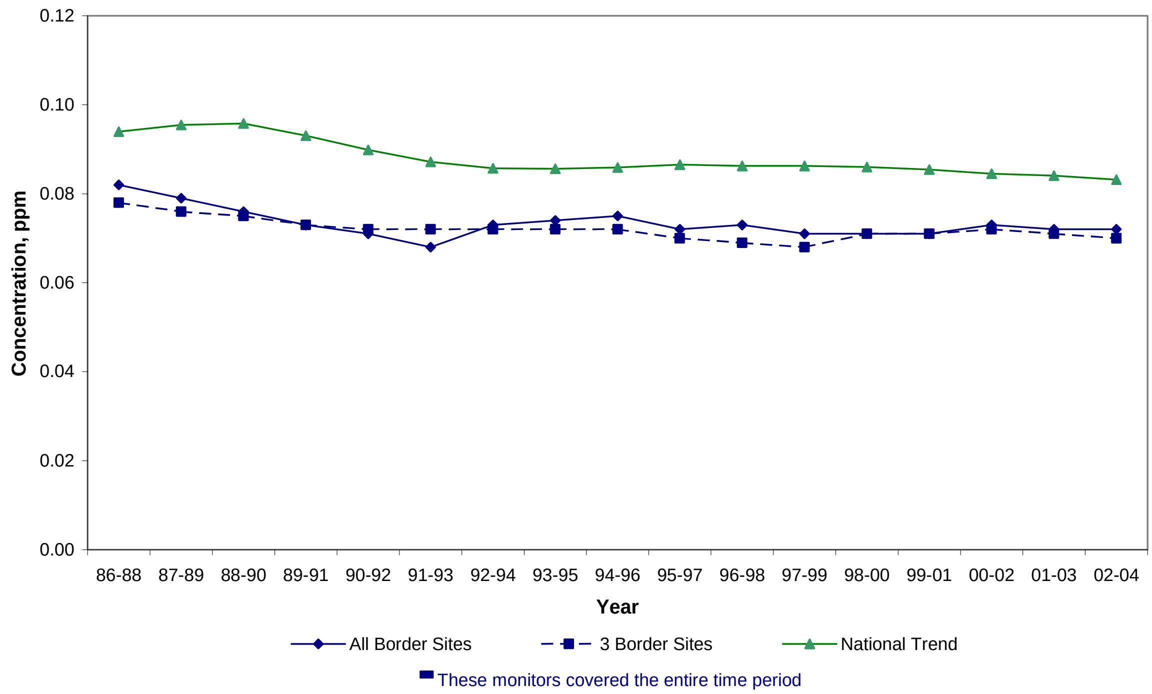


Figure 296R-2b: Region 6: U.S.-Mexico Border PM10 Concentrations
Design Values

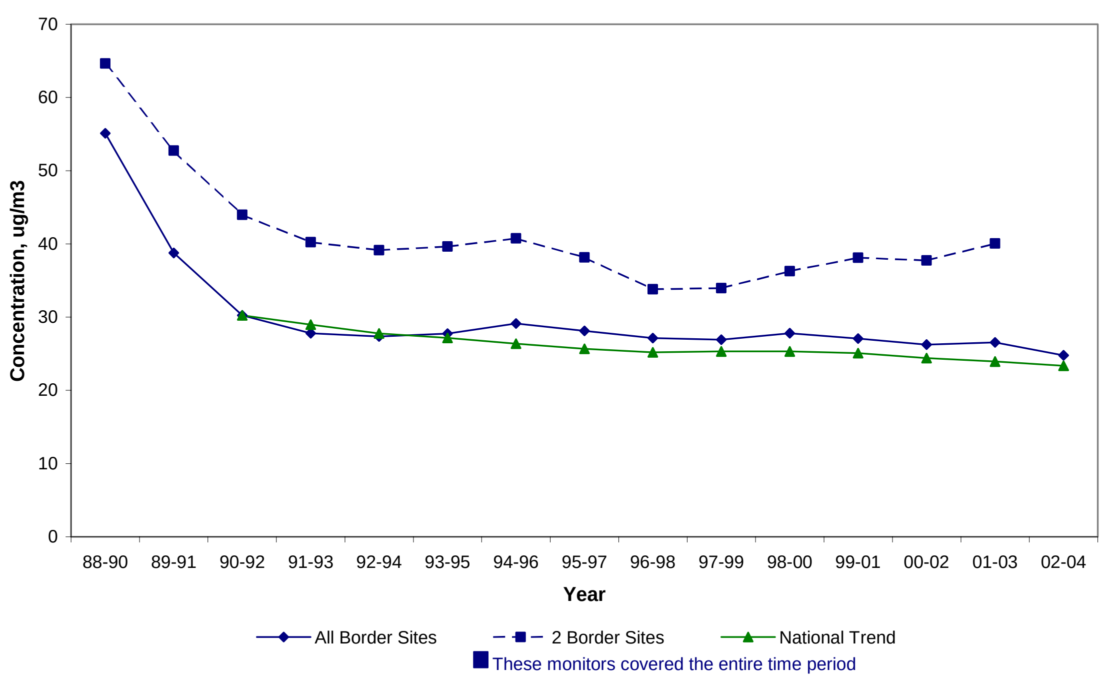
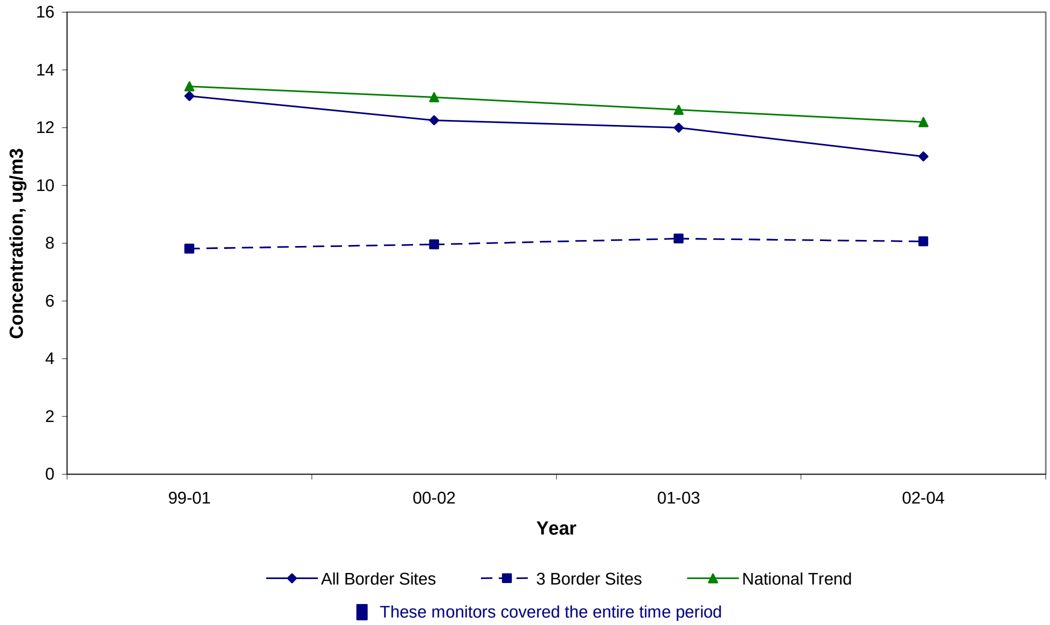


Figure 296R-2c: Region 6: U.S.-Mexico Border PM2.5 Concentrations Design Values



R.O.E. Indicator QA/QC

Data Set Name: OZONE AND PM FOR US COUNTIES IN THE US/MEXICO BORDER REGION
Indicator Number: 296R (89383)
Data Set Source:
Data Collection Date:
Data Collection Frequency:
Data Set Description: Design Value for Ozone, PM2.5 (annual mean), PM-2.5 (24-hour), PM10 (annual mean), PM-10 (24-hour) for US/Mexico border counties
Primary ROE Question: What are the trends in outdoor air quality and their effects on human health and the environment?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes, the ambient air quality data are based on data retrieved from the Air Quality System (AQS) in November 2004. These are direct measurements of pollutant concentrations at monitoring stations operated by state and local governments throughout the U.S.-Mexico border zone. The monitoring stations are generally located in larger urban areas. The monitoring network along the U.S.-Mexico border zone conforms to uniform criteria for monitor siting, instrumentation, and quality assurance. All data reported through these indicators are from EPA Federal Reference Monitors. The measurements collected were from monitors following all requirements of the National Air Monitoring Stations (NAMS)/State and Local Air Monitoring Stations (SLAMS) network. A description of this network includes: " 40 CFR 50 - National Ambient Air Quality Standards (NAAQS) and reference methods for determining criteria air pollutant concentrations in the atmosphere " 40 CFR 53 - Process for determining reference or equivalent methods for determining criteria air pollutant concentrations in the atmosphere " 40 CFR 58 - Ambient air quality surveillance (monitoring) requirements

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The border sites consist of NAMS, SLAMS, and other special-purpose monitors. NAMS were established to ensure a long-term national network for urban area-oriented ambient monitoring and to provide a systematic, consistent database for air quality comparisons and trends analysis. SLAMS allow state or local governments to develop networks tailored for their immediate monitoring needs. Special purpose monitors follow all NAMS/SLAMS reporting and design criteria but may not be deliberately sited to remain in the same location for long periods. This is desirable in order to respond to changing emissions characteristics in the border area The measurements collected were from monitors following all requirements of the NAMS/SLAMS network. The monitoring objectives for the NAMS/SLAMS network are found in: " 40 CFR 58,

Appendix D http://www.epa.gov/ttn/amtic/ " 40 CFR 58.2(c) " EPA 454/R-98-004, Part I, Section 3.2 http://www.epa.gov/ttn/amtic/cpreldoc.html

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes, PM-10, PM-2.5 and Ozone data are collected via EPA designated methods. Particulate Matter: PM-10 and PM-2.5 concentration data are collected via EPA designated methods in 24-hour, non-continuous fashion at a one, three or six day intervals depending upon the sampling frequency at each site. The daily measurements are obtained from monitoring instruments that produce one measurement per 24-hour period and typically operate on a systematic sampling schedule of once every 6 days, or 61 samples per year. EPA has determined that an every 6th day sampling schedule is sufficient to accurately characterize air quality for comparison to the NAAQS. A 75% minimal data completeness is required for trends purposes. The annual design value statistics presented in the indicators are the 3-year average annual mean for both PM-10 and PM-2.5. For PM-10, the 24-hour design value statistics presented in the indicators is the maximum concentration (rank of daily value based on number of samples) observed during a 3-year period [see 6.3.1 of the PM-10 SIP Development Guideline, EPA-450/2-86-001]. For PM-2.5, the 24-hour design value is the 3-year average 98th percentile concentration [see Chapter 4, Section 1 of the Guideline on Data Handling Conventions for the PM NAAQS, EPA-454/R99-008]. The rationale for use of these design values is presented in Guideline on Data Handling Conventions for the PM NAAQS, EPA-454/R99-008. Ozone: Ozone concentration data is collected via EPA designated methods from monitoring instruments which operate continuously. The ozone design value is used for this indicator and is defined as the 3-year average of the fourth highest annual 8-hour average concentrations at a given site. The ozone design value is a scientifically acceptable method of presenting ozone trends. EPA selected the design value concept in order to reduce variability in year-to-year changes in the ozone ambient concentrations so that one could make a more confident estimate of how ozone levels are changing. Ozone sites meet the annual trends data completeness requirement if they have at least 50 percent of the daily data available for the ozone season, which varies by state, but typically runs from May through September. Eight hour ozone concentrations are presented as running averages. For more information, see Guidelines on Data Handling Conventions for the 8-hour Ozone NAAQS, EPA-454/R98-017, December 1998.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The design value indicators for PM-10 and PM-2.5 and Ozone are valuable measures of air quality trends in the border zone. The design values are valuable as indicators because they are designed to minimize temporal variability in concentrations, in particular, the variability due to meteorology. The air quality monitoring sites in the border zone were selected to address population exposure to pollution and, to a lesser extent, to reflect pollution levels within sensitive ecosystems. The data for these indicators were collected under a standard, national protocol of ambient air quality surveillance. All the sites were either part of the NAMS/SLAMS network or are considered special purpose monitors, which nonetheless follow the NAMS/SLAMS monitoring sampling design. Furthermore, all sites collect data via EPA designated methods.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The prime rationale for siting the existing PM-10, PM-2.5, and Ozone monitors in the border zone was to determine air pollution concentrations in populated areas. A secondary rationale was to supply trends information for sensitive ecosystems. Additional rural monitoring in the border zone may help scientists assess transport and ecological effects; this is increasingly important with recent findings of significant long-range transport of PM-2.5 in North America (see "Big Bend Regional Aerosol and Visibility Observational Study Final Report, September 2004," http://vista.cira.colostate.edu/improve/Studies/BRAVO/Studybravo.htm).

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Yes, the design value statistic is logically compared to the NAAQS. If the design value is below that of the NAAQS, the area is considered in attainment for a given NAAQS. Using such a robust statistic as the design value, one can track the progression of any changes with confidence to assess potential air quality threats. For more discussion about the establishment of the design value and its utility, see Guidelines on Data Handling Conventions for the 8-hour Ozone NAAQS, EPA-454/R98-017, December 1998.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

National Air Quality and Emissions Trends Report, 2003 Special Studies Edition - http://www.epa.gov/air/airtrends/aqtrnd03/ General Air Quality and National Monitoring Network - http://www.epa.gov/ttn/amtic/moninfo.html PM 2.5 Monitoring Information - http://www.epa.gov/ttn/amtic/amticpm.html Standard data documentation is available to support these data and can be accessed at: http://www.epa.gov/ttn/airs/aqs/index.html

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes, the data used to calculate this indicator is available from EPA's Air Quality System (AQS) database. Information about this database, including how it may be accessed is found at http://www.epa.gov/ttn/airs/airsaqs/.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The Ambient Monitoring Technology Information Center (AMTIC) contains information and files on ambient air quality monitoring programs (this includes information on ozone and particulate monitoring), details on monitoring methods, relevant documents and articles, information on air quality trends and nonattainment areas, and federal regulations related to ambient air quality monitoring. This information can be found at http://www.epa.gov/ttn/amtic/. The PM 2.5, PM 10 and Ozone monitoring network design for the U.S.-Mexico border used methods and approaches consistent with those used nationwide. EPA's AQS database (http://www.epa.gov/ttn/airs/airsaqs/) may be used to access monitoring information pertaining to the counties highlighted on the maps for this indicator.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The Quality Assurance (QA)/Quality Control (QC) of the national air monitoring program has several major components: the Data Quality Objective (DQO) process, reference and equivalent methods program, EPA's National Performance Audit Program (NPAP), system audits, and network reviews (Available on the Internet: www.epa.gov/ttn/amtic/npaplist.html) To ensure quality data, the SLAMS are required to meet the following: 1) each site must meet network design and site criteria; 2) each site must provide adequate QA assessment, control, and corrective action functions according to minimum program requirements; 3) all sampling methods and equipment must meet EPA reference or equivalent requirements; 4) acceptable data validation and record keeping procedures must be followed; and 5) data from SLAMS must be summarized and reported annually to EPA. Finally, there are system audits that regularly review the overall air quality data collection activity for any needed changes or corrections. Further information available on the Internet: http://www.epa.gov/cludygxb/programs/namslam.html and through United States EPA's Quality Assurance Handbook (EPA-454/R-98-004 Section 15) For ozone, There is a Quality Assurance Project Plan from each state or local agency operating a NAMS/SLAMS monitor meeting the AEPA Requirements for Quality Assurance Project Plans@, EPA QA/R-5. The quality assurance plans for specific sites are publicly available by request to the reporting agency or the corresponding EPA Regional Office. The plans are audited at least once every three years as required in 40 CFR 58, Appendix A, Section 2.5. In addition, the data repository itself (i.e. AQS) provides direct access to two of the more prominent quality assurance indicators (i.e., precision and accuracy).

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical urvey inference, no generalization is possible)?

Yes, the air quality statistics presented relate to the pollutant-specific NAAQS and comply with the recommendations of the Intra-Agency Task Force on Air Quality Indicators. A composite average of each trend statistic is used in the graphical presentations. All sites were weighted equally in calculating the composite average trend statistic. Only sites with complete data for a given year are used in calculation of indicator values. The resulting data sets are statistically balanced, allowing simple statistical procedures and graphics to be easily applied. This procedure is conservative since endpoint rates of change are dampened by the interpolated estimates. Spatial statistics and interpolation were not employed to determine concentrations in areas the monitoring network is not intended to provide coverage.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes, the underlying datasets for PM-10, PM-2.5 and Ozone found in AQS also contain Precision and Accuracy data., Two prominent quality assurance indicators.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No, the indicator is calculated from data collected via EPA designated methods. This data must meet completeness and QA/QC criteria to be included in the indicator calculation. The networks of monitors that gather the data are reviewed and approved by EPA based on their adequacy in characterizing the air pollution concentrations in a given area. The level of uncertainty is reduced to an acceptable level for the purpose of this indicator.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

No, the border monitoring network is designed to provide data for assessing public health consequences of the concentration of selected criteria pollutants. The monitors are concentrated in urban areas (not all border counties are currently part of the monitoring network), but there is also modest coverage in most rural areas. The Sampling design provides a finer scale monitoring (county level) than needed (regional and border-wide level). Therefore, sampling density is more than sufficient for the intended use. Pollutant specific guidance for establishing NAMS/SLAMS networks is provided in 40 CFR 58, Appendix D.

Indicator: Ozone Injury to Forest Plants (115)

Air pollution can have a significant cumulative impact on forested ecosystems by affecting regeneration, productivity, and species composition (EPA, 1996). In the U.S., tropospheric ozone is one of the pollutants of primary concern. Ozone injury to forest plants can be diagnosed by examination of plant leaves. Foliar injury is usually the first visible sign of injury to plants from ozone exposure and indicates impaired physiological processes in the leaves (Grulke, 2003).

The U.S. Department of Agriculture Forest Service tracks ozone injury to forest plants as part of the Forest Health Monitoring (FHM) Program (USDA 2004). The FHM Program, which is now known as Phase 3 of the Forest Inventory Analysis, examines forest plant health characteristics at ground monitoring sites across the country. Sites are selected using a systematic sampling grid, which is based on a global sampling design (White et al., 1992; Smith et al., 2003). At each site, FHM looks for damage on the foliage of multiple ozone-sensitive forest plant species. Ozone injury is cumulative over the course of the growing season, and so these examinations are conducted in July and August, when ozone injury is typically highest.

Monitoring of ozone injury to plants in the FHM program has expanded in scope over the last 10 years. In 1994, when the program began, monitoring sites were located in ten states. By 2002, the program included more than 1,000 monitoring sites in 41 states. The data presented in this indicator are based on observations collected between 1994 and 2000. The ozone damage to forest plants is classified using a four-category biosite index: no injury, low injury, moderate injury, and severe injury.

Biosite value	Bioindicator response	Assumption of risk	Possible impact	Relative air quality[2]
0 - < 5	Little or no foliar injury	None	Visible injury to highly sensitive species, e.g. black cherry	Good
5 - < 15	Light to moderate foliar injury	Low	Visible injury to moderately sensitive species, e.g. tulip poplar	Moderate
15 - < 25	Moderate to severe foliar injury	Moderate	Visible and invisible injury. Tree-level response.[3]	Unhealthy for sensitive species
≥ 25	Severe foliar injury	High	Visible and invisible injury. Ecosystem-level response.[3]	Unhealthy

[1]The categorizations of the biosite index are subjective and based solely on expert opinion
[2]Relative ozone air quality from a plant's perspective.
[3]According to the EPA's Proposed Guidelines for Ecological Risk Assessment (Federal Register 61 (175):47552-47631).

What the Data Show

"Severe injury" was not observed at any of the monitoring sites in the Rocky Mountain region, but was observed at 9% of the sites in the South, 8% of the sites in the North, and 1% of the sites in the Pacific Coast (Figure 115-1). On the other hand, monitoring sites classified as having no foliar injury were most prevalent in the Rocky Mountain region (100% of monitoring sites) and in the Pacific Coast region (97% of sites), as compared to the North region (76% of sites) and South region (77% of sites).

Indicator Limitations

- Field and laboratory studies were reviewed to identify the forest plant species in each region that are highly sensitive to ozone air pollution. Other forest plant species, or even genetic variants of the same species, may not be harmed at ozone levels that cause effects on the selected ozone-sensitive species. The forest plants evaluated differ from one region to the next; these differences might explain part of the spatial variations shown in this indicator.
- Ozone may have other adverse impacts on plants (e.g., reduced productivity) that do not show signs of visible foliar injury (EPA 1996).
- Though the FHM has extensive spatial coverage based on a robust sample design, not all forested areas in the U.S. are monitored for ozone injury.

Data Sources

The data sources for this indicator were the Forest Health Monitoring (FHM) Program database (http://www.fiaozone.net/tabular.html), National Report on Sustainable Forests - 2003, Final Draft, U.S. Department of Agriculture, Forest Service, 2002, and Coulston et al., 2004. A Preliminary Assessment of the Montreal Process Indicators of Air Pollution for the United States, *Environmental Monitoring and Assessment*, 95: 57-74.

References

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Coulston, J.W., Riitters, K.H., Smith, G.C. 2004. A preliminary assessment of the Montréal process indicators of air pollution for the United States. Environ. Monit. Assess. 95:57-74.

U.S.Environmental Protection Agency. (1996.) Air quality criteria for ozone and related photochemical oxidants. Research Triangle Park, NC: Office of Research and Development; report nos. EPA/600/AP-93/004aF-cF. 3v. Available from: NTIS, Springfield, VA; PB96-185582, PB96-185590, and PB96-185608. Available: www.epa.gov/ncea/ozone.htm.

Grulke, N.E. 2003. The physiological basis of ozone injury assessment attributes in Sierran conifers. In: Bytnerowicz, A., Arbaugh, M.J., Alonso, R. (eds.) Ozone air pollution in the Sierra Nevada: distribution and effects on forests. Elsevier Science, Ltd., New York, NY, pp 55-81.

Skelly, J.M., Davis, D.D., Merrill, W., Cameron, E.A., Brown, D.B., Dochinger, L.S. 1987. Diagnosing injury to eastern forest trees - a manual for identifying damage caused by air pollution, pathogens, insects, and abiotic stresses. NAPAP Forest Response Program, National Vegetation Survey, available from: Publications Distribution Center, Pennsylvania State University, 122 pp.

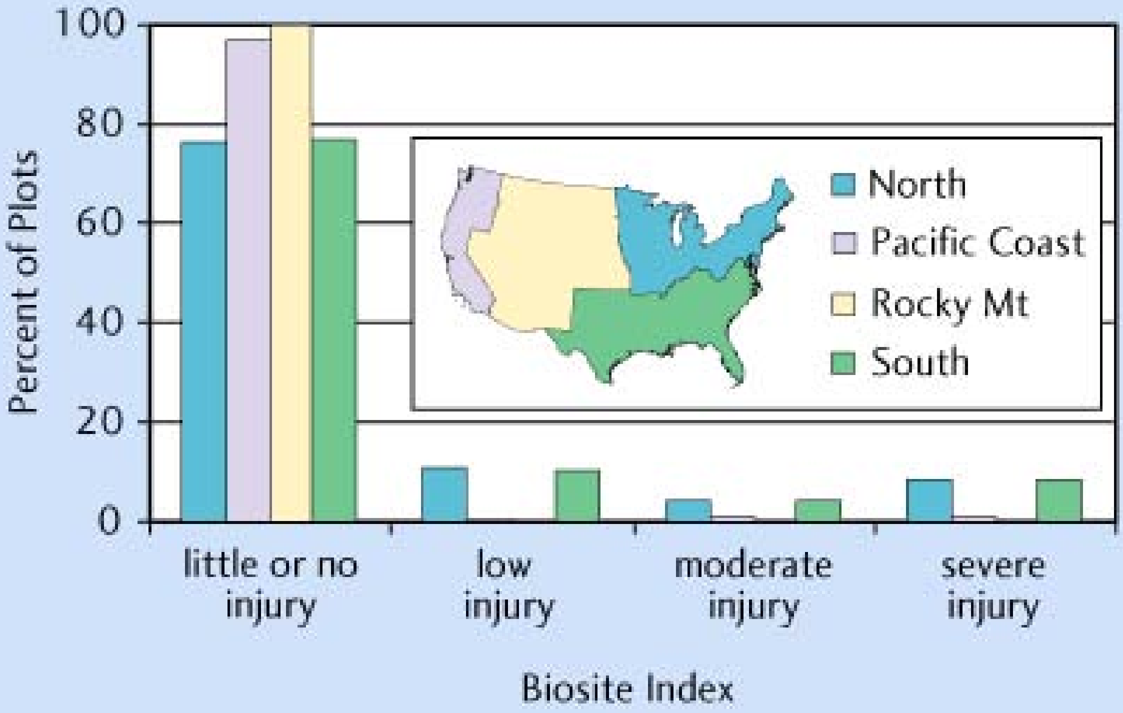
Smith, G., Coulston, J., Jepsen, E. Prichard, T. 2003. A national ozone biomonitoring program - results from field surveys of ozone sensitive plants in Northeastern forests (1994-2000). Environ. Monit. Assess. 87:271-291.

USDA Forest Service. 2004. Data Report: A Supplement to the National Report on Sustainable Forests – 2003. Washington, D.C.: USDA Forest Service.

White, D., Kimerling, A.J., Overton, W.S. 1992. Cartographic and geometric component of a global sampling design for environmental monitoring. Cartogr. Geograph. Info. Sys. 19:5-22.

Graphics

Figure 115-1: Ozone injury to trees, 1994-2000



Coverage: 32 states.

Source: USDA, Forest Service. *National Report on Sustainable Forests—2003. Final Draft.* 2002.

R.O.E. Indicator QA/QC

Data Set Name: OZONE INJURY TO FOREST PLANTS
Indicator Number: 115 (89101)
Data Set Source: http://www.fiaozone.net/datadownload.htm
Data Collection Date: 1992 - present
Data Collection Frequency: annually, 1054 biomonitoring plots in 2002
Data Set Description: Ozone injury to plants can be diagnosed by examination of plant leaves (Skelly et al., 1987; Bennett et al., 1994). Foliar injury is the first visible sign of injury to plants from ozone exposure and indicates impairment of physiological processes in the leaves (Grulke, 2003).
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Field methods for this indicator can be found at: http://www.fiaozone.net/assets/manuals/2003Final%20Distribution%20Copy%20NORTHEAST%20ozone_east_2_0.doc Each predetermined ozone-sensitive plant species with ozone injury is evaluated for the percent of the plant that is injured and the average severity of injury. For each plant located, the percentage of injured area and the severity of injury are both rated on a scale of 0 to 5. Both amount and severity estimates are confined to the exposed portion of the plant. If a plant does not have injury, it is still tallied with zeros for these measurements. The bioindicator species selected for each region are those that have been determined through field and laboratory studies to be highly sensitive to ozone air pollution. However, genetic differences within and between species can introduce uncertainty. For example, within a species, differences in genetics between individuals result in differential sensitivities to ozone. This means that often an individual of a species with severe air pollution injury may be found growing immediately adjacent to another individual of the same species with few or no symptoms.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

A systematic sampling grid, based on a global sampling design, is used as the basis for determining biomonitoring site locations for ozone plant injury assessment (White et al., 1992). A detailed discussion of the sampling design can be found in Smith et al. (2003).

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

A plot-level foliar injury indicator referred to as a Biosite Index (BI) was formulated from the amount of injury and severity ratings recorded for each plant and the numbers of plants and species evaluated at each site. A complete discussion of the derivation and robustness of the BI can be found in Smith et al. (2003). Ozone uptake by plants is greatly affected by soil moisture. Seventy percent of the variability in BI was explained by ozone concentration (expressed as the SUM06 metric) and the Palmer Drought Severity Index (PDSI) (Smith et al., 2003).

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The number of ozone biomonitoring sites has increased each year since 1994, as more states implement Forest Health Monitoring, now known as Phase 3 of Forest Inventory and Analysis (FIA). In 2000, there were 918 biomonitoring sites in 32 states. Ozone biomonitoring data for 2002 were downloaded and found to have data from 1054 sites in 41 states. Ozone injury is cumulative over the course of the growing season. Thus, more ozone injury can be observed on plants later in the season, prior to the onset of autumnal senescence. Quantifying ozone injury on the FIA ozone plots is limited to an evaluation window from late-July to mid-August. The evaluation window for crews in the Northern Region (NO) begins 28 July and extends through 22 August. In the Southern Region (SO), the window is open from 21 July through 22 August. The ozone injury evaluations are generally completed over a 5 to 20 day period during the sampling window depending on the size of the State and the number of crews dedicated to the ozone survey. During the evaluation window, all ozone sites on the ozone biomonitoring grid are evaluated for ozone injury. The same sites are evaluated every year.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The ozone biomonitoring sites are selected in openings near the FIA plot. Ozone biomonitoring sites are selected purposively to target areas where ozone-sensitive plant species occur. The opening should be greater than three acres (1.2 hectares) with less than 50% crown closure. More than three ozone-sensitive plant species should be found, with at least 30 plants of each of three species; 10-30 plants of additional species. Soil conditions should have low drought potential and good fertility. No recent (1-3 years) disturbance should be evident and no obvious signs of soil compaction.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

In some States with a particular interest in air quality, foliar injury data are also collected from ozone sites on an intensified ozone grid. These supplementary ozone sites are standardized for certain site characteristics that influence ozone uptake by sensitive plants (Heck 1968; Krupa and Manning 1988), and are often co-located with physical air quality monitors. They are intended to improve the regional responsiveness of the ozone indicator. Biosite categories represent a relative measure of plant-level response to ambient ozone exposure. Injury severity is an estimate of the mean severity of symptoms on injured foliage (0 = no injury; 1=1-6%; 2 = 7- 25%; 3 = 26-50%; 4 = 51-75%; 5 >75%). This rating system is applied across all regions. In response to whether the expected baseline for ozone injury is zero, in the absence of any anthropogenic precursors for ozone formation, there is a natural background level for ozone. Most estimates of what that background concentration is fall below the levels that cause visible injury on sensitive plant species that were fumigated in controlled exposure studies. However, that is not to say that there are no physiological effects of background ozone on plants.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Complete sampling and analytical procedures for this indicator can be found in the USDA Forest Service's FIA field methods guide.
http://www.fiaozone.net/assets/manuals/2003Final%20Distribution%20Copy%20NORTHEAST%20ozone_east_2_0.doc

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Ozone biomonitoring data sets dating back to 1997 through 2002 are available for download as ASCII text or SAS data set files at the following URL: http://www.fiaozone.net/tabular.html. The contact person for this indicator is the National Ozone Bioindicator Leader: Dr. Gretchen Smith University of Massachusetts Department of Forestry and Wildlife Management Holdsworth Natural Resource Center Amherst, MA 01003-4210 Phone (413) 545-1680 Fax (413) 545-4358 advisor@fiaozone.net

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Descriptions of the survey design are clear, complete and sufficient to enable the survey to be reproduced, except for the fact that biomonitoring plot locations are confidential. A similar survey could be conducted but not at the same locations as the FIA ozone biomonitoring network.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Voucher specimens (pressed leaves with symptoms) are collected for each species for proper symptom identification. For each voucher, injury type and location codes are recorded to fully describe the injury observed in the field. Additional quality control measures include field audits and remeasurement of 10% of the biomonitoring sites. Complete quality assurance and quality control measures can be found in the FIA field methods guide at: http://www.fiaozone.net/assets/manuals/2003Final%20Distribution%20Copy%20NORTHEAST%20ozone_east_2_0.doc

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

The biosite index was used along with nine other air pollution indicators in cluster analyses to characterize forest types with respect to air pollution exposure (Coulston et al., 2004). The indicators included the average and coefficient of variation (CV) of the biosite index, ozone exposure index, and nitrate, ammonia, and sulfate deposition levels. Cluster scores showed relative differences between forest types based on the air pollution indicators. Forest types in the eastern U.S. had higher relative air pollution exposure scores than western forest types. The oak-hickory forest type, which covers much of the North and South RPA regions, had the highest relative air pollution exposure score and had a relatively low CV score. Other eastern forest types of high exposure scores and relatively low CV scores were loblolly-shortleaf pine, elm-ash-cottonwood, and oak-pine. Of the western forest types chaparral had the highest exposure score. Additionally, western hardwoods, pinyon-juniper, fir-spruce, ponderosa pine, and lodgepole pine exhibited high exposures scores, but also had high CV scores. High CV scores would indicate that there may pockets of high and/or low exposure across the range of these forest types. The larch, redwood, and western white pine forest types had both low exposure and low CV scores. The larch and western white pine have a small geographic distribution, limited to mostly northeastern Washington, northern Idaho, and northwestern Montana. The redwood forest type is limited to mostly coastal areas of northern California.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Quality assurance / quality control data are available upon request. Contact Brian Cordova at cordovab@unlv.nevada.edu. Complete quality assurance and quality control measures can be found in the FIA field methods guide at: http://www.fiaozone.net/assets/manuals/2003Final%20Distribution%20Copy%20NORTHEAST%20ozone_east_2_0.doc

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

The recognition of ozone injury symptoms in the field is not an exact science, and many other foliar injury symptoms can be mistaken for ozone injury. Voucher specimens are sent to a national expert for verification of injury.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The exact coordinates of each ozone biomonitoring plot are confidential. Thus, matching up ozone biomonitoring data with other explanatory or independent variables that would aid in the interpretation of spatiotemporal trends in ozone injury is a challenge.

Indicator: Ozone Levels over North America (015)

Ozone is a gas present throughout the Earth's atmosphere. The environmental and human health implications of ground-level ozone are very different from those of ozone higher in the atmosphere, leading to the maxim: "Good up high, bad nearby" (EPA, 2003). In the troposphere, the part of the atmosphere closest to the Earth's surface, ozone poses significant health and ecological risks, but higher in the atmosphere, a thin natural layer of ozone shields and protects the Earth's surface from the sun's harmful ultraviolet (UV) rays. This ozone layer is found more than 10 miles above the Earth's surface, in the portion of the atmosphere known as the stratosphere. Releases of ozone-depleting substances—chemicals of human origin, such as chlorofluorocarbons and halons (see indicator 117) have damaged (thinned or depleted) the ozone layer. Stratospheric ozone depletion allows more UV radiation to reach the ground, which may in turn lead to more cases of skin cancer, cataracts, and other health problems (EPA, 1996).

Data mapped for this indicator are derived chiefly from the Total Ozone Mapping Spectrometer (TOMS), flown on NASA's Nimbus-7 satellite. The TOMS measures amounts of backscattered UV radiation at various wavelengths. Backscattered radiation levels at wavelengths where ozone absorption does and does not take place are compared with radiation directly from the sun at the same wavelengths, allowing derivation of the total amount of ozone in the Earth's atmosphere. Data are reported in Dobson Units (DU) which measure how thick the ozone layer would be if compressed in the Earth's atmosphere (at sea level and at 0°C.) One DU is defined to be 0.01 mm thickness at standard temperature and pressure.

What the Data Show

Figure 015-1 shows that total ozone measurements from the four monitoring stations declined during the period 1979 to 1993, after which they leveled off, though at a level lower than pre-1980. The large annual variation shown in each of the four cities is a result of ozone transport processes that cause increased levels in the winter and spring and lower ozone levels in the summer and fall at these latitudes

According to the most recent international scientific assessment, the global-average total column ozone during the period 1997 to 2001 was about 3 percent below average pre-1980 values (WMO, 2003). Trends over North America reflect this global phenomenon.

Indicator Limitations

- NOAA collects data on total column ozone using a combination of surface (Dobson Spectrophotometer) and satellite (Total Ozone Mapping Spectrometer (TOMS) and Solar Backscatter Ultraviolet (SBUV)) instruments. Once seasonal variance is removed all three instruments show very good agreement. SBUV instruments can produce data only for daylight-viewing conditions, so SBUV data are not available at polar latitudes during winter darkness.

Data Sources

Data provided by the National Oceanic and Atmospheric Administration (NOAA), 2003.
http://www.cpc.ncep.noaa.gov/products/stratosphere/winter_bulletins/nh_03-04/

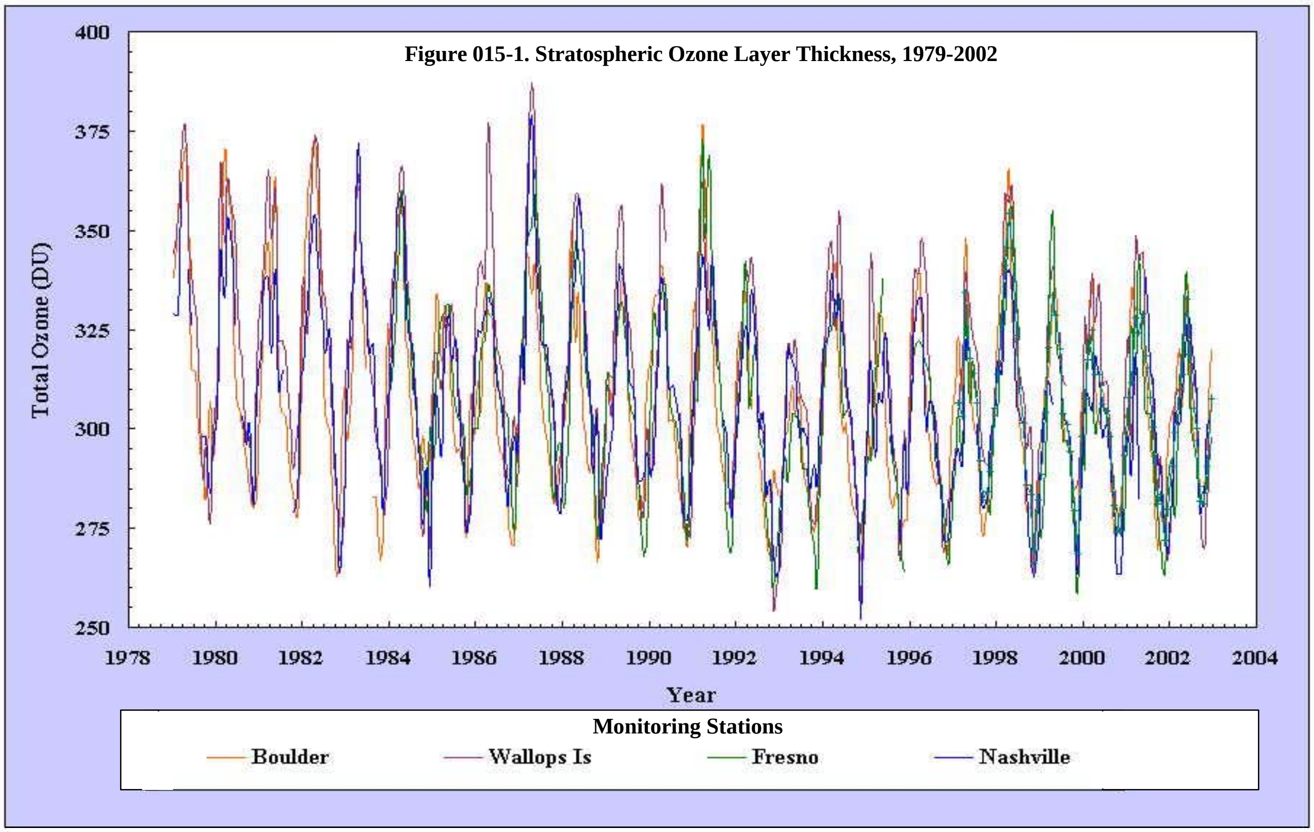
References

World Meteorological Organization, et al. Scientific Assessment of Ozone Depletion: 2002. Geneva, Switzerland. March 2003.

EPA, 1993. Ozone: Good Up High Bad Nearby, EPA 451/K-03-001. Washington, DC; US Environmental Protection Agency, Office of Air and Radiation, June 2003.
U.S. Environmental Protection Agency.

EPA, 1996. Air Quality Criteria for Ozone and Related Photochemical Oxidants, EPA 600-P-93-004F-cF. Research Triangle Park, NC; US Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, July 1996.

Graphics



R.O.E. Indicator QA/QC

Data Set Name: OZONE LEVELS OVER NORTH AMERICA
Indicator Number: 015 (89075)
Data Set Source: NOAA Climate Prediction Center
Data Collection Date: 1979-2002
Data Collection Frequency: ongoing
Data Set Description: Ozone Levels over North America
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Data mapped for this indicator are derived chiefly from the Total Ozone Mapping Spectrometer (TOMS), flown on NASAs Nimbus-7 satellite. The TOMS measures amounts of backscattered UV radiation at various wavelengths. Backscattered radiation levels at wavelengths where ozone absorption does and does not take place are compared with radiation directly from the sun at the same wavelengths, allowing scientists to derive a total ozone amount in the Earth s atmosphere. The data for this indicator are presented in Dobson Units (DU) which measure how thick the ozone layer would be if compressed in the Earth s atmosphere (at sea level and at 0°C.) One DU is defined to be 0.01 mm thickness at standard temperature and pressure.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

NASA's most visible and best-known ozone research program is the Total Ozone Mapping Spectrometer (TOMS). Since the launch of the first TOMS aboard the Nimbus-7 polar-orbiting satellite in 1978, NASA has provided scientists with reliable, high-resolution daily maps of global ozone levels. Managed by NASA's Goddard Space Flight Center (GSFC), Greenbelt, Md., TOMS is a primary source of data on global ozone day-to-day variability and long-term trends. Ozone-depletion data from TOMS underpins several international agreements to phase out the use of CFCs and other ozone-depleting chemicals. A long-term, consistent record of ozone levels is essential to understanding and predicting ozone depletion. To ensure that ozone data will be available, NASA has been continuing the TOMS program using U.S. and international launches. On Aug. 15, 1991, the former Soviet Union launched a Meteor-3 satellite carrying a TOMS instrument provided by NASA. The Meteor-3/TOMS instrument ensured continuity of data when Nimbus-7/TOMS ceased operating in May 1993. The Japanese Advanced Earth Observations Satellite (ADEOS) carried a fourth TOMS into orbit when it launched in 1996.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The most recent authoritative assessment of the Earth s stratospheric ozone is the Scientific Assessment of Ozone Depletion: 2002 (Scientific Assessment Panel, 2003), conducted under the auspices of the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO).

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Ozone in the stratosphere protects humans and ecosystem from harmful UV-radiation, is a key aspect of air quality that affects humans an ecosystems. The monitoring data cover the entire range of situations in which people and ecosystems are exposed to natural UV radiation.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The TOMS data cover the entire earth surface, so UV-B exposure can be monitored for any UV-B sensitive system, subject to the minimum resolution of the sensor.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

No.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Nimbus-7 was launched on October 24, 1978; measurements began about a week later. For the purpose of obtaining daily high-resolution global maps of atmospheric ozone, TOMS measured the solar irradiance and the radiance backscattered by the Earth’s atmosphere in six select wavelength bands in the ultraviolet. TOMS scanned in 3-degree steps to 51 degrees on each side of the subsatellite point, in a direction perpendicular to the orbital plane. Consecutive cross-scans overlapped, creating a contiguous mapping of ozone. The Nimbus-7 TOMS Version 7 User's Guide contains information about the data products derived from the measurements made by the Total Ozone Mapping Spectrometer (TOMS) experiment aboard the Nimbus 7 satellite. It discusses the calibration of the instrument, the algorithm used to derive ozone values from the measurements, the uncertainties in the data, and the organization of the data products. The data begin October 31, 1978 and end May 6, 1993. These data are archived at the Goddard Space Flight Center Distributed Active Archive Center (DAAC). Since the previous release of TOMS data, continuing study of the TOMS data products and the process of deriving them has led to many improvements in the generation the data. A copy of the Nimbus-7 TOMS Version 7 User's Guide can be downloaded from the following web-site - http://toms.gsfc.nasa.gov/n7toms/n7sat.html.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Data from Nimbus-7 TOMS (11/1978 through 05/1993) and Earth Probe TOMS (08/1996 through 08/2003) have been reprocessed and were distributed at the 2004 Quadrennial Ozone Symposium in June 2004. A 2 DVD set contains data and images from both instruments for all of the TOMS products: ozone, aerosol, reflectivity, and erythemal UV. Copies of the DVD's can be obtained from the Goddard Space Flight Center's Distributed Active Archive Center (DAAC)- http://daac.gsfc.nasa.gov/data/dataset/TOMS/DVD-ROMs. Version 8 data are now available for the entire Nimbus-7 data record (November 1978 through May 1993) and for the Earth Probe data record from August 1996 through August 2003 via anonymous ftp as zip files. Each zip file contains the compressed individual files - http://daac.gsfc.nasa.gov/www/get_data.shtml.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Launched on 25 October 1978 from Vandenberg Air Force Base, California, the Nimbus-7 spacecraft was the last in a series of operational weather satellites operated by the US National Oceanic and Atmospheric Administration (NOAA) and the US National Aeronautics and Space Administration (NASA). Nimbus-7 was placed in a sun-synchronous orbit at an altitude of 955 km. Equatorial crossings are local noon for ascending node and local midnight for descending node. Spacecraft inclination is 99.1 degrees, with a leeward latitude of 80.77 degrees. Orbital period is 104.15 minutes, and consecutive equator crossings are separated by 26.1 degrees longitude. The communications and data handling subsystem, which manages all information flow for the Nimbus-7 platform, is composed of the S-band communications system and tape recorder subsystem. The S-band communication system includes the S-band command and telemetry system , the data processing system and the command clock. The S-band command and telemetry system consists of two S-band transponders, a command and data interface unit, four earth view antennas, a sky view antenna, and two S-band transmitters (2211 MHz). Commands are transmitted to the observatory by pulse code modulation, phase-shift keying/frequency modulation/phase modulation of the assigned 2093.5 MHz S-band uplink carrier. Stored command capability provides for command execution at predetermined times. Additional information is available at http://toms.gsfc.nasa.gov/n7toms/nimbus7tech.html. The communications and data handling subsystem, which manages all information flow for the Nimbus-7 platform, is composed of the S-band communications system and tape recorder subsystem. The S-band communication system includes the S-band command and telemetry system , the data processing system and the command clock. The S-band command and telemetry system consists of two S-band transponders, a command and data interface unit, four earth view antennas, a sky view antenna, and two S-band transmitters (2211 MHz). Commands are transmitted to the observatory by pulse code modulation, phase-shift keying/frequency modulation/phase modulation of the assigned 2093.5 MHz S-band uplink carrier. Stored command capability provides for command execution at predetermined times. Additional information is available at http://toms.gsfc.nasa.gov/n7toms/nimbus7tech.html

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The Nimbus-7 TOMS Version 7 User's Guide contains information about the data products derived from the measurements made by the Total Ozone Mapping Spectrometer (TOMS) experiment aboard the Nimbus-7 satellite. It discusses the calibration of the instrument, the algorithm used to derive ozone values from the measurements, the uncertainties in the data, and the organization of the data products. A description of the Dobson Spectrophotometer's accuracy is available at: http://www.cmdl.noaa.gov/ozwv/dobson/papers/report13/report13.html.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Not Applicable.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

A comprehensive study of the instrument properties and their variations with time has been made, producing a more accurate derivation of radiances from the raw instrument counts. Improvements have been made to the input physical data, the treatment of physical processes, and the parameterizations of atmospheric conditions used in the radiative transfer calculations that are part of the algorithm. The process of deriving ozone and reflectivity has been modified to incorporate a linear correction for wavelength dependence in the reflectivity, other wavelength-dependent physical effects, or wavelength-dependent errors. The resulting Version 7 TOMS data have a long-term 2s calibration uncertainty of ±1.5 percent in total ozone over 14.5 years. In addition, a number of local anomalies in the earlier data have been eliminated. More details can be found in the Nimbus-7 TOMS Version 7 User's Guide.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

TOMS provides no data during nighttime or during the longer periods of darkness in polar regions.

Indicator: Primary Particulate Matter Emissions (008b)

Particulate matter (PM) is the general term used to describe solid particles and liquid droplets found in the air. The composition and size of these airborne particles and droplets vary significantly: some particles are large enough to be seen as dust or dirt, while others are so small they can be seen only using a powerful microscope. Two size ranges, known as PM10 and PM2.5, are widely monitored, both at major emissions sources and in the ambient air. PM10 includes particles that have aerodynamic diameters less than or equal to 10 microns (µm), approximately equal to one-seventh the diameter of human hair. PM2.5 is the subset of PM10 particles that have aerodynamic diameters less than or equal to 2.5 µm. Particles within the two size ranges exhibit significantly different behavior in the atmosphere. PM2.5, or fine particles, can remain airborne for long time frames and travel hundreds of miles. Coarse particles, or the subset of PM10 that is larger than 2.5 µm, do not remain airborne as long and their spatial impact is typically limited because they tend to deposit to the ground in the downwind areas of emissions sources. Larger coarse particles are not readily transported across urban or broader areas because they are generally too large to follow air streams and they tend to be removed easily by impaction on surfaces. In short, as the particle size increases, the amount of time the particles remain airborne decreases. The indicator “Ambient Concentrations of PM” describes the way PM can harm human health and the environment (EPA 2004).

PM can be emitted directly or formed in the atmosphere. “Primary” particles refer to those that emissions sources release directly into the air. These include dust from roads and soot from combustion sources. In general, coarse PM is composed largely of primary particles. “Secondary” particles, on the other hand, are formed in the atmosphere from chemical reactions involving primary gaseous emissions; thus, these particles form at locations distant from the sources that release the precursor gases. Examples include sulfates formed from sulfur dioxide emissions from power plants and industrial facilities and nitrates formed from nitrogen oxides released from power plants, mobile sources, and other combustion sources. Unlike coarse PM, a much greater portion of fine PM (or PM2.5) contains secondary particles (EPA 2004).

This indicator tracks trends in annual average primary PM emissions data tracked by the National Emissions Inventory (NEI). For PM, the NEI tracks emission rate data, both measured and estimated, for primary particles only Because secondary particles are not released directly from stacks, the NEI instead tracks the precursors that contribute to formation of secondary particles. These precursors include nitrogen oxides (Indicator “Nitrogen Oxide Emissions”) and sulfur dioxide (Indicator “Sulfur Dioxide Emissions”). The NEI is a composite of data from many different data sources including industry and numerous state, tribal, and local agencies. Different data sources use different data collection methods, and many of the emissions data are estimates rather than actual measurements. Emissions are tracked for stationary point and non-point sources as well as onroad and non-road mobile sources. NEI data have been collected since 1990 and cover all 50 states and their counties, D.C., the U.S. territories of Puerto Rico and Virgin Islands, and some of the territories of federally-recognized American Indian nations. Data are presented only for 1990 and the years from 1996 forward because although data are available for 1991 – 1995, they have not been updated and comparisons of these data with those from other inventory years could lead to incorrect trends assumptions. Inventory years 1990 and from 1996 forward are up to date.

What the Data Show

According to NEI data, national total PM10 emissions from anthropogenic sources (or sources of human origin), excluding wildfires and prescribed burnings, decreased by 6 percent between 1990 and 2002, from 3,215,903 to 3,011,406 tons (Figure 008b-1). National total PM2.5 emissions from anthropogenic sources (or sources of human origin), excluding wildfires and prescribed burnings, increased by 4 percent between 1990 and 2002, from 2,325,914 to 2,426,060 tons (Figure 008b-2).

The four source categories in the figures include: 1) "fuel combustion" which includes emissions from power plants, industrial, commercial and institutional sources as well as residential heaters and boilers, 2) "industrial and other processes" which includes large point sources such as refineries and smelters as well as smaller sources such as drycleaners and service stations, 3) "on road vehicles" which includes cars, trucks, buses, and motorcycles and 4) "non-road vehicles and engines" such as farm and construction equipment, lawnmowers, chainsaws, boats/ships, snowmobiles, aircraft, and others. In recent years, the largest source of PM emissions in both size categories has been fuel combustion followed by industrial and other processes.

Trends in PM10 and PM2.5 emissions varied across the ten EPA Regions between 1990 and 2002. Seven of the Regions showed a net decrease in PM10 emissions while the other three (Regions 3, 4, and 8) registered net increases, the most substantial being in Regions 3 and 4. PM2.5 emissions increased in half the Regions during the 1990-2002 period. Trends for PM2.5 were similar to those for PM10 with Regions 3 and 4 once again showing the greatest net increases.

Indicator Limitations

- Although PM emissions trends have been generated using well-established estimation methods, the data generally reflects estimates based on empirical and engineering models and not actual measurement of primary PM emissions. Some point sources have conducted testing for PM10 and PM2.5.
- The methodology for estimating emissions is continually reviewed and sometimes changes (e.g., the inclusion of "condensables" in 1999); emissions data presented in this indicator are organized into source categories and subsets of PM to minimize the extent to which methodological changes would bias the trend analyses.
- This indicator tracks only primary PM emissions, which do not account for formation of secondary particles from reactions involving precursor gases. Emissions relevant to secondary particle formation include nitrogen oxides (Indicator "Nitrogen Oxide Emissions") and sulfur dioxide (Indicator "Sulfur Dioxide Emissions").
- Not all states and local agencies-provide the same data or level of detail for a given year.

Data Sources

U.S. Environmental Protection Agency. National Emissions Inventory - http://www.epa.gov/ttn/chief/net/neidata.html

References

Interagency Monitoring of Protected Visual Environments Network and EPA Speciation Network, 2002

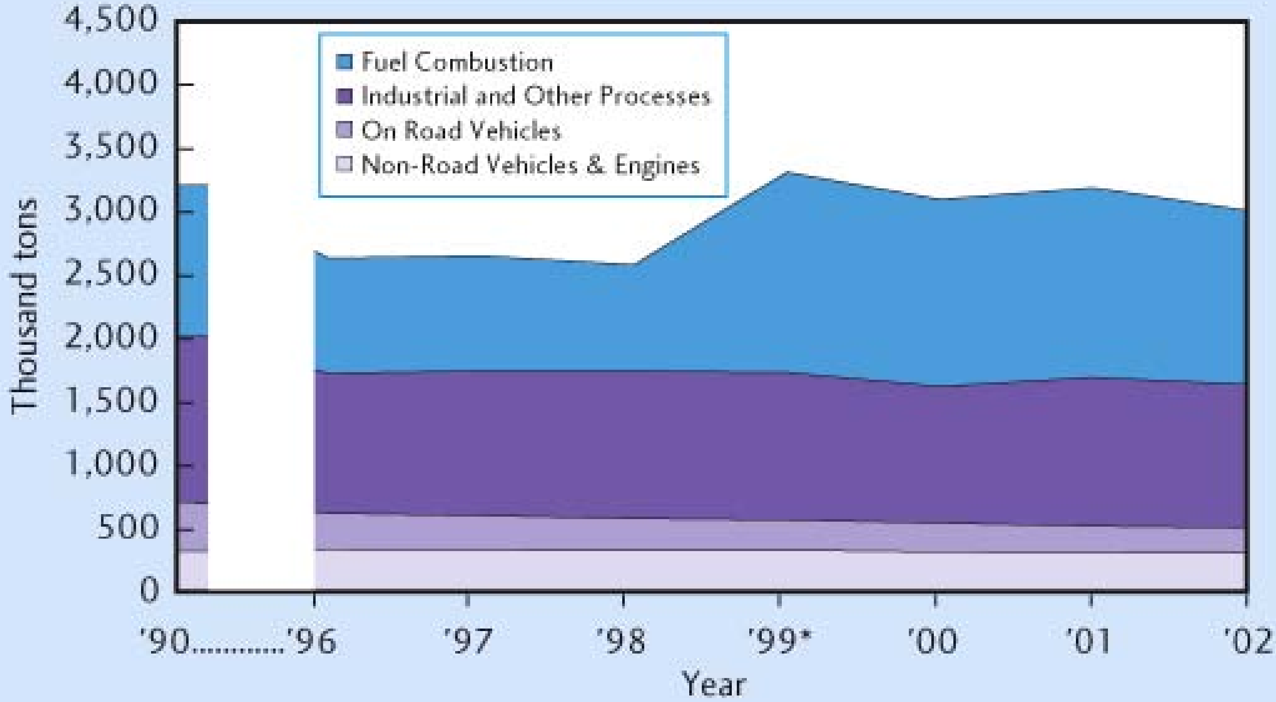
U.S. Environmental Protection Agency. 2003. Latest Findings on National Air Quality – 2002 Status and Trends, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

U.S. Environmental Protection Agency. 2003. National Air Quality and Emissions Trends Report - 2003 Special Studies Edition, EPA 454/R-03-005. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, September 2003.

U.S. Environmental Protection Agency. 2004. The Particle Pollution Report, EPA 454/R-04-002. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, December 2004.

Graphics

Figure 008b-1: National PM_{10} emissions, 1990 and 1996-2002

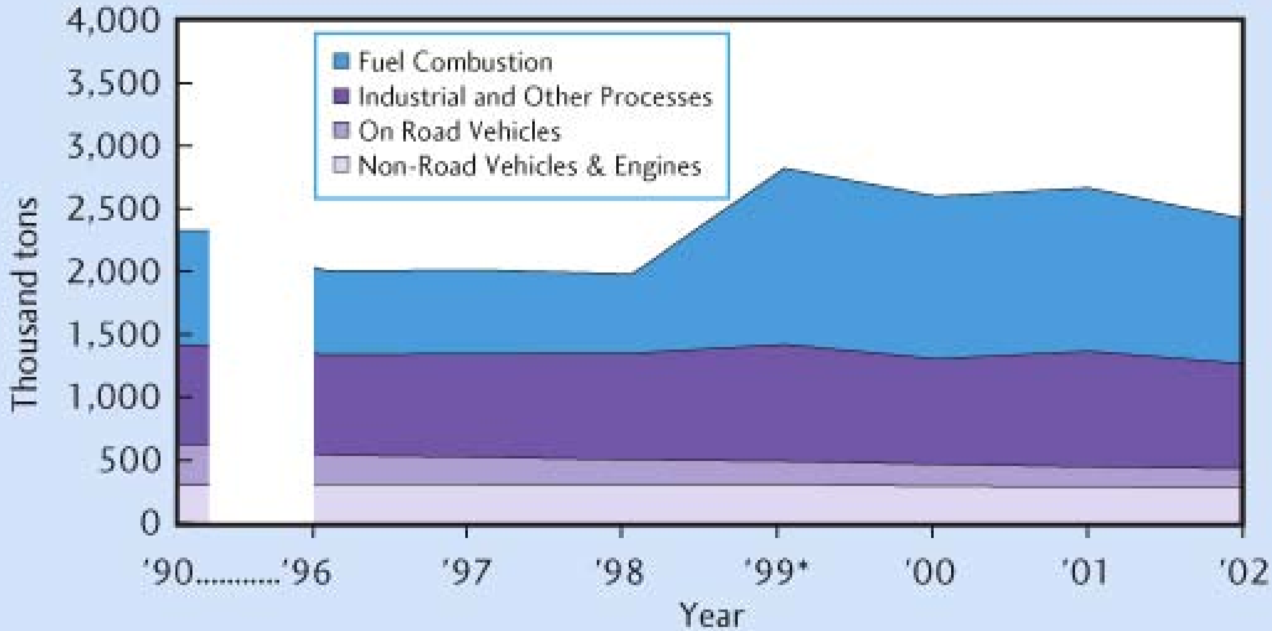


* Starting in 1999, the emission estimation methodology was changed to include emissions from "condensible" particulate matter.

Source: National Emissions Inventory (NEI).

Note: data are presented for 1990 and 1996-2002, as datasets from these inventory years are all fully up-to-date. Data are available for inventory years 1991–1995, but these data have not been updated to allow comparison with data from 1990 and 1996–2002.

Figure 008b-2: National $PM_{2.5}$ emissions, 1990 and 1996-2002

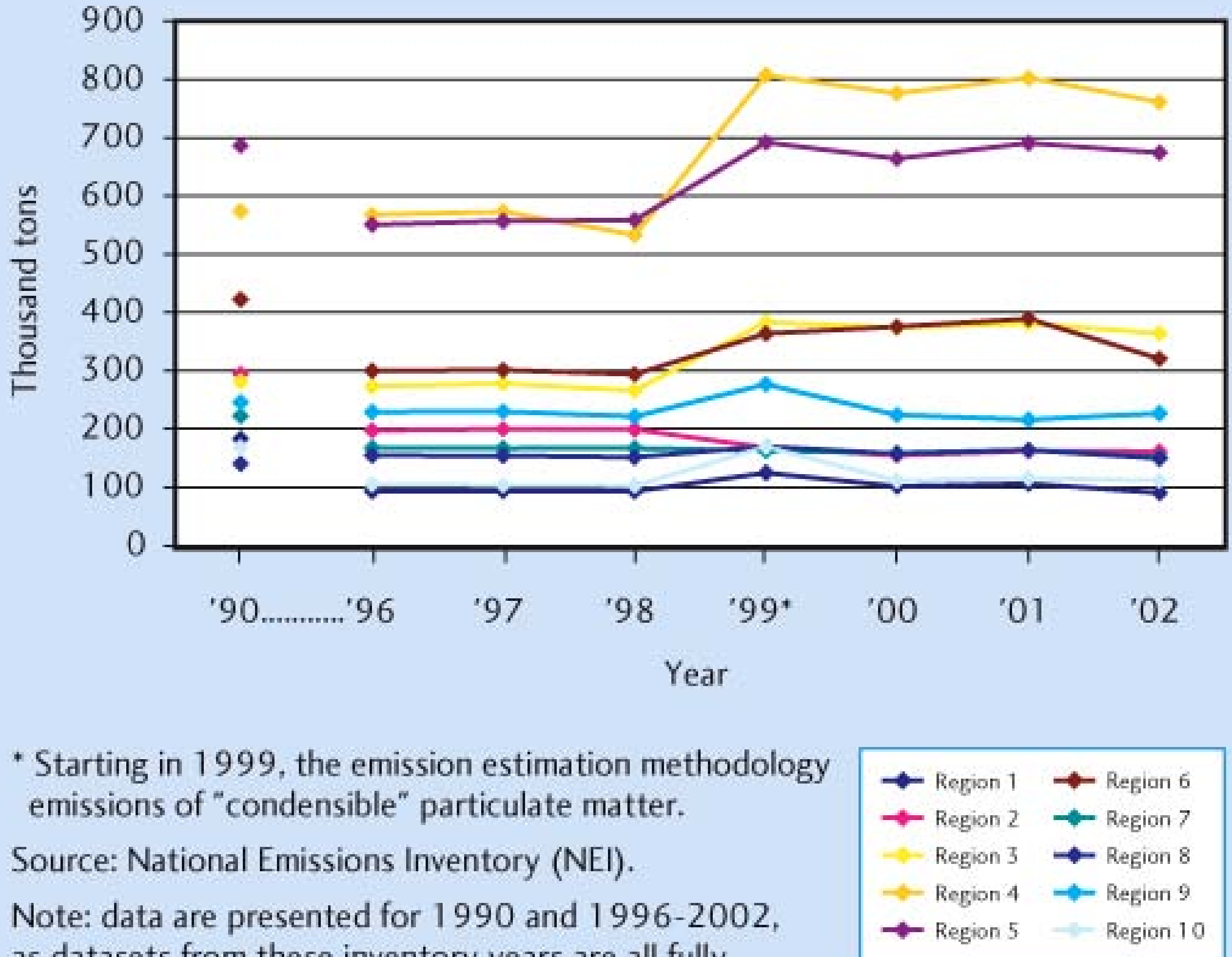


* Starting in 1999, the emission estimation methodology was changed to include emissions from "condensible" particulate matter.

Source: National Emissions Inventory (NEI).

Note: data are presented for 1990 and 1996–2002, as datasets from these inventory years are all fully up-to-date. Data are available for inventory years 1991–1995, but these data have not yet been updated to allow comparison with data from 1990 and 1996–2002.

Figure 008b-3: PM_{10} emissions by EPA region, 1990 and 1996-2002

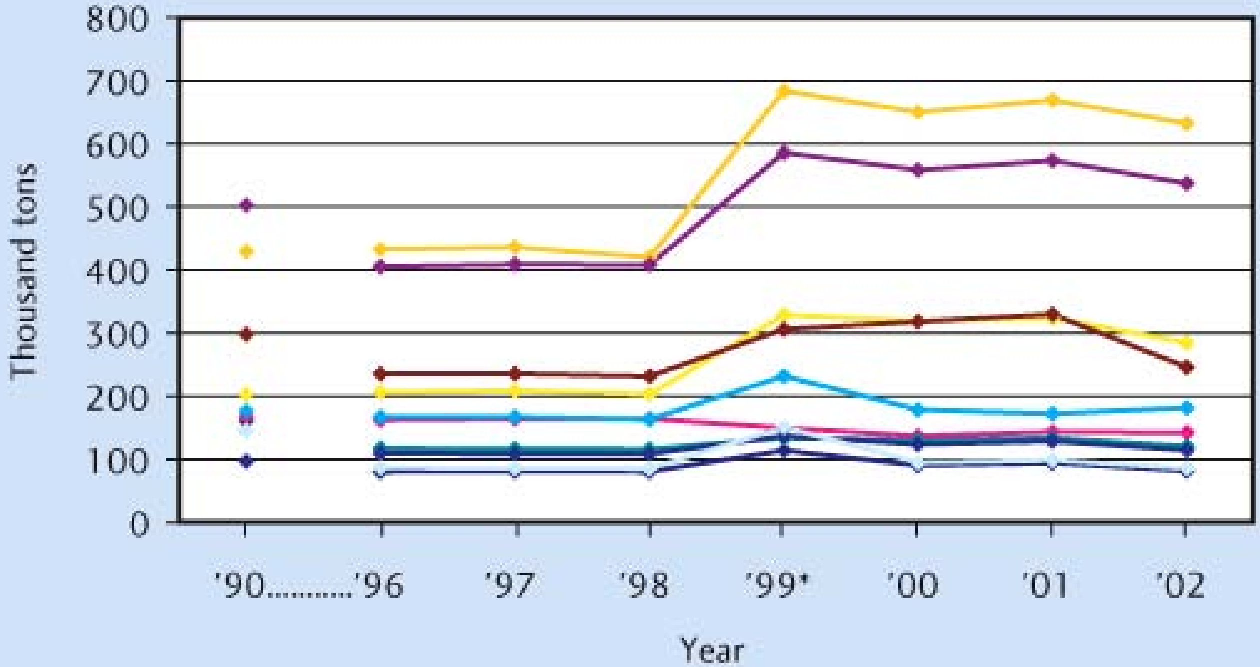


* Starting in 1999, the emission estimation methodology emissions of "condensible" particulate matter.

Source: National Emissions Inventory (NEI).

Note: data are presented for 1990 and 1996-2002, as datasets from these inventory years are all fully up-to-date. Data are available for inventory years 1991–1995, but these data have not been updated to allow comparison with data from 1990 and 1996–2002.

Figure 008b-4: $PM_{2.5}$ emissions by EPA region, 1990 and 1996-2002



* Starting in 1999, the emission estimation methodology emissions of "condensible" particulate matter.

Source: National Emissions Inventory (NEI).

Note: data are presented for 1990 and 1996-2002, as datasets from these inventory years are all fully up-to-date. Data are available for inventory years 1991–1995, but these data have not been updated to allow comparison with data from 1990 and 1996–2002.

R.O.E. Indicator QA/QC

Data Set Name: PM EMISSIONS
Indicator Number: 008c (89082)
Data Set Source: EPA National Emissions Inventory
Data Collection Date: ongoing PM2.5 1999-pres pm10 1980-present
Data Collection Frequency: varies annually-triennially
Data Set Description: PM Emissions (PM2.5 & PM10)
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. While the NEI is a composite of data from many different data sources and methods, most of which are estimates instead of actual measurements with associated precision and accuracy, the methods are widely accepted as technically valid. These methods are considered largely sufficient in their application to derive the indicator data and conclusions presented to the typical user of the ROE. The NEI contains annual emissions (units = tons/year) of the criteria pollutants and the hazardous air pollutants (HAPs) noted in the Clean Air Act Amendments of 1990 (CAAA). The methods used to develop the NEI pollutant data vary by source sector and involve multiple data sources. A general description of methods by source sector is included below. Source emissions can be measured using monitoring equipment or estimated by using emission factors and emission process activity levels. Mathematical models may be used to characterize and simulate emissions that are influenced by several variables. For most source types, estimation techniques are the most practical. The NEI emissions are grouped into four main source sectors: Point sources and NonPoint sources (these are also referred to as stationary sources) and Onroad Mobile and Nonroad mobile sources (these are referred to as mobile sources). The Point source sector contains data on individual industrial, commercial and institutional facilities and is further divided into two subsectors: Electric Generating Units (EGUs) and NonEGUs. For the NEI sector data that is collected from state and local agencies - they either gather the data from their facilities or estimate the emissions themselves, using average and industry-specific emission factors. Some of the techniques they may use to generate their point and nonpoint estimates are referenced in a guidebook of methods which is endorsed by the EPA and the state and local agencies (STAPPA/ALAPCO). The guidebook of methods is located on http://www.epa.gov/ttn/chief/eiip/techreport/. Depending on the source sector and the pollutants of interest, the EPA uses other data sources in addition to the data received by the state and local agencies. Those other data sources, where applicable, are generally described below by sector, and identified specifically in the EPA s Preparation Plan for the 2002 NEI, located on http://www.epa.gov/ttn/chief/net/2002inventory.html. In addition to identifying the data sources, the NEI 2002 Preparation Plan also describes the EPA's current method of quality checking the different data sources, and blending and merging among them, as well as augmenting data in order to complete the data set over space and time for specific source sectors and pollutants. The EPA Preparation Plan for the 1999 NEI (http://www.epa.gov/ttn/chief/net/nei_plan_feb2001.pdf) describes the data sources and process used to compile the 1999 HAP data which is included in the indicator. There is a triennial development effort and focus on compiling data for the NEI which results in the most complete national emissions inventory data every third year. For the criteria emissions in the NEI, data is also developed for the years in between the 3-year inventory cycles. For some sectors and pollutants, the methods used may be the same as those applied for the 3-year inventory, or the data may be extrapolated from the most recent third year inventory using economic projections or more simply as a mathematical interpolation between previous and subsequent years of record. While the NEI is a composite of data from many different data sources and methods, most of which are estimates instead of actual measurements with associated precision and accuracy, the methods are widely accepted as technically valid. These methods are considered largely sufficient in their application to derive the indicator data and conclusions presented to the typical user of the ROE.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

There is not a sampling design per se for the overall NEI data development project, at least not in the typical terms of a statistical sampling design. The data methods are predominantly based on estimation techniques rather than measurement techniques with associated precision and accuracy and standard error. For most sector data, emission factors are used with average emission process rates and average activity indicators to estimate typical emissions expected from similar processes in different geographical areas. Emission factors typically are based on emission testing or other sampling observations of sources and are generally developed and revised as need arises and more data becomes available. Highway vehicle emissions factors, however, are based on relatively recent research-driven sampling approaches that are documented in information collection plans implemented by the EPA s Office and Transportation and Air Quality Planning (http://www.epa.gov/otaq/ap42.htm). For onroad mobile sources, estimates are made by month or by season to account for typical temperatures and fuel properties. Estimates of vehicle miles traveled are based on the United States Department of Transportation (US DOT) Highway Performance Monitoring System, which makes use of a formal sample panel of roadway segments. Like onroad mobile sources, emissions from some other processes are estimated for time periods less than annual. As an example, pollutant emissions for seasonal processes are estimated for only a portion of the year in which they occur (i.e., winter burning season). The NEI attempts to capture the full universe of large point source facilities, which are closely monitored and located individually by the state and local agencies. Most Point EGU emissions are individually measured with continuous monitoring devices. These data are summarized to annual average emissions for all 50 states and their counties, D.C., the U.S. territories of Puerto Rico and Virgin Islands, and as available, for some of the territories of federally-recognized American Indian nations, and are widely used and accepted as an indicator of national and regional emission trends over time.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The annual emissions are directly estimated in most cases, or are simply totaled from monthly or seasonal estimates - there is no transformation.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The NEI is designed to explicitly answer the question posed in the ROE. This indicator estimates emissions from all anthropogenic sources of a primary air pollutant.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The emission estimates that comprise the NEI are non-specific for sensitive populations or ecosystems. Rather, the data are specific for types of emission processes and as such, are representative of how much and where those process emissions occur by county for the nonpoint sources and by individual facility location for the point sources.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator(s) directly addresses changes in air pollutant emissions from year-to-year and the contributions of various types of emissions sources, by county, and for every state. Air pollutant emissions are a reliable gauge of impact on the environment and when considered along with air quality transport and transformation issues, are the foundation for air quality analysis, including health indicators. Emission reductions generally indicate positive impact on air quality. Average annual pollutant emission trends over time may also reference a specific year or years in the time series, during which emission reductions were realized due to previous year implementation of federal, regional, or local control and compliance programs. There are no thresholds or ranges of values associated with safe levels of emissions for this indicator.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The NEI is a composite of many data sources, much of which is provided by state and local agencies and comes to EPA with little or no documentation on the specific methods used to generate the estimates. An emission inventory guidebook of methods, which is endorsed by the EPA and the state and local agencies (STAPPA/ALAPCO), is generally used by state and local agencies as reference for acceptable methods. The guidebook of methods is located on http://www.epa.gov/ttn/chief/eiip/techreport/. For emissions that are reported by the states as direct measurements from monitoring devices, the analytical procedures are referenced on http://www.epa.gov/ttn/emc/. Documentation of the procedures that EPA used to compile the NEI data for some of the more recent years in the time series is located on http://www.epa.gov/ttn/chief/net/neidata.html and is more organized and descriptive than documentation for previous year data. Documentation for the earlier years noted in the time series is located on http://www.epa.gov/ttn/chief/trends/procedures/neiproc99.pdf. Some of the methods noted have subsequently been revised for specific processes and years as EPA has gone back to update and apply improved methods. The documentation sources noted above will also describe use of emission factors. Documentation on process specific emission factors and how they were derived is located on http://www.epa.gov/ttn/chief/ap42/index.html.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The national annual NEI criteria emission trends summaries, as presented in the indicator, are publicly available on http://www.epa.gov/airtrends/econ-emissions.html. The national annual NEI hazardous air pollutant (HAP) data for year 1999, as presented in the indicator, are publicly available on http://www.epa.gov/air/data/index.html. Data format information typically resides at the same location as the data itself.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The EPA's documentation (see that noted in T3Q1) of how the NEI data estimates are generated will facilitate reproduction of some emission process estimates. As the EPA's documentation has evolved and improved over the years, it is expected that the more recent data years are documented in a more organized and transparent manner and would best enable reproducibility of emission estimates. Where EPA's documentation for specific years indicates that data was incorporated as that received from the state and local agencies, there is no additional documentation available by which to reproduce the state-derived values.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Much of the data that is used to compile the NEI is gathered indirectly from multiple and numerous sources, as referenced in the estimation methods information under T1Q1. These indirect data sources are presumed to have their own QA practices. Where state-supplied emissions estimates are used for some sectors and pollutants, it is presumed that states have QA plans in most cases but EPA does not systematically obtain information on QA practices from the states. The EPA contractors who use data sources and EPA-developed emissions factors to make emissions estimates operate under general contract-wide quality assurance plans, which can be made available on request. In addition, the EPA's more recent QC practices performed during the blending and merging of data from numerous sources, are described in the 2002 NEI Preparation Plan located on http://www.epa.gov/ttn/chief/net/2002inventory.html.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

No statistical generalization is performed to generate the national annual emissions trends presented in the indicator. The annual pollutant totals are developed at the plant or county level and then simply totaled and summarized at the regional and national levels.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No. At present, statistical uncertainty measures are not available for the underlying data that comprise the indicator. Most of the QA routines that are currently performed by EPA are sector data comparisons between different years or geographic areas, rather than on individual data variables. Much of the associated data variables for a specific sector are implied or not highly characterized, and therefore do not lend themselves well at present to quantitative uncertainty analysis.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Yes, OAQPS has developed standardized procedures for quality assuring the NEI as discussed in the "2002 NEI Preparation Plan" (http://www.epa.gov/ttn/chief/net/2002neiplan_081004final.pdf). The procedures include use of software to facilitate and standardize review of the data by EPA regional offices and state, local and tribal agencies. During the review process, industries often closely review their emission estimates to ensure they have been correctly incorporated in the NEI. In addition, OAQPS is able to use techniques which contrast data from various sources and from several inventory years to understand variability and identify areas in need of additional review. Where several data sources are available, assessments of data quality are conducted by OAQPS to ensure use of the highest quality emissions data when developing the NEI. The sum of the review procedures used for developing the NEI is believed to yield data of sufficient quality to support the conclusions which typical users will derive from the indicators. However, for the most rigorous applications, the NEI may be used in conjunction with ambient monitoring data and air quality and source receptor models to better characterize air quality problems and thus reduce uncertainties.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The indicator represents aggregated data. Most of the data is the result of a calculation that combines an emission rate per unit of input or output and a measure of that input or output, rather than a direct measurement of emissions. All states and counties are represented in the NEI, however not all states and local agencies may provide the same data or level of detail for a given year. State and local agencies may prioritize their data development efforts on emissions in county and metropolitan areas that are nonattainment for specific ambient air quality standards, i.e., ozone or PM2.5 NAAQS. The result may be more complete and quality assured data submissions to the NEI for these areas. Where data is absent or incomplete, EPA performs some data extrapolation from previous year data or other data sources. Inference follows many processes, depending on source type, etc. To the extent possible, facility-specific or county-specific information is used. In some cases, all counties in a state are assumed to have common properties influencing emissions, for example daily low and high temperatures. Best available or at most plausible substitutes are used where needed. For example, gasoline fuel properties are not available for all counties, known fuel properties in nearby counties subject to similar regulations on gasoline are used instead. Various and not fully consistent methodologies have been used to develop the emission estimates in the NEI. This is to be expected considering the variety of organizations that have contributed the estimates.

Indicator: Sulfur Dioxide Emissions (008d)

Sulfur dioxide (SO_2) belongs to the family of sulfur oxide (SO_x) gases. These gases are formed when fuel containing sulfur (mainly coal and oil) is burned and during metal smelting and other industrial processes. The highest monitored concentrations of SO_2 have been recorded in the vicinity of large industrial facilities. High concentrations of SO_2 can cause multiple health and environmental effects (EPA 2003a, p 12).

Health effects associated with SO_2 depend on the exposure concentrations and durations, and on the susceptibility of exposed populations. When asthmatics at moderate exertion have short-term exposures to elevated SO_2 levels, for example, they might experience reduced lung function and symptoms such as wheezing, chest tightness, or shortness of breath. Effects associated with longer-term exposures to high concentrations of SO_2, in conjunction with high levels of particulate matter (PM), include respiratory illness, alterations in the lungs' defenses, and aggravation of existing cardiovascular disease. The most susceptible populations under these conditions include individuals with cardiovascular disease or chronic lung disease, children, and the elderly (EPA 1982).

Many other environmental concerns are associated with high concentrations of SO_2. For example, airborne SO_2, along with NO_x, contribute to acidic deposition (see Indicator 011); SO_2 is a major precursor to PM2.5 (see Indicator 003); and SO_2 contributes to impaired visibility (see Indicator 006). SO_2 exposure also can harm vegetation by increasing foliar injury, decreasing plant growth and yield, and decreasing the number and variety of plant species in a given community. Finally, SO_2 can accelerate the corrosion of natural and man-made materials (e.g., concrete and limestone) that are used in buildings, statues, and monuments that are part of nation's cultural heritage EPA 1982).

This indicator presents trends in annual SO_2 emissions tracked by the National Emissions Inventory (NEI). The NEI is a composite of data from many different data sources, including industry and numerous state, tribal, and local agencies. Different data sources use different data collection methods, and many of the emissions data are based on estimates rather than actual measurements. Emissions are tracked for stationary point and non-point sources as well as onroad and non-road mobile sources. NEI data have been collected since 1990 and cover all 50 states and their counties, D.C., the U.S. territories of Puerto Rico and Virgin Islands, and some of the territories of federally-recognized American Indian nations. Data are presented only for 1990 and the years from 1996 forward because although data are available for 1991 – 1995, they have not been updated and comparisons of these data with those from other inventory years could lead to incorrect trends assumptions. Inventory years 1990 and from 1996 forward are up to date.

What the Data Show

National estimated SO_2 emissions decreased 33 percent between 1990 and 2002 (Figure 008d-1). The considerable reduction between 1990 and 1996 was caused largely by implementation of the Acid Rain Program; subsequent year-to-year variations are driven in part by the yearly changes in emissions from the electric utility industry (EPA 2003b, p 44). Between 1990 and 2002, air emissions from electric utilities have consistently accounted for roughly two-thirds of the nationwide SO_2 emissions.

Net SO2 emissions declined in all EPA Regions between 1990 and 2002 except in Region 6 where there was a slight increase (Figure 008d-2). Since 1996, SO2 emissions have remained fairly constant in Regions 1, 2, 7, 8, 9, and 10. A more substantial decline was seen in Regions 4 and 5 over the same period.

Indicator Limitations

- Though emissions from most electric utilities are measured directly using continuous monitoring devices, SO_2 emissions data for most other source types are estimates. These estimates are generated using well-established approaches, but still have inherent uncertainties.
- The methodology for estimating emissions is continually reviewed and is subject to revision. EPA is currently conducting such an evaluation of emissions data, and emissions estimates may be updated. Trend data prior to these revisions must be considered in the context of those changes.
- Not all states and local agencies-provide the same data or level of detail for a given year.

Data Sources

U.S. Environmental Protection Agency. National Emissions Inventory - http://www.epa.gov/ttn/chief/net/neidata.html

References

U.S. Environmental Protection Agency. 1982. Air Quality Criteria for Particulate Matter and Sulfur Oxides, EPA 600/P-82-020a-c. Research Triangle Park, NC; US Environmental Protection Agency, Office of Research and Development, Environmental Criteria and Assessment Office.

U.S. Environmental Protection Agency. 1986. Second Addendum to the Air Quality Criteria for Particulate Matter and Sulfur Oxides (1982); Assessment of Newly Available Health Effects Information, EPA 450-S-86-012. Research Triangle Park, NC; US Environmental Protection Agency, Office of Research and Development, Environmental Criteria and Assessment Office.

U.S. Environmental Protection Agency. 2003. Latest Findings on National Air Quality – 2002 Status and Trends, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

U.S. Environmental Protection Agency. 2003. National Air Quality and Emissions Trends Report - 2003 Special Studies Edition, EPA 454/R-03-005. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, September.

Graphics

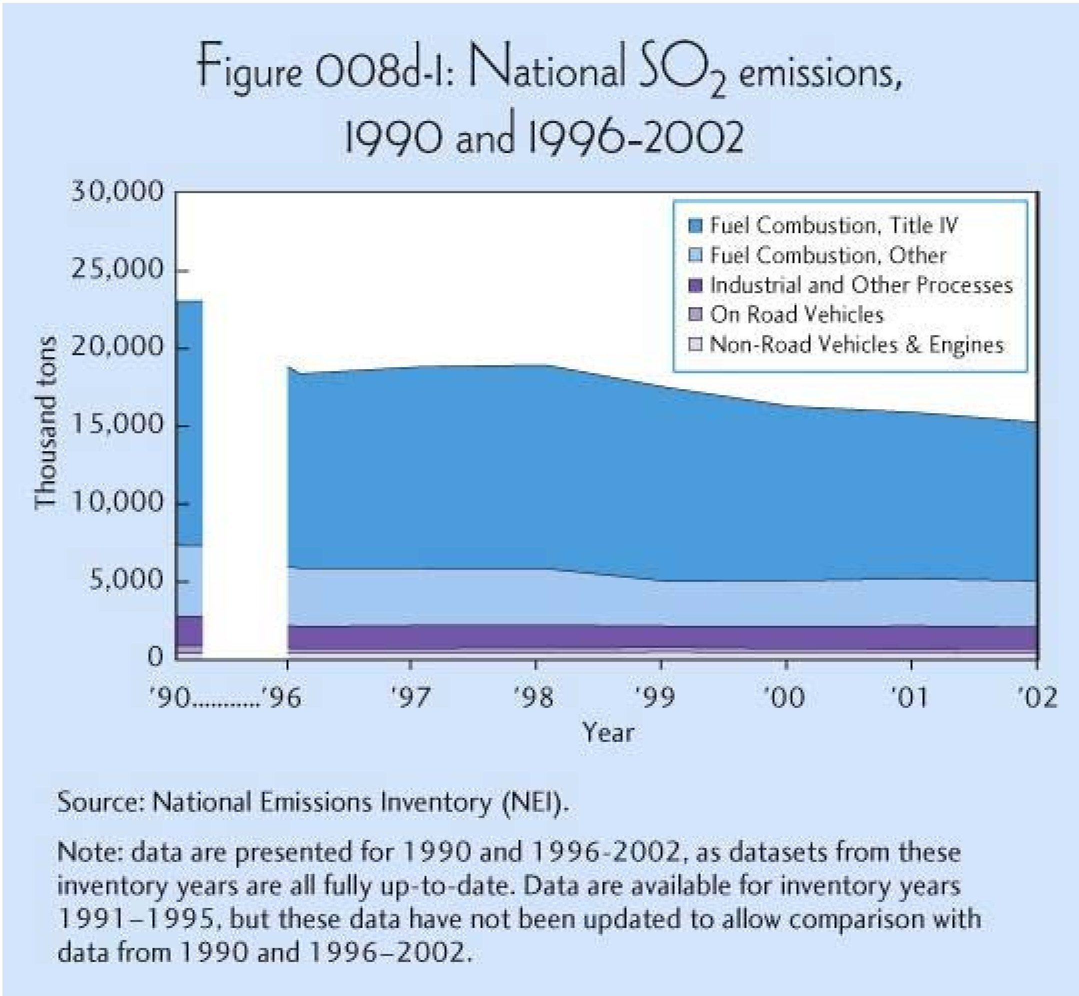
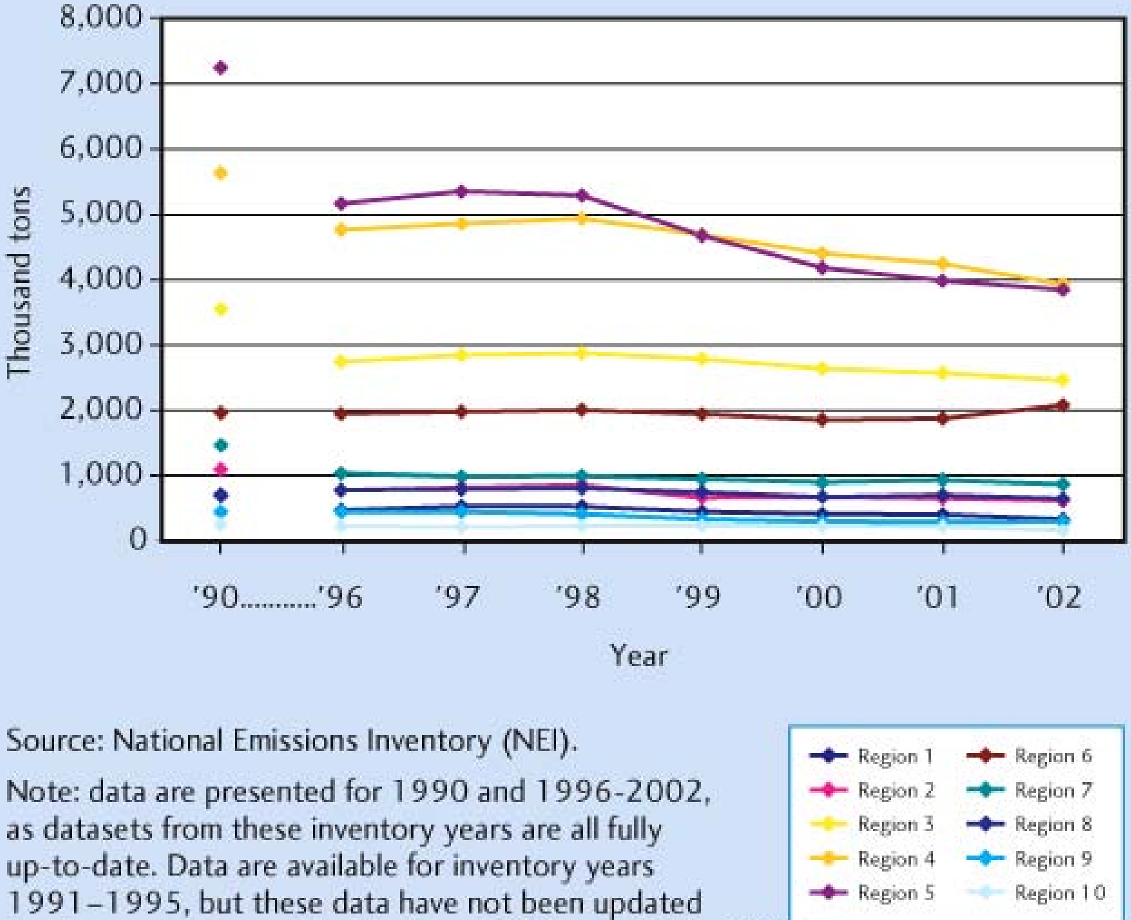


Figure 008d-1: National SO_2 emissions, 1990 and 1996-2002

Source: National Emissions Inventory (NEI).

Note: data are presented for 1990 and 1996-2002, as datasets from these inventory years are all fully up-to-date. Data are available for inventory years 1991–1995, but these data have not been updated to allow comparison with data from 1990 and 1996–2002.

Figure 008d-2: SO_2 emissions by EPA region, 1990 and 1996-2002



Source: National Emissions Inventory (NEI).

Note: data are presented for 1990 and 1996-2002, as datasets from these inventory years are all fully up-to-date. Data are available for inventory years 1991–1995, but these data have not been updated to allow comparison with data from 1990 and 1996–2002.

R.O.E. Indicator QA/QC

Data Set Name: SO2 EMISSIONS
Indicator Number: 008d (89081)
Data Set Source: EPA National Emissions Inventory
Data Collection Date: ongoing: at least 1980 to present
Data Collection Frequency: varies from continuously to trienially
Data Set Description: SO2 Emissions
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. While the NEI is a composite of data from many different data sources and methods, most of which are estimates instead of actual measurements with associated precision and accuracy, the methods are widely accepted as technically valid. These methods are considered largely sufficient in their application to derive the indicator data and conclusions presented to the typical user of the ROE. The NEI contains annual emissions (units = tons/year) of the criteria pollutants and the hazardous air pollutants (HAPs) noted in the Clean Air Act Amendments of 1990 (CAAA). The methods used to develop the NEI pollutant data vary by source sector and involve multiple data sources. A general description of methods by source sector is included below. Source emissions can be measured using monitoring equipment or estimated by using emission factors and emission process activity levels. Mathematical models may be used to characterize and simulate emissions that are influenced by several variables. For most source types, estimation techniques are the most practical. The NEI emissions are grouped into four main source sectors: Point sources and NonPoint sources (these are also referred to as stationary sources) and Onroad Mobile and Nonroad mobile sources (these are referred to as mobile sources). The Point source sector contains data on individual industrial, commercial and institutional facilities and is further divided into two subsectors: Electric Generating Units (EGUs) and NonEGUs. For the NEI sector data that is collected from state and local agencies - they either gather the data from their facilities or estimate the emissions themselves, using average and industry-specific emission factors. Some of the techniques they may use to generate their point and nonpoint estimates are referenced in a guidebook of methods which is endorsed by the EPA and the state and local agencies (STAPPA/ALAPCO). The guidebook of methods is located on http://www.epa.gov/ttn/chief/eiip/techreport/. Depending on the source sector and the pollutants of interest, the EPA uses other data sources in addition to the data received by the state and local agencies. Those other data sources, where applicable, are generally described below by sector, and identified specifically in the EPA s Preparation Plan for the 2002 NEI, located on http://www.epa.gov/ttn/chief/net/2002inventory.html. In addition to identifying the data sources, the NEI 2002 Preparation Plan also describes the EPA's current method of quality checking the different data sources, and blending and merging among them, as well as augmenting data in order to complete the data set over space and time for specific source sectors and pollutants. The EPA Preparation Plan for the 1999 NEI (http://www.epa.gov/ttn/chief/net/nei_plan_feb2001.pdf) describes the data sources and process used to compile the 1999 HAP data which is included in the indicator. There is a triennial development effort and focus on compiling data for the NEI which results in the most complete national emissions inventory data every third year. For the criteria emissions in the NEI, data is also developed for the years in between the 3-year inventory cycles. For some sectors and pollutants, the methods used may be the same as those applied for the 3-year inventory, or the data may be extrapolated from the most recent third year inventory using economic projections or more simply as a mathematical interpolation between previous and subsequent years of record. While the NEI is a composite of data from many different data sources and methods, most of which are estimates instead of actual measurements with associated precision and accuracy, the methods are widely accepted as technically valid. These methods are considered largely sufficient in their application to derive the indicator data and conclusions presented to the typical user of the ROE.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

There is not a sampling design per se for the overall NEI data development project, at least not in the typical terms of a statistical sampling design. The data methods are predominantly based on estimation techniques rather than measurement techniques with associated precision and accuracy and standard error. For most sector data, emission factors are used with average emission process rates and average activity indicators to estimate typical emissions expected from similar processes in different geographical areas. Emission factors typically are based on emission testing or other sampling observations of sources and are generally developed and revised as need arises and more data becomes available. Highway vehicle emissions factors, however, are based on relatively recent research-driven sampling approaches that are documented in information collection plans implemented by the EPA s Office and Transportation and Air Quality Planning (http://www.epa.gov/otaq/ap42.htm). For onroad mobile sources, estimates are made by month or by season to account for typical temperatures and fuel properties. Estimates of vehicle miles traveled are based on the United States Department of Transportation (US DOT) Highway Performance Monitoring System, which makes use of a formal sample panel of roadway segments. Like onroad mobile sources, emissions from some other processes are estimated for time periods less than annual. As an example, pollutant emissions for seasonal processes are estimated for only a portion of the year in which they occur (i.e., winter burning season). The NEI attempts to capture the full universe of large point source facilities, which are closely monitored and located individually by the state and local agencies. Most Point EGU emissions are individually measured with continuous monitoring devices. These data are summarized to annual average emissions for all 50 states and their counties, D.C., the U.S. territories of Puerto Rico and Virgin Islands, and as available, for some of the territories of federally-recognized American Indian nations, and are widely used and accepted as an indicator of national and regional emission trends over time.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The annual emissions are directly estimated in most cases, or are simply totaled from monthly or seasonal estimates - there is no transformation.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The NEI is designed to explicitly answer the question posed in the ROE. This indicator estimates emissions from all anthropogenic sources of a primary air pollutant.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The emission estimates that comprise the NEI are non-specific for sensitive populations or ecosystems. Rather, the data are specific for types of emission processes and as such, are representative of how much and where those process emissions occur by county for the nonpoint sources and by individual facility location for the point sources.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator(s) directly addresses changes in air pollutant emissions from year-to-year and the contributions of various types of emissions sources, by county, and for every state. Air pollutant emissions are a reliable gauge of impact on the environment and when considered along with air quality transport and transformation issues, are the foundation for air quality analysis, including health indicators. Emission reductions generally indicate positive impact on air quality. Average annual pollutant emission trends over time may also reference a specific year or years in the time series, during which emission reductions were realized due to previous year implementation of federal, regional, or local control and compliance programs. There are no thresholds or ranges of values associated with safe levels of emissions for this indicator.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The NEI is a composite of many data sources, much of which is provided by state and local agencies and comes to EPA with little or no documentation on the specific methods used to generate the estimates. An emission inventory guidebook of methods, which is endorsed by the EPA and the state and local agencies (STAPPA/ALAPCO), is generally used by state and local agencies as reference for acceptable methods. The guidebook of methods is located on http://www.epa.gov/ttn/chief/eiip/techreport/. For emissions that are reported by the states as direct measurements from monitoring devices, the analytical procedures are referenced on http://www.epa.gov/ttn/emc/. Documentation of the procedures that EPA used to compile the NEI data for some of the more recent years in the time series is located on http://www.epa.gov/ttn/chief/net/neidata.html and is more organized and descriptive than documentation for previous year data. Documentation for the earlier years noted in the time series is located on http://www.epa.gov/ttn/chief/trends/procedures/neiproc99.pdf. Some of the methods noted have subsequently been revised for specific processes and years as EPA has gone back to update and apply improved methods. The documentation sources noted above will also describe use of emission factors. Documentation on process specific emission factors and how they were derived is located on http://www.epa.gov/ttn/chief/ap42/index.html.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The national annual NEI criteria emission trends summaries, as presented in the indicator, are publicly available on http://www.epa.gov/airtrends/econ-emissions.html. The national annual NEI hazardous air pollutant (HAP) data for year 1999, as presented in the indicator, are publicly available on http://www.epa.gov/air/data/index.html. Data format information typically resides at the same location as the data itself.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The EPA's documentation (see that noted in T3Q1) of how the NEI data estimates are generated will facilitate reproduction of some emission process estimates. As the EPA's documentation has evolved and improved over the years, it is expected that the more recent data years are documented in a more organized and transparent manner and would best enable reproducibility of emission estimates. Where EPA's documentation for specific years indicates that data was incorporated as that received from the state and local agencies, there is no additional documentation available by which to reproduce the state-derived values.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Much of the data that is used to compile the NEI is gathered indirectly from multiple and numerous sources, as referenced in the estimation methods information under T1Q1. These indirect data sources are presumed to have their own QA practices. Where state-supplied emissions estimates are used for some sectors and pollutants, it is presumed that states have QA plans in most cases but EPA does not systematically obtain information on QA practices from the states. The EPA contractors who use data sources and EPA-developed emissions factors to make emissions estimates operate under general contract-wide quality assurance plans, which can be made available on request. In addition, the EPA's more recent QC practices performed during the blending and merging of data from numerous sources, are described in the 2002 NEI Preparation Plan located on http://www.epa.gov/ttn/chief/net/2002inventory.html.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

No statistical generalization is performed to generate the national annual emissions trends presented in the indicator. The annual pollutant totals are developed at the plant or county level and then simply totaled and summarized at the regional and national levels.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No. At present, statistical uncertainty measures are not available for the underlying data that comprise the indicator. Most of the QA routines that are currently performed by EPA are sector data comparisons between different years or geographic areas, rather than on individual data variables. Much of the associated data variables for a specific sector are implied or not highly characterized, and therefore do not lend themselves well at present to quantitative uncertainty analysis.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Yes, OAQPS has developed standardized procedures for quality assuring the NEI as discussed in the "2002 NEI Preparation Plan" (http://www.epa.gov/ttn/chief/net/2002neiplan_081004final.pdf). The procedures include use of software to facilitate and standardize review of the data by EPA regional offices and state, local and tribal agencies. During the review process, industries often closely review their emission estimates to ensure they have been correctly incorporated in the NEI. In addition, OAQPS is able to use techniques which contrast data from various sources and from several inventory years to understand variability and identify areas in need of additional review. Where several data sources are available, assessments of data quality are conducted by OAQPS to ensure use of the highest quality emissions data when developing the NEI. The sum of the review procedures used for developing the NEI is believed to yield data of sufficient quality to support the conclusions which typical users will derive from the indicators. However, for the most rigorous applications, the NEI may be used in conjunction with ambient monitoring data and air quality and source receptor models to better characterize air quality problems and thus reduce uncertainties.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The indicator represents aggregated data. Most of the data is the result of a calculation that combines an emission rate per unit of input or output and a measure of that input or output, rather than a direct measurement of emissions. All states and counties are represented in the NEI, however not all states and local agencies may provide the same data or level of detail for a given year. State and local agencies may prioritize their data development efforts on emissions in county and metropolitan areas that are nonattainment for specific ambient air quality standards, i.e., ozone or PM2.5 NAAQS. The result may be more complete and quality assured data submissions to the NEI for these areas. Where data is absent or incomplete, EPA performs some data extrapolation from previous year data or other data sources. Inference follows many processes, depending on source type, etc. To the extent possible, facility-specific or county-specific information is used. In some cases, all counties in a state are assumed to have common properties influencing emissions, for example daily low and high temperatures. Best available or at most plausible substitutes are used where needed. For example, gasoline fuel properties are not available for all counties, known fuel properties in nearby counties subject to similar regulations on gasoline are used instead. Various and not fully consistent methodologies have been used to develop the emission estimates in the NEI. This is to be expected considering the variety of organizations that have contributed the estimates.

Indicator: Greenhouse Gas Emissions (348)

The Earth's climate is determined by the balance between energy received from the sun and emitted back to space from the Earth and its atmosphere. Certain gases in the atmosphere, such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxides (N_2O), water vapor and others, trap some of the outgoing energy, retaining heat in the Earth's atmosphere. These are the so-called "greenhouse gases" (GHG).

Some human activities, such as the burning of fossil fuels, emit greenhouse gases and other substances that directly or indirectly affect the balance of incoming and outgoing radiation, thereby affecting climate on regional and global scales. The best understood greenhouse gases emitted by human activities are carbon dioxide, methane, nitrous oxides, and certain fluorinated compounds which all trap heat. Emissions of CO, NO_x and nonmethane VOC, and substances that deplete the stratospheric ozone layer also indirectly affect the Earth's radiative balance, for example, by altering greenhouse gas concentrations or changing the reflectivity of clouds.

Changes in GHG emissions are influenced by many long and short-term factors, including population and economic growth, energy price fluctuations, technological changes, and seasonal temperatures. On an annual basis, the overall consumption of fossil fuels, which accounts for most GHG emissions in the United States, generally fluctuates in response to changes in general economic conditions, energy prices, weather, and the availability of non-fossil alternatives (US EPA, 2004).

This indicator represents data and analysis from the US GHG Inventory (US EPA, 2004), an assessment of the anthropogenic sources and sinks of greenhouse gas emissions for the United States and its Territories for the period1990 through 2002, excluding emissions not covered by the UN Framework Convention on Climate Change (e.g. CFC, HFCs, methyl bromide, etc.). The methods for these estimates are documented in US EPA (2004), and accord with guidelines used consistently among other industrialized nations (IPCC 1996). The indicator is expressed in terms of CO_2 equivalents (CO_2 Eq). Emissions of different gases are weighted by "global warming potentials" (GWP), a measure of how much a given mass of GHG is estimated to contribute to global warming over a selected period of time. It is a relative scale which compares the gas in question to that of the same mass of carbon dioxide, of which the GWP is one. This indicator uses GWP recommended by the Intergovernmental Panel on Climate Change (IPCC 1996) for a 100 year time horizon – the amount of a gas's effect on radiative forcing over 100 years.

What the Data Show

Overall, total U.S. emissions have risen by 13 percent (from 6,120 to 6,935 Tg CO_2 Eq.) between 1990 and 2002 (Figure 348-1). Emissions are influenced primarily by levels of economic activity and the mix among sectors, weather conditions, fuel choices, and technologies in place, such as the energy efficiency of vehicles or the building stock. The primary greenhouse gas emitted by human activities in the United States is CO_2, representing approximately 83 percent of total greenhouse gas emissions. Methane is the second largest GHG emission. Methane emissions have steadily declined over the 1990-2002 period, from 643 to 598 Tg CO_2 Eq.

Electricity generation has consistently been the largest producer of GHG emissions, followed by transportation (Figure 348-2). Emissions rates from both sectors have grown steadily during the period from 1990 to 2002, while GHG emissions from industry have decreased over the same period, and those from commercial, agricultural, and residential sectors have remained fairly constant.

Across economic sectors, the largest source of greenhouse gas emissions in the U.S. is combustion of fossil fuels (Figure 348-3). Fossil fuel consumption has accounted for approximately 80 percent of U.S.

greenhouse gas emissions since 1990. Emissions from this source category grew by 17 percent (796.3 Tg CO_2 Eq.) from 1990 to 2002 and were responsible for most of the increase in national emissions during this period (US EPA, 2004). Transportation is narrowly the largest emitter of fossil fuel CO_2 emissions, slightly exceeding the direct and electricity-related emissions from industry. Residential and commercial sectors, primarily through electricity consumption, account for about 2/3 to ¾ as much emissions as transportation or industry.

Methane, the second most important greenhouse gas emission in the U.S., at 8.6% of the total, comes mostly from waste landfills, leakages from natural gas systems, enteric fermentation (digestion processes) in cattle and other animals, and coal mining (Figure 348-4). Methane also is emitted by a large number of small agricultural and industrial activities. Trends in emissions from the remaining source categories can be found in EPA 2002).

Indicator Limitations

- This indicator does not yet include emissions of greenhouse gases or other radiatively important substances that are not covered by the United National Framework Convention on Climate Change, such as those gases controlled by the Montreal Protocol and its Amendments, including CFCs and HFCs.
- This indicator also does not include aerosols and other emissions that are not well-mixed in the atmosphere, such as sulfate, ammonia, black carbon and organic carbon.

Data Sources

US EPA, Inventory Of U.S. Greenhouse Gas Emissions And Sinks: 1990 – 2002, 2004. Available at: http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2004.html

References

IPCC (1996) *Climate Change 1995: The Science of Climate Change*. Intergovernmental Panel on Climate Change; J.T. Houghton, L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg, and K. Maskell, eds.; Cambridge University Press. Cambridge, U.K.

Graphics

Figure 348-1

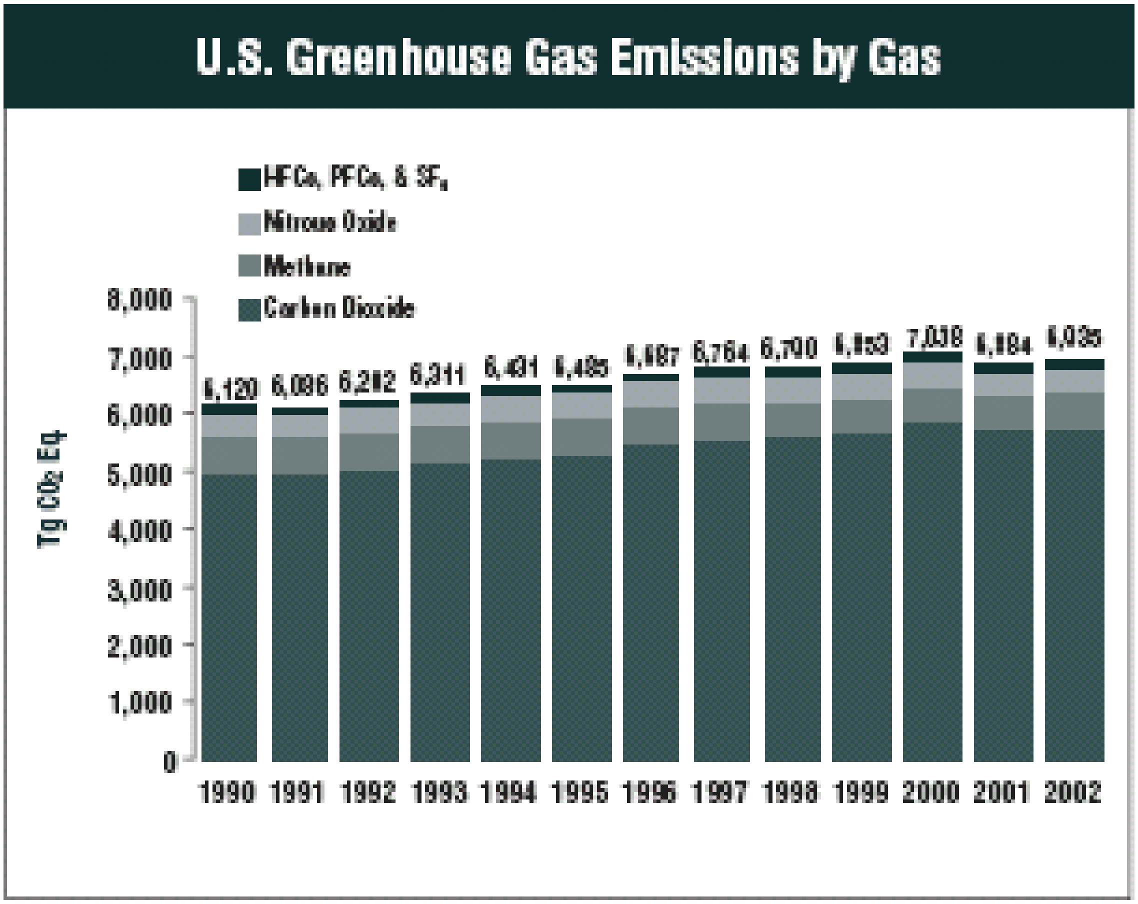
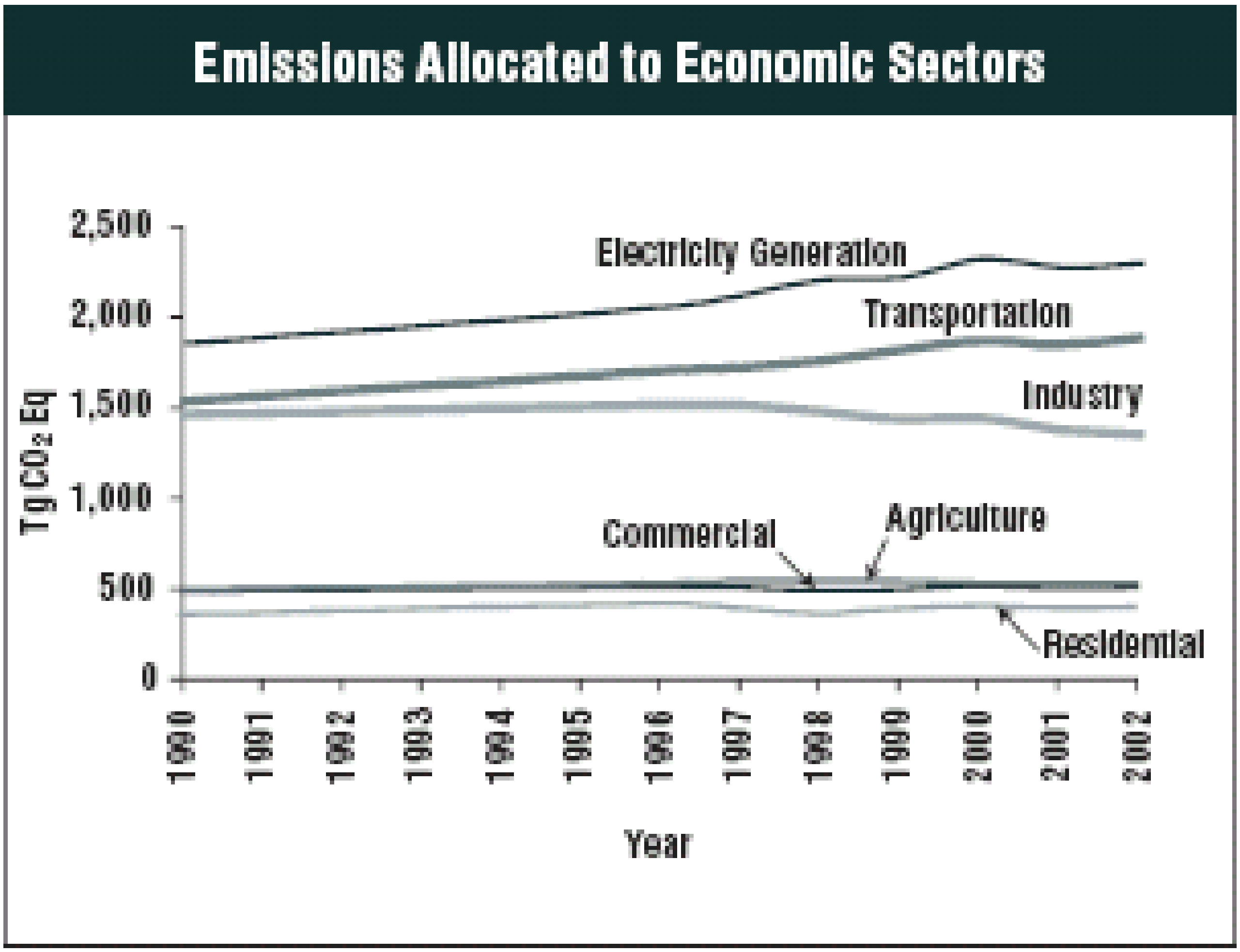
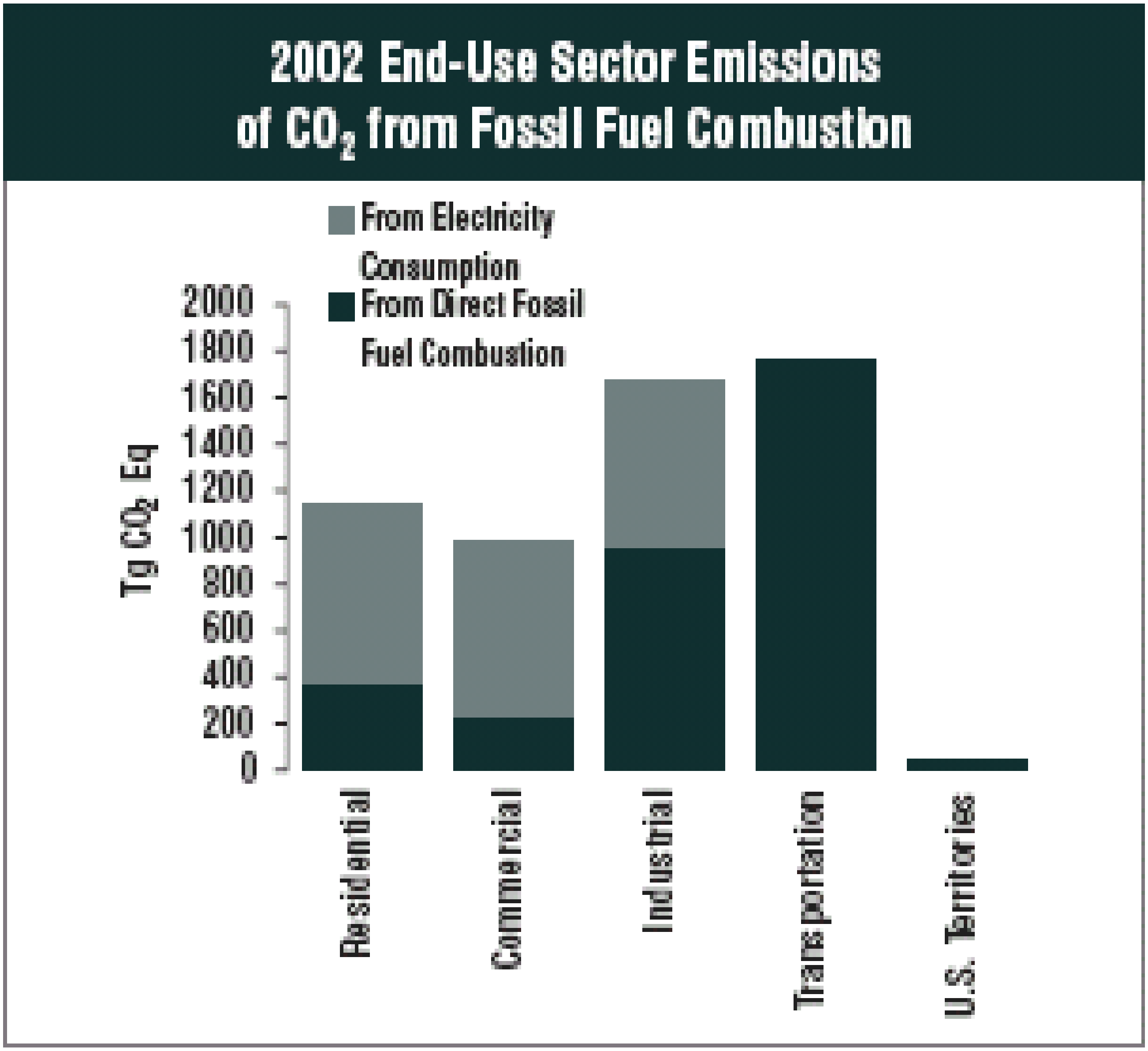


Figure 348-2



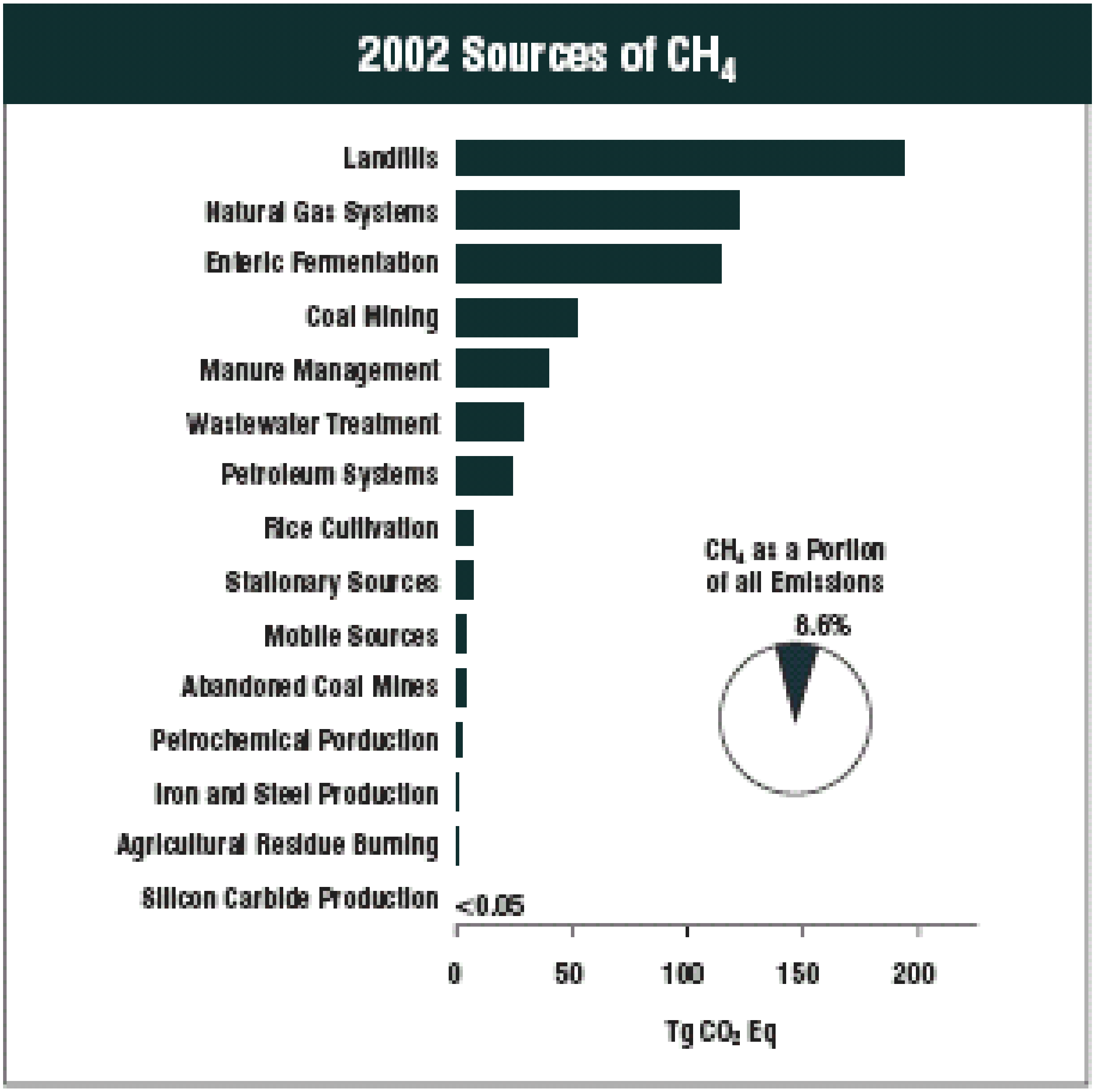
Emissions Allocated to Economic Sectors
2,500
2,000
1,500
1,000
500
0
Tg CO2 Eq
Electricity Generation
Transportation
Industry
Commercial
Agriculture
Residential
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Year

Figure 348-3



2002 End-Use Sector Emissions of CO_2 from Fossil Fuel Combustion
From Electricity Consumption
From Direct Fossil Fuel Combustion
Tg CO_2 Eq
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Residential
Commercial
Industrial
Transportation
U.S. Territories

Figure 348-4



2002 Sources of CH_4
Landfills
Natural Gas Systems
Enteric Fermentation
Coal Mining
Manure Management
Wastewater Treatment
Petroleum Systems
Rice Cultivation
Stationary Sources
Mobile Sources
Abandoned Coal Mines
Petrochemical Porduction
Iron and Steel Production
Agricultural Residue Burning
Silicon Carbide Production
<0.05
0
50
100
150
200
Tg CO_2 Eq
CH_4 as a Portion of all Emissions
8.6%

R.O.E. Indicator QA/QC

Data Set Name: U.S. GREENHOUSE GAS EMISSIONS
Indicator Number: 348 (114469)
Data Set Source: US Greenhouse Gas Inventory, 1990 to 2002
Data Collection Date: 1990 to present
Data Collection Frequency: mostly 1 year; some source variation
Data Set Description: U.S. Greenhouse Gas Emissions by Sector and Gas
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The emission and source activity data from which the emission estimates are derived are described thoroughly in the report US Greenhouse Gas Emissions, 1990 - 2002, which can be found at: http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2004.html The scientifically approved methods and discussion of estimation of uncertainty can be found in the IPCC GHG Inventory Guidelines, at http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm (Revised 1996 IPCC Guidelines) and http://www.ipcc-nggip.iges.or.jp/public/gp/english/ (Good Practice Guidance and Uncertainty Management).

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The US GHG Inventory is based on scientifically developed and reviewed methods, documented in the IPCC GHG Inventory Guidelines, at: http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm (Revised 1996 IPCC Guidelines). The US GHG Inventory, along with its accompanying Common Reporting Format tables, serves as a thorough assessment of the anthropogenic sources and sinks of greenhouse gas emissions for the United States for the time series 1990 through 2002. The Inventory covers only the years identified in the inventory; it is not extrapolated or interpolated, except in the case of interpolation between years in which the US forest inventories are conducted for that sector. Although the Inventory is intended to be comprehensive, certain sources have been identified yet excluded from the estimates presented due to data limitations or a lack of thorough understanding of the emission process. For a complete list of sources excluded, see Annex 5 of the final report. Fuller discussion of the sampling and data sources on which the Inventory is based can be found at: http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2004.html

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. See http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm (Revised 1996 IPCC Guidelines) and http://www.ipcc-nggip.iges.or.jp/public/gp/english/ (Good Practice Guidance and Uncertainty Management). In some cases, the US estimation methods or data quality are better than what has been approved in the IPCC Guidelines and Good Practice Guidance. The detailed descriptions of these, source by source, are in the US GHG Inventory (see T1Q2 for weblink).

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The US GHG Inventory tries to be comprehensive of all source or removal types, excluding, however, those emissions that are not covered by the UN Framework Convention on Climate Change (e.g. CFC, HFCs, methyl bromide, etc.) Information on these can be found in the ROE section on Stratospheric Ozone Depletion. Those estimates, however, are not entirely consistent with those in the US GHG Inventory. Further, although continuous monitoring of CO2 and some other emissions are available for large energy combustion facilities in the US, more comprehensive monitoring of source types, sizes and types of facilities would be desirable to reduce the uncertainty estimates in the Inventory QA/QC. Discussion of this, source by source, is available in the US GHG Inventory publication (see T1Q2 for weblink).

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Not applicable.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

No. This indicator shows the net time series of emissions. No threshold level for "dangerous" has been established for emissions or concentrations in the atmosphere, although the general objective to establish this level is an obligation of the U.S. and other Parties to the United Nations Framework Convention on Climate Change (1992).

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Documentation is available is available in the US GHG Inventory publication (see T1Q2 for weblink).

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. See the US GHG Inventory publication (see T1Q2 for weblink). The EPA contact person is Leif Hockstad, hockstad.leif@epa.gov, (202)343-9432.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The description of methods, data and estimates is extremely complete and has been through thorough peer and public review. Details regarding the methods, QA/QC and peer reviews are described in the US EPA 2004 Inventory, and further information can be obtained from the EPA Contact Person.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The United States recently implemented a systematic approach to QA/QC. While QA/QC has always been an integral part of the U.S. national system for Inventory development, the procedures followed for the current inventory have been formalized in accordance with the QA/QC plan and the UNFCCC reporting guidelines. While the current U.S. emissions inventory provides a solid foundation for the development of a more detailed and comprehensive national inventory, there are uncertainties associated with the emission estimates. Some of the current estimates, such as those for CO2 emissions from energy related activities and cement processing, are considered to have low uncertainties. For some other categories of emissions, however, a lack of data or an incomplete understanding of how emissions are generated increases the uncertainty associated with the estimates presented. Recognizing the benefit of conducting an uncertainty analysis, the UNFCCC reporting guidelines follow the recommendations of the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (hereafter referred to as the IPCC Good Practice Guidance) and require that countries provide single point estimates for many source and sink categories. Currently, a qualitative discussion of uncertainty is presented for all source and sink categories in the US Greenhouse Gas Inventory. Within the discussion of each emission source, specific factors affecting the uncertainty surrounding the estimates are discussed. Most sources also contain a quantitative uncertainty assessment, in accordance with the new UNFCCC reporting guidelines. Thorough discussion of these points can be found in the US GHG Inventory publication (see T1Q2 for weblink).

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The US GHG Inventory, along with its accompanying Common Reporting Format tables, serves as a thorough assessment of the anthropogenic sources and sinks of greenhouse gas emissions for the United States for the time series 1990 through 2002. Although this inventory is intended to be comprehensive, certain sources have been identified yet excluded from the estimates presented for various reasons. Generally speaking, sources not accounted for in this Inventory are excluded due to data limitations or a lack of thorough understanding of the emission process. The United States is continually working to improve upon the understanding of such sources and seeking to find the data required to estimate related emissions. As such improvements are made, new emission sources are quantified and included in the Inventory. For a complete list of sources excluded, see Annex 5.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. See the US GHG Inventory publication (see T1Q2 for weblink) and http://www.ipcc-nggip.iges.or.jp/public/gp/english/ (Good Practice Guidance and Uncertainty Management).

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No. Even considering the uncertainties of omitted sources and lack of precision in known and estimated sources, the conclusions inferred from the data are solid. The quality of the indicator is very high.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

No. Although there are gaps in the data and limitations in the measurements upon which the estimates are based, the estimates provide a good representation of the trends in the indicator over the time period for which these estimates are made.

Indicator: Visibility (006)

Visibility impairment is one of the most obvious effects of air pollution. It is observed not only in urban areas, but also in many of the best known and most treasured natural parks and wilderness areas, such as the Grand Canyon, Great Smoky Mountains, Mount Rainier, Shenandoah, Yellowstone, and Yosemite National Parks. (Latest Findings on National Air Quality–2002 Status and Trends, EPA 454/K-03-001). Visibility impairment occurs when air pollution, both particles and gases, scatter and absorb light. This not only limits the distance one can see, but can also degrade the color, clarity, and contrast of scenes. As the Indicator “Ambient PM Concentrations” describes further, the same pollutants that impair visibility are also linked to serious health effects.

The particles that impair visibility include both primary and secondary pollutants. The primary pollutants of concern are particles that sources emit directly into the atmosphere, like dust from roads or soot (elemental carbon) from wood combustion. The secondary pollutants, on the other hand, are particles that form in the atmosphere from chemical reactions and physical processes involving sulfates (formed from sulfur dioxide emissions from power plants and other industrial facilities) and nitrates (formed from nitrogen oxides emitted from power plants, automobiles, and other types of combustion sources). Humidity can significantly increase the effect of pollution on visibility, causing some particles to become more efficient at scattering light and impairing visibility. (Latest Findings on National Air Quality–2002 Status and Trends, EPA 454/K-03-001)

In the eastern United States, where annual average relative humidity levels are between 70 and 80%, reduced visibility mainly results from secondarily formed sulfates and high humidity, along with a somewhat lower contribution from organic carbon and nitrates (EPA 2003). The effect of humidity is particularly strong in summer. In the western United States, on the other hand, primary emissions from sources like wood smoke and nitrates contribute a larger percentage of the total particulate loading, though secondarily formed sulfates also contribute to visibility impairment. Humidity is less of a factor in the West, as average values are generally between 50 and 60%. Without the effects of pollution, a natural visual range in the United States should be approximately 75 to 150 km (45 to 90 miles) in the East and 200 to 300 km (120 to 180 miles) in the West (Latest Findings on National Air Quality–2002 Status and Trends, EPA 454/K-03-001).

This indicator reports visibility data that were collected at 47 monitoring sites between 1992 and 2001 at National Parks and other protected sites under the Interagency Monitoring of Protected Visual Environments (IMPROVE) network. The IMPROVE network began monitoring of 20 sites in 1988 and has since expanded to a network of 110 sites. Visibility is calculated from particle speciation data using an algorithm that estimates light extinction as the sum of each component mass concentration times its typical extinction efficiencies. The algorithm includes an adjustment for ammonium sulfate and ammonium nitrate to account for their adsorption of water vapor from the atmosphere under elevated relative humidity conditions. The IMPROVE particle data is generated by laboratory analysis of 24-hour duration filter samples collected at each site on a one day in three schedule. The worst and best visibility conditions presented here refer to the mean of the 20% worst visibility days and mean of the best 20% visibility days at each site each year.

What the Data Show

Visibility data are presented separately for the Eastern (Figure 006-1) and the Western (Figure 006-2) United States. Each figure shows how the average visibility (in kilometers) changed from one year to the next for days with best visibility, mid-range visibility, and worst visibility.

The figures show that the worst visibility in the West is comparable to the best visibility in the East. In 2001, the mean visual range for the worst days in the East was 29 km (18.1 miles), compared to 117 km (73.1 miles) for the best visibility days. In the West, the mean visual range ranged from 103 km (64 miles) on the worst days to 234 km (145 miles) on the best days. In both regions, visibility trends remained fairly stable between 1992 and 2001.

Indicator Limitations

- These data represent visibility in a sampling of selected national park and wilderness areas and are not representative of other rural or urban areas.

Data Sources

Interagency Monitoring of Protected Visual Environments (IMPROVE) network - http://vista.cira.colostate.edu/improve/

References

U.S. Environmental Protection Agency. Latest Findings on National Air Quality–2002 Status and Trends, EPA 454/K-03-001. Research Triangle Park, NC; U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

U.S. Environmental Protection Agency. The Particulate Pollution Report: Current Understanding of Air Quality and Emissions through 2003, EPA 454/R-04-002. Research Triangle Park, NC; U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, December 2004.

U.S. Environmental Protection Agency. The Ozone Report: Measuring Progress through 2003, EPA 454/K-04-001. Research Triangle Park, NC; U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, April 2004.

Graphics

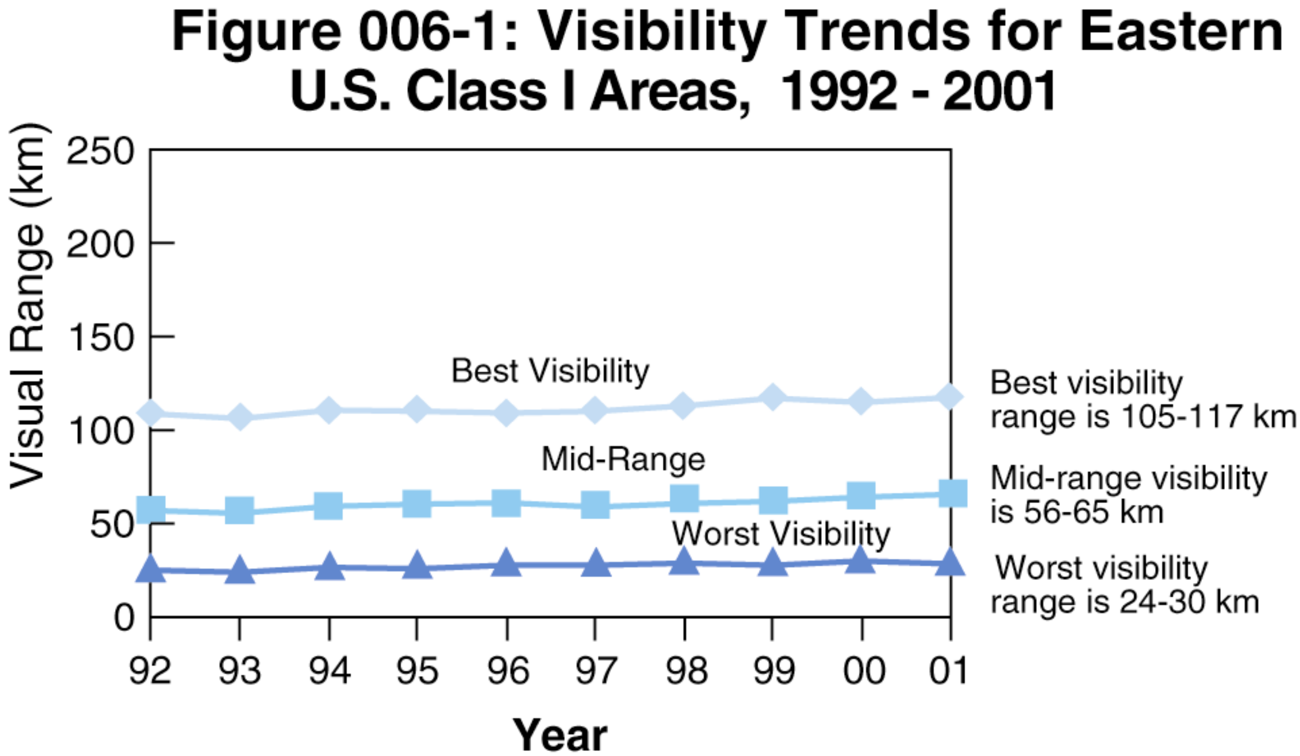
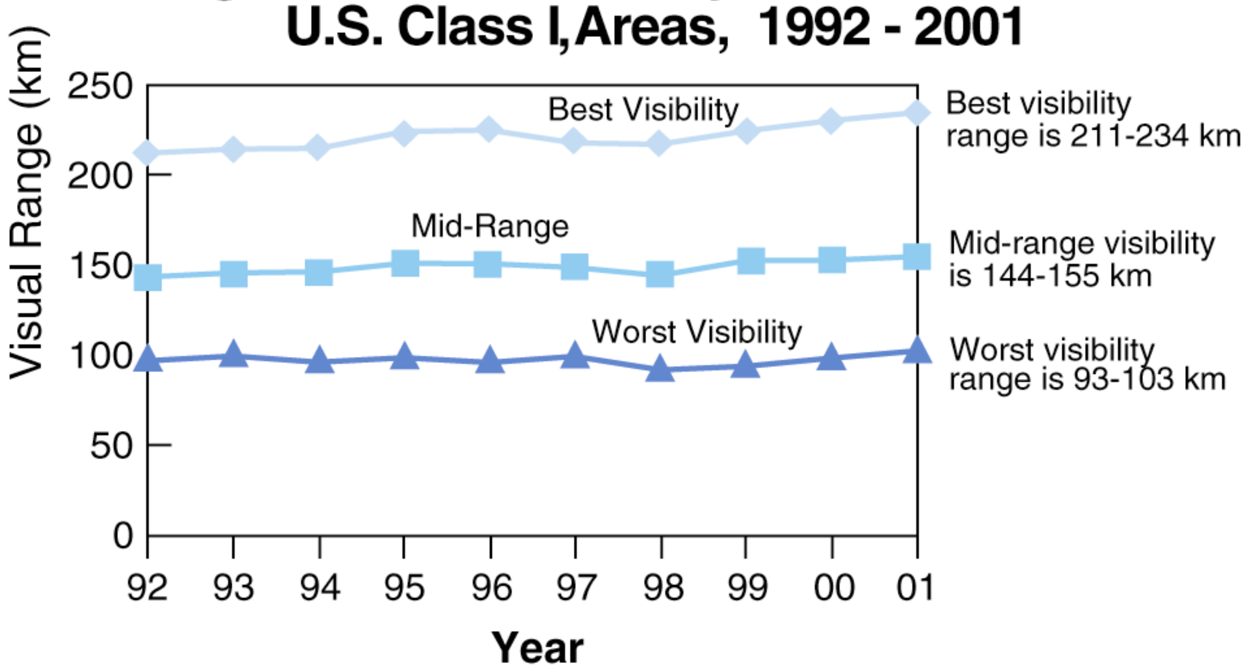


Figure 006-1: Visibility Trends for Eastern U.S. Class I Areas, 1992 - 2001
Visual Range (km)
250
200
150
100
50
0
Best Visibility
Mid-Range
Worst Visibility
92
93
94
95
96
97
98
99
00
01
Year
Best visibility range is 105-117 km
Mid-range visibility is 56-65 km
Worst visibility range is 24-30 km

Figure 006-2: Visibility Trends for Western U.S. Class I,Areas, 1992 - 2001



R.O.E. Indicator QA/QC

Data Set Name: VISIBILITY
Indicator Number: 006 (89071)
Data Set Source: IMPROVE Monitoring Network database at: http://vista.cira.colostate.edu/improve/
Data Collection Date: 1992-2001
Data Collection Frequency: Wednesdays & Saturdays throughout the year
Data Set Description: Trends in Visibility
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The Interagency Monitoring of Protected Visual Environments (IMPROVE) was established as a cooperative effort among EPA, states, National Park Service, U.S. Forest Service, Bureau of Land Management, and U.S. Fish and Wildlife Service. The IMPROVE data guide provides a detailed overview of the IMPROVE samplers and analysis. This document can be downloaded at the following web site - http://vista.cira.colostate.edu/improve/Publications/otherDocs/IMPROVEDataGuide/IMPROVEDataGuide.htm IMPROVE has also been a key participant in visibility-related research, including the advancement of monitoring instrumentation, analysis techniques, visibility modeling, policy formulation and source attribution field studies.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The IMPROVE monitoring program was established in 1985 to aid the creation of Federal and State implementation plans for the protection of visibility in Class I areas (156 national parks and wilderness areas) as stipulated in the 1977 amendments to the Clean Air Act. In 2000, the IMPROVE Monitoring Network started an expansion from 30 to 110 monitoring sites. The expansion work was completed in the fall of 2001. States, tribes, and federal land management agencies support more than 50 additional sites. Collectively, these will be used to track future progress in accordance with the regional haze program. The network samplers monitor on Wednesdays and Saturdays throughout the year, yielding 104 samples per year and 26 samples per season. To be included in this analysis, sites were required to have data for at least 50 percent of the scheduled samples (13 days) for every calendar quarter. IMPROVE monitoring sites are selected as trends sites if they have complete data for at least 8 of the 10 years between 1990 and 1999 (or 6 of 8 years for those who began monitoring in 1992).

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The source data sets were obtained from Dr. James Sisler of Colorado State University. The annual average statistics in these files were used to assess trends. The IMPROVE data are not reported in terms of a calendar year. The IMPROVE year runs from March to February of the following year. It follows that the four seasons are: March to May (spring), June to August (summer), September to November (autumn), and December to the following February (winter). The network samplers monitor on Wednesdays and Saturdays throughout the year, yielding 104 samples per year and 26 samples per season. To be included in this analysis, sites were required to have data for at least 50 percent of the scheduled samples (13 days) for every calendar quarter. IMPROVE monitoring sites are selected as trends sites if they have complete data for at least 8 of the 10 years between 1990 and 1999 (or 6 of 8 years for those who began monitoring in 1992). A year is valid only if there are at least 13 samples (50 percent complete) per season for both measured and reconstructed PM2.5. The same linear interpolation applied to the criteria pollutants is applied here. The IMPROVE sites meeting the data completeness criteria are shown in Figure B-1 (National Air Quality and Emissions Trends Report, 2003). For consistency, the same sites are used in both the PM2.5 section. The exceptions are Washington, DC, and South Lake Tahoe, which are not included in the visibility trends analysis because they are urban sites.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Recognizing the importance of visual air quality, congress included legislation in the 1977 Clean Air Act to prevent future and remedy existing visibility impairment in Class I areas. To aid the implementation of this legislation, the IMPROVE program was initiated in 1985. This program implemented an extensive long term monitoring program to establish the current visibility conditions, track changes in visibility and determine causal mechanism for the visibility impairment in the National Parks and Wilderness Areas.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The IMPROVE sites meeting the data completeness criteria are shown in Figure B-1 (National Air Quality and Emissions Trends Report, 2003). For consistency, the same sites are used in both the PM2.5 section. The exceptions are Washington, DC, and South Lake Tahoe, which are not included in the visibility trends analysis because they are urban sites.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

There are no established national standards, but background visibility ranges from approximately 7 deciviews (182-193 km) in the western U.S. to 11-14 deciviews (100-130 km) in the eastern U.S. Malm, W.C. 1999. Introduction to Visibility. Cooperative Institute for Research in the Atmosphere (CIRA), NPS Visibility Program, Colorado State University, Fort Collins, CO 80523. http://www.epa.gov/air/visibility/introvis.pdf

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Detailed information about the improve monitoring sites including location, sampling equipment and history of changes at the monitoring site can be found at http://vista.cira.colostate.edu/improve/Web/MetadataBrowser/MetadataBrowser.aspx?State=CO&Program=IMPROVE&MeasurementType=Aerosol

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. The aerosol and optical data are made publicly available approximately nine months after collection. In addition, seasonal and annual data reports, special study data reports, technical publications, and other data and analysis reports are prepared. These IMPROVE resources can be obtained from this website - http://vista.cira.colostate.edu/improve/Data/IMPROVE/improve_data.htm

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The description of the IMPROVE network can be found http://vista.cira.colostate.edu/improve/

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The IMPROVE Quality Management Plan (QMP) for the environmental data operations of the Aerosol Monitoring Network component of the IMPROVE Visibility Monitoring Program outlines the roles of organizations involved in the IMPROVE Aerosol Monitoring Network. The IMPROVE Aerosol Quality Assurance Project Plan developed by Crocker Nuclear Laboratory documents the quality assurance and quality control activities of the IMPROVE Aerosol monitoring network. These documents can be downloaded at the following web site - http://vista.cira.colostate.edu/improve/Publications/publications.htm

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The annual average statistics in these files were used to assess trends. The IMPROVE data are not reported in terms of a calendar year. The IMPROVE year runs from March to February of the following year. It follows that the four seasons are: March to May (spring), June to August (summer), September to November (autumn), and December to the following February (winter). The network samplers monitor on Wednesdays and Saturdays throughout the year, yielding 104 samples per year and 26 samples per season. To be included in this analysis, sites were required to have data for at least 50 percent of the scheduled samples (13 days) for every calendar quarter. IMPROVE monitoring sites are selected as trends sites if they have complete data for at least 8 of the 10 years between 1990 and 1999 (or 6 of 8 years for those who began monitoring in 1992). A year is valid only if there are at least 13 samples (50 percent complete) per season for both measured and reconstructed PM2.5. The same linear interpolation applied to the criteria pollutants is applied here. The IMPROVE sites meeting the data completeness criteria are shown in Figure B-1 (National Air Quality and Emissions Trends Report, 2003). For consistency, the same sites are used in both the PM2.5 section. The exceptions are Washington, DC, and South Lake Tahoe, which are not included in the visibility trends analysis because they are urban sites.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

In addition, the IMPROVE data undergo extensive QA/QC procedures and analyses by its contractors and the National Park Service before it is released. UC Davis conducts three levels of QA/QC on the aerosol sampling equipment and data. For a full description see the Data Processing and Validation SOP. A copy of these procedures can be downloaded from http://vista.cira.colostate.edu/improve/Publications/SOPs/UCDavis_SOPs/sop351.pdf

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

This web site - http://vista.cira.colostate.edu/improve/Data/QA_QC/issues.htm documents issues and potential problems with the IMPROVE data and its interpretation. When possible, recommendations are provided for minimizing the influence of these issues on data analysis.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Limitations of this indicator include the following: " The indicator compares trends within visibility range categories, but it would also be useful to indicate how often visibility falls into each range during a year. " The data represent only a sampling of national park and wilderness areas; nevertheless, this indicator provides a good picture of the impact of air pollution on the nation s parks and protected areas. As of 2001, the network monitored 110 sites.

Indicator: Volatile Organic Compound Emissions (008e)

Volatile organic compounds (VOCs) are a large group of organic chemicals that readily evaporate at room temperature. The individual VOCs that are most harmful to human health are regulated as air toxics (see Indicators “Ambient Concentrations of Selected Air Toxics,” “Air Toxics Emissions,” and “Blood VOC Level”). Health effects vary by pollutant. Emissions of all VOCs combined are also considered an important environmental and human health issue because ozone, another air pollutant (see “Ambient Ozone Concentrations”), is formed from chemical reactions involving airborne VOCs, airborne nitrogen oxides, and sunlight. VOCs are emitted from a variety of sources, including motor vehicles, chemical manufacturing facilities, refineries, factories, consumer and commercial products, and natural (biogenic) sources (Latest Findings on National Air Quality – 2002 Status and Trends, EPA 454/K-03-001).

This indicator presents VOC emissions data tracked by the National Emissions Inventory (NEI). The NEI is a composite of data from many different data sources, including industry and numerous state, tribal, and local agencies. Different data sources use different data collection methods, and many of the emissions data are based on estimates rather than actual measurements. Emissions are tracked for stationary point and non-point sources as well as onroad and non-road mobile sources. NEI data have been collected since 1990 and cover all 50 states and their counties, D.C., the U.S. territories of Puerto Rico and Virgin Islands, and some of the territories of federally-recognized American Indian nations. Data are presented only for 1990 and the years from 1996 forward because although data are available for 1991 – 1995, they have not been updated and comparisons of these data with those from other inventory years could lead to incorrect trends assumptions. Inventory years 1990 and from 1996 forward are up to date.

What the Data Show

Figure 008e-1 displays VOC emissions by four source categories: 1) “fuel combustion” which includes emissions from power plants, industrial, commercial and institutional sources as well as residential heaters and boilers, 2) “industrial and other processes” which includes large point sources such as refineries and smelters as well as smaller sources such as drycleaners and service stations, 3) “on road vehicles” which includes cars, trucks, buses, and motorcycles and 4) “non-road vehicles and engines” such as farm and construction equipment, lawnmowers, chainsaws, boats/ships, snowmobiles, aircraft, and others. According to NEI data, national total VOC emissions from anthropogenic sources (or sources of human origin), excluding wildfires and prescribed burnings, decreased by 32 percent between 1990 and 2002 (from 23,048,000 to 15,662,000 tons). The overwhelming majority of emissions reductions were observed among industrial processes and onroad mobile sources. Combined, these two source categories accounted for 80% of the total nationwide estimated VOC emissions in 1990, but accounted for only 72% of the nationwide emissions in 2002.

Trends in VOC emissions among the ten EPA Regions were consistent with the overall decline seen nationally from 1990-2002 (Figure 008e-2). All Regions showed a net decrease in VOC emissions ranging from 12 to 44 percent.

Indicator Limitations

- The emissions data are largely based on estimates. Although these estimates are generated using well-established approaches, the estimates have inherent uncertainties.
- The methodology for estimating emissions is continually reviewed and is subject to revision. Trend data prior to any revisions must be considered in the context of those changes.
- Not all states and local agencies-provide the same data or level of detail for a given year.

Data Sources

U.S. Environmental Protection Agency. National Emissions Inventory - http://www.epa.gov/ttn/chief/net/neidata.html

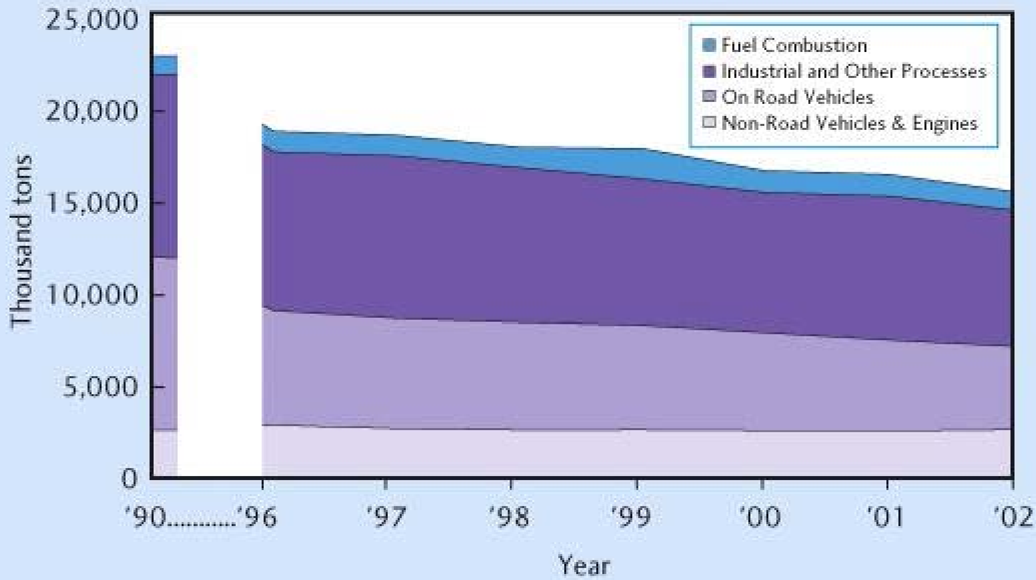
References

U.S. Environmental Protection Agency. Latest Findings on National Air Quality – 2002 Status and Trends, EPA 454/K-03-001. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003.

U.S. Environmental Protection Agency. National Air Quality and Emissions Trends Report - 2003 Special Studies Edition, EPA 454/R-03-005. Research Triangle Park, NC; US Environmental Protection Agency, Office of Air Quality Planning and Standards, September 2003.

Graphics

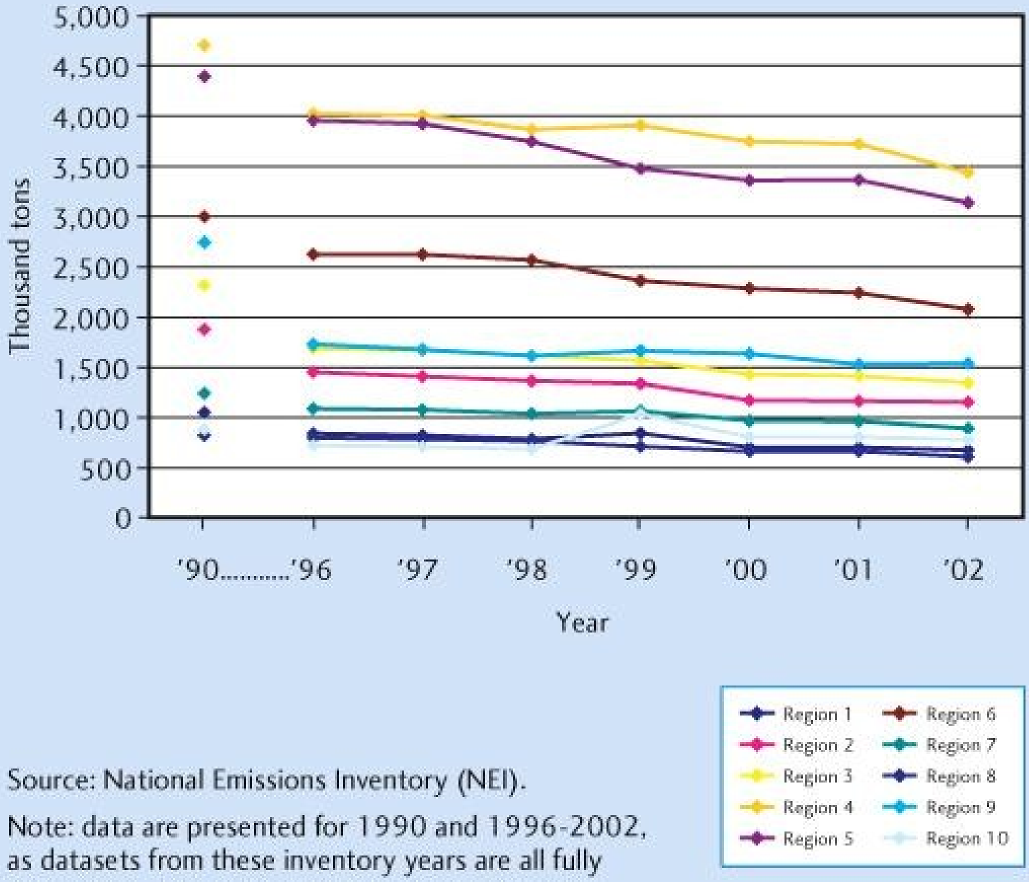
Figure 008e-1: National VOC emissions, 1990 and 1996-2002



Source: National Emissions Inventory (NEI).

Note: data are presented for 1990 and 1996-2002, as datasets from these inventory years are all fully up-to-date. Data are available for inventory years 1991–1995, but these data have not been updated to allow comparison with data from 1990 and 1996–2002.

Figure 008e-2: VOC emissions by EPA region, 1990 and 1996-2002



Source: National Emissions Inventory (NEI).

Note: data are presented for 1990 and 1996-2002, as datasets from these inventory years are all fully up-to-date. Data are available for inventory years 1991–1995, but these data have not been updated to allow comparison with data from 1990 and 1996–2002.

R.O.E. Indicator QA/QC

Data Set Name: VOC EMISSIONS
Indicator Number: 008e (89079)
Data Set Source: EPA National Emissions Inventory
Data Collection Date: ongoing: at least 1980 to present
Data Collection Frequency: varies from annually to trienially
Data Set Description: VOC Emissions
Primary ROE Question: What are the trends in outdoor air quality and effects on human health and ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. While the NEI is a composite of data from many different data sources and methods, most of which are estimates instead of actual measurements with associated precision and accuracy, the methods are widely accepted as technically valid. These methods are considered largely sufficient in their application to derive the indicator data and conclusions presented to the typical user of the ROE. The NEI contains annual emissions (units = tons/year) of the criteria pollutants and the hazardous air pollutants (HAPs) noted in the Clean Air Act Amendments of 1990 (CAAA). The methods used to develop the NEI pollutant data vary by source sector and involve multiple data sources. A general description of methods by source sector is included below. Source emissions can be measured using monitoring equipment or estimated by using emission factors and emission process activity levels. Mathematical models may be used to characterize and simulate emissions that are influenced by several variables. For most source types, estimation techniques are the most practical. The NEI emissions are grouped into four main source sectors: Point sources and NonPoint sources (these are also referred to as stationary sources) and Onroad Mobile and Nonroad mobile sources (these are referred to as mobile sources). The Point source sector contains data on individual industrial, commercial and institutional facilities and is further divided into two subsectors: Electric Generating Units (EGUs) and NonEGUs. For the NEI sector data that is collected from state and local agencies - they either gather the data from their facilities or estimate the emissions themselves, using average and industry-specific emission factors. Some of the techniques they may use to generate their point and nonpoint estimates are referenced in a guidebook of methods which is endorsed by the EPA and the state and local agencies (STAPPA/ALAPCO). The guidebook of methods is located on http://www.epa.gov/ttn/chief/eiip/techreport/. Depending on the source sector and the pollutants of interest, the EPA uses other data sources in addition to the data received by the state and local agencies. Those other data sources, where applicable, are generally described below by sector, and identified specifically in the EPA's Preparation Plan for the 2002 NEI, located on http://www.epa.gov/ttn/chief/net/2002inventory.html. In addition to identifying the data sources, the NEI 2002 Preparation Plan also describes the EPA's current method of quality checking the different data sources, and blending and merging among them, as well as augmenting data in order to complete the data set over space and time for specific source sectors and pollutants. The EPA Preparation Plan for the 1999 NEI (http://www.epa.gov/ttn/chief/net/nei_plan_feb2001.pdf) describes the data sources and process used to compile the 1999 HAP data which is included in the indicator. There is a triennial development effort and focus on compiling data for the NEI which results in the most complete national emissions inventory data every third year. For the criteria emissions in the NEI, data is also developed for the years in between the 3-year inventory cycles. For some sectors and pollutants, the methods used may be the same as those applied for the 3-year inventory, or the data may be extrapolated from the most recent third year inventory using economic projections or more simply as a mathematical interpolation between previous and subsequent years of record. While the NEI is a composite of data from many different data sources and methods, most of which are estimates instead of actual measurements with associated precision and accuracy, the methods are widely accepted as technically valid. These methods are considered largely sufficient in their application to derive the indicator data and conclusions presented to the typical user of the ROE.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

There is not a sampling design per se for the overall NEI data development project, at least not in the typical terms of a statistical sampling design. The data methods are predominantly based on estimation techniques rather than measurement techniques with associated precision and accuracy and standard error. For most sector data, emission factors are used with average emission process rates and average activity indicators to estimate typical emissions expected from similar processes in different geographical areas. Emission factors typically are based on emission testing or other sampling observations of sources and are generally developed and revised as need arises and more data becomes available. Highway vehicle emissions factors, however, are based on relatively recent research-driven sampling approaches that are documented in information collection plans implemented by the EPA's Office and Transportation and Air Quality Planning (http://www.epa.gov/otaq/ap42.htm). For onroad mobile sources, estimates are made by month or by season to account for typical temperatures and fuel properties. Estimates of vehicle miles traveled are based on the United States Department of Transportation (US DOT) Highway Performance Monitoring System, which makes use of a formal sample panel of roadway segments. Like onroad mobile sources, emissions from some other processes are estimated for time periods less than annual. As an example, pollutant emissions for seasonal processes are estimated for only a portion of the year in which they occur (i.e., winter burning season). The NEI attempts to capture the full universe of large point source facilities, which are closely monitored and located individually by the state and local agencies. Most Point EGU emissions are individually measured with continuous monitoring devices. These data are summarized to annual average emissions for all 50 states and their counties, D.C., the U.S. territories of Puerto Rico and Virgin Islands, and as available, for some of the territories of federally-recognized American Indian nations, and are widely used and accepted as an indicator of national and regional emission trends over time.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The annual emissions are directly estimated in most cases, or are simply totaled from monthly or seasonal estimates - there is no transformation.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The NEI is designed to explicitly answer the question posed in the ROE. This indicator estimates emissions from all anthropogenic sources of a primary air pollutant.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The emission estimates that comprise the NEI are non-specific for sensitive populations or ecosystems. Rather, the data are specific for types of emission processes and as such, are representative of how much and where those process emissions occur by county for the nonpoint sources and by individual facility location for the point sources.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator(s) directly addresses changes in air pollutant emissions from year-to-year and the contributions of various types of emissions sources, by county, and for every state. Air pollutant emissions are a reliable gauge of impact on the environment and when considered along with air quality transport and transformation issues, are the foundation for air quality analysis, including health indicators. Emission reductions generally indicate positive impact on air quality. Average annual pollutant emission trends over time may also reference a specific year or years in the time series, during which emission reductions were realized due to previous year implementation of federal, regional, or local control and compliance programs. There are no thresholds or ranges of values associated with safe levels of emissions for this indicator.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The NEI is a composite of many data sources, much of which is provided by state and local agencies and comes to EPA with little or no documentation on the specific methods used to generate the estimates. An emission inventory guidebook of methods, which is endorsed by the EPA and the state and local agencies (STAPPA/ALAPCO), is generally used by state and local agencies as reference for acceptable methods. The guidebook of methods is located on http://www.epa.gov/ttn/chief/eiip/techreport/. For emissions that are reported by the states as direct measurements from monitoring devices, the analytical procedures are referenced on http://www.epa.gov/ttn/emc/. Documentation of the procedures that EPA used to compile the NEI data for some of the more recent years in the time series is located on http://www.epa.gov/ttn/chief/net/neidata.html and is more organized and descriptive than documentation for previous year data. Documentation for the earlier years noted in the time series is located on http://www.epa.gov/ttn/chief/trends/procedures/neiproc99.pdf. Some of the methods noted have subsequently been revised for specific processes and years as EPA has gone back to update and apply improved methods. The documentation sources noted above will also describe use of emission factors. Documentation on process specific emission factors and how they were derived is located on http://www.epa.gov/ttn/chief/ap42/index.html.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The national annual NEI criteria emission trends summaries, as presented in the indicator, are publicly available on http://www.epa.gov/airtrends/econ-emissions.html. The national annual NEI hazardous air pollutant (HAP) data for year 1999, as presented in the indicator, are publicly available on http://www.epa.gov/air/data/index.html. Data format information typically resides at the same location as the data itself.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The EPA's documentation (see that noted in T3Q1) of how the NEI data estimates are generated will facilitate reproduction of some emission process estimates. As the EPA's documentation has evolved and improved over the years, it is expected that the more recent data years are documented in a more organized and transparent manner and would best enable reproducibility of emission estimates. Where EPA's documentation for specific years indicates that data was incorporated as that received from the state and local agencies, there is no additional documentation available by which to reproduce the state-derived values.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Much of the data that is used to compile the NEI is gathered indirectly from multiple and numerous sources, as referenced in the estimation methods information under T1Q1. These indirect data sources are presumed to have their own QA practices. Where state-supplied emissions estimates are used for some sectors and pollutants, it is presumed that states have QA plans in most cases but EPA does not systematically obtain information on QA practices from the states. The EPA contractors who use data sources and EPA-developed emissions factors to make emissions estimates operate under general contract-wide quality assurance plans, which can be made available on request. In addition, the EPA's more recent QC practices performed during the blending and merging of data from numerous sources, are described in the 2002 NEI Preparation Plan located on http://www.epa.gov/ttn/chief/net/2002inventory.html.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

No statistical generalization is performed to generate the national annual emissions trends presented in the indicator. The annual pollutant totals are developed at the plant or county level and then simply totaled and summarized at the regional and national levels.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No. At present, statistical uncertainty measures are not available for the underlying data that comprise the indicator. Most of the QA routines that are currently performed by EPA are sector data comparisons between different years or geographic areas, rather than on individual data variables. Much of the associated data variables for a specific sector are implied or not highly characterized, and therefore do not lend themselves well at present to quantitative uncertainty analysis.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Yes, OAQPS has developed standardized procedures for quality assuring the NEI as discussed in the "2002 NEI Preparation Plan" (http://www.epa.gov/ttn/chief/net/2002neiplan_081004final.pdf). The procedures include use of software to facilitate and standardize review of the data by EPA regional offices and state, local and tribal agencies. During the review process, industries often closely review their emission estimates to ensure they have been correctly incorporated in the NEI. In addition, OAQPS is able to use techniques which contrast data from various sources and from several inventory years to understand variability and identify areas in need of additional review. Where several data sources are available, assessments of data quality are conducted by OAQPS to ensure use of the highest quality emissions data when developing the NEI. The sum of the review procedures used for developing the NEI is believed to yield data of sufficient quality to support the conclusions which typical users will derive from the indicators. However, for the most rigorous applications, the NEI may be used in conjunction with ambient monitoring data and air quality and source receptor models to better characterize air quality problems and thus reduce uncertainties.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The indicator represents aggregated data. Most of the data is the result of a calculation that combines an emission rate per unit of input or output and a measure of that input or output, rather than a direct measurement of emissions. All states and counties are represented in the NEI, however not all states and local agencies may provide the same data or level of detail for a given year. State and local agencies may prioritize their data development efforts on emissions in county and metropolitan areas that are nonattainment for specific ambient air quality standards, i.e., ozone or PM2.5 NAAQS. The result may be more complete and quality assured data submissions to the NEI for these areas. Where data is absent or incomplete, EPA performs some data extrapolation from previous year data or other data sources. Inference follows many processes, depending on source type, etc. To the extent possible, facility-specific or county-specific information is used. In some cases, all counties in a state are assumed to have common properties influencing emissions, for example daily low and high temperatures. Best available or at most plausible substitutes are used where needed. For example, gasoline fuel properties are not available for all counties, known fuel properties in nearby counties subject to similar regulations on gasoline are used instead. Various and not fully consistent methodologies have been used to develop the emission estimates in the NEI. This is to be expected considering the variety of organizations that have contributed the estimates.

Indicator: Blood Cotinine Level (102, 107)

Environmental tobacco smoke (ETS) contains a mixture of toxic chemicals, including known human carcinogens. Persistent exposure to ETS is associated with an increased risk for lung cancer and other diseases (CDC, 2003). Children are at particular risk from exposures to ETS, which may exacerbate existing asthma among susceptible children and also greatly increase the risk for lower respiratory-tract illness, such as bronchitis and pneumonia, among younger children (CDC, 2003).

Exposure to ETS leaves traces of specific chemicals in people's blood, urine, saliva, and hair. In its nationwide health surveys, the Centers for Disease Control and Prevention (CDC) measures blood concentrations of cotinine to assess exposure to ETS. Cotinine is a chemical that forms inside the body following exposure to nicotine, an ingredient in all tobacco products and a component of ETS. Following nicotine exposures, cotinine can usually be detected in blood for at least 1 or 2 days (Pirkle et al., 1996). Active smokers almost always have blood cotinine levels higher than 10 nanograms per milliliter (ng/mL), while non-smokers exposed to low levels of ETS typically have blood concentrations less than 1 ng/mL (CDC, 2003). Following heavy exposure to ETS, non-smokers can have blood cotinine levels between 1 and 15 ng/mL. As part of the National Health and Nutrition Examination Survey III (NHANES III, 1988-1991), CDC determined that the median blood serum level (50^{th} percentile) of cotinine among non-smokers in the general U.S. population was 0.20 ng/mL (Pirkle et al., 1996).

This indicator reflects blood cotinine concentrations in ng/mL for the United States population, aged three year and older, as measured in the 1999-2000 National Health and Nutrition Examination Survey (NHANES). NHANES is a series of surveys conducted by CDC's National Center for Health Statistics (NCHS) that is designed to collect data on the health and nutritional status of the civilian, non-institutionalized U.S. population using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. These data are presented here as a baseline with the intent of reporting trends in the future.

What the Data Show

In NHANES 1999-2000 (see Table 102_107Cotinine), the median serum levels among non-smokers nationwide was 0.06 ng/mL. This marks a 70% decrease from levels measured in the 1988-1991 NHANES III survey — a reduction that suggests a marked decrease in exposure to ETS (Pirkle et al., 1996). Further, decreased blood cotinine levels were observed in each of the population groups defined by age, sex, and race/ethnicity (CDC, 2003).

Table 102-107Cotinine shows the results of the NHANES 1999–2000 survey, both for the overall population and for different sub-populations. These data reveal three current trends: (1) non-smoking males have higher cotinine levels than non-smoking females; (2) of the ethnic groups considered, non-Hispanic African Americans had the highest cotinine levels; and (3) on average, people below age 20 have higher levels of blood cotinine than people aged 20 years and older.

Indicator Limitations

- NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 2 years of data in NHANES 1999-2000, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representative of coverage.

- The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2000 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses.

- For NHANES 1999-2000, the first stage of selection was the PSU-level. The PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 NHANES sample is selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates.

- NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999 and 2000, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported.

- The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value.

- The measurement of an environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.

Data Sources

Centers for Disease Control and Prevention (CDC). 2003. Second National Report on Human Exposure to Environmental Chemicals. (Accessed November 21, 2004). http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

References

Centers for Disease Control and Prevention (CDC). 2003. Second National Report on Human Exposure to Environmental Chemicals. (Accessed November 21, 2004). http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

Pirkle JL, Flegal KM, Bernert JT, Brody DJ, Etzel RA, Maurer KR. 1996. Exposure of the U.S. Population to Environmental Tobacco Smoke: The Third National Health and Nutrition Examination Survey, 1988 to 1991. Journal of American Medical Association 275:1233-1240.

Graphics

Air Chapter – Indoor Air Exposure – Cotinine Levels

Table 102_107Cotinine. Selected percentiles of serum cotinine concentrations (in ng/mL) for the United States non-smoking population, aged 3 years and older, National Health and Nutrition Examination Survey (NHANES), 1999-2000

	Sample Size	10th	25th	50th	75th	90th
Total, Age 3 years and older	5,999	<LOD	<LOD	0.06	0.24	1.02
Sex						
Male	2,789	<LOD	<LOD	0.08	0.30	1.20
Female	3,210	<LOD	<LOD	<LOD	0.18	0.85
Race Ethnicity*						
Black, non-Hispanic	1,333	<LOD	<LOD	0.13	0.50	1.43
Mexican American	2,242	<LOD	<LOD	<LOD	0.14	0.51
White, non-Hispanic	1,949	<LOD	<LOD	0.05	0.21	0.95
Age Group						
3-11 years	1,174	<LOD	<LOD	0.11	0.50	1.88
12-19 years	1,733	<LOD	<LOD	0.11	0.54	1.65
20+ years	3,052	<LOD	<LOD	<LOD	0.17	0.63

*Other racial/ethnic groups are included in the Total only

<LOD = Less than the limit of detection of 0.05 ng/mL in serum

Source: Centers for Disease Control and Prevention. 2003. Second National Report on Human Exposure to Environmental Chemicals. (Accessed November 21, 2004) http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

R.O.E. Indicator QA/QC

Data Set Name: BLOOD COTININE LEVEL
Indicator Number: 102 (89102)
Data Set Source: CDC, NHANES
Data Collection Date: ongoing
Data Collection Frequency: two year cycles starting with 1999
Data Set Description: Blood Cotinine Level
Primary ROE Question: What are the trends in indoor air quality and it's effects on human health?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. Blood samples were collected and processed in accordance with the methods indicated in the National Health and Nutrition Examination Survey (NHANES) Specimen Collection and Laboratory/Medical Technologists Procedures Manual (LPM). See: http://www.cdc.gov/nchs/data/nhanes/blood.pdf; http://www.cdc.gov/nchs/data/nhanes/LAB1-6.pdf. Serum cotinine is measured by an isotope dilution high performance liquid chromatography/atmospheric pressure chemical ionization tandem mass spectrometric (ID HPLC-APCI MS/MS) method. Briefly, the serum sample is spiked with methyl-D, cotinine as an internal standard, and following an equilibration period, the sample is applied to a basified solid phase extraction column. Cotinine is extracted off the column with methylene chloride, the organic extract is concentrated, and the residue is injected onto a short, C18 HPLC column. The eluant from these injections is monitored by APCI-MS/MS, and the m/z 80 daughter ion from the m/z 177 quasi-molecular ion in quantitated, along with additional ions for the internal standard, external standard, and for confirmation. Cotinine concentrations are derived from the ratio of native to labeled cotinine in the sample by comparisons to a standard curve (http://www.cdc.gov/nchs/data/nhanes/frequency/lab06_doc.pdf). The units used for this indicator were ng/L (http://www.cdc.gov/nchs/data/nhanes/frequency/varlab.pdf).

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. NHANES is designed to provide statistically representative national averages. Starting with NHANES 1999, the survey is conducted annually. All participants aged 3 years or older in NHANES 1999-2000 were measured for blood cotinine. The measurements produced by NHANES for this indicator were used in the "Second National Report on Human Exposure to Environmental Chemicals" published by the National Center for Environmental Health in 2003 (http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf).

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The data presented are direct measurements.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

This indicator is based on a national probability-based sampling design and is deemed of sufficient quality for generalization to the nation. The samples for 1999-2000 were used for this analysis. Quality assurance measures were in place. Beginning in 1999, NHANES became a continuous and annual survey. The sampling plan for each year follows a complex, stratified, multistage, probability-cluster design to select a representative sample of the civilian, noninstitutionalized population. Every year, approximately 7,000 individuals, of all ages, are interviewed in their homes; of these, approximately 5,000 complete the health examination component of the survey. The survey sample size for NHANES 1999-2000 is 9,965 (http://www.cdc.gov/nchs/data/nhanes/gendoc.pdf).

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The current sampling design includes oversampling of African Americans, Mexican Americans, adolescents (12-19 year olds), older Americans (60 years of age and older), and pregnant women to produce more reliable estimates for these groups.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator simply indicates that exposure to environmental tobacco smoke (ETS) has occurred. Cotinine is a major metabolite of nicotine and is currently regarded as the best biomarker in active smokers and in nonsmokers exposed to ETS. Nonsmokers exposed to typical levels of ETS have cotinine levels of less than 1 ng/mL, with heavy exposure to ETS producing levels in the 1-10 ng/mL range. Active smokers almost always have levels higher than 10 ng/mL, and sometimes higher than 500 ng/mL. As reported in "Second National Report on Human Exposure to Environmental Chemicals" published by the National Center for Environmental Health in 2003 (http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf). The measurement of an environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Documentation for NHANES 1999-2000 is found on NCHS/CDC website at the following URL: http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files. The following provides more specific examples: The Addendum to the NHANES III for the 1999-2000 dataset clearly outlines the 1999-2000 sampling design and recommends analytic procedures (http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf; http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf).The "Second National Report on Human Exposure to Environmental Chemicals" published by the National Center for Environmental Health in 2003 more generally describes the NHANES 1999-2000 sampling plan (http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf).Laboratory measurement information: http://www.cdc.gov/nchs/data/nhanes/frequency/lab06_doc.pdf. And the "Weighting Notes" posted on the NHANES website also offer helpful advice (http://www.cdc.gov/nchs/data/nhanes/frequency/weights%20to%20usev6.pdf). Information contained in Table A1 can be found at: Centers for Disease Control and Prevention. 2003. Second National Report on Human Exposure to Environmental Chemicals. (Accessed November 21, 2004) http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

For the most part, Individual level data are available, but data access limitations do exist for some variables due to confidentiality issues (http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files).

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The Addendum to the NHANES III for the 1999-2000 dataset clearly outlines the 1999-2000 sampling design and recommends analytic procedures (http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf; http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf).

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The quality assurance plans for NHANES 1999-2000 are available from the Division of Data Dissemination, NCHS, 6525 Belcrest Rd. Hyattsville, MD, 20782-2003. Tel. 301-458-4636. http://www.cdc.gov/nchs/about/quality.htm.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The NHANES 1999-2004 survey is designed to be annually nationally representative of the U.S. citizen, non-institutionalized population (see page 11 of the addendum linked below) (http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf).

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes (see pages 11-19 of the addendum linked below) (http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf).

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 2 years of data in NHANES 1999-2000, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representative of coverage. The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2000 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses. For NHANES 1999-2000, the first stage of selection was the PSU-level. The PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 NHANES sample is selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates. NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999 and 2000, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported. The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value. For more information, see the addendum to NHANES III linked below: http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

As subsequent years are added to this survey, estimates will become more stable. However, with the laboratory data, there is no guarantee that an environmental chemical will be measured from year to year. Cotinine was measured in the next two year cycle 2001-2002 (http://www.cdc.gov/exposurereport/pdf/third_report_chemicals.pdf). Serum cotinine was measured in all people in the survey year aged three years and older. The measurement of an environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.

Indicator: U.S. Homes Above EPA's Radon Action Levels (013)

Radon is a radioactive gas. It comes from the decay of uranium that is naturally occurring and commonly present in rock and soils. It typically moves up through the ground to the air above and into a home through pathways in ground contact floors and walls. Picocuries per liter of air (pCi/L) is the unit of measure for radon in air (the metric equivalent is Bequerels per cubic meter of air or Bq/m^3).

Each year radon causes an estimated 21,000 lung cancer deaths in the United States (17,260 among smokers and 2,740 among never-smokers). Radon is the second leading cause of lung cancer after smoking, and smokers are at higher risk of developing Radon-induced lung cancer. Radon accounts for about 13% of all lung cancer mortality (EPA, 2003). Because radon remains a serious public health issue, Dr. Richard Carmona, the U.S. Surgeon General, on January 13th 2005 issued a national Radon Health Advisory.

The lung cancer risk from exposure to radon in the indoor air of homes has been confirmed by case control studies involving both European and North American homes (Darby et al. 2005, Krewski et al. 2005). The earlier EPA risk assessment and that of the National Research Council/NAS were based on the risk to miners extrapolated to homes (NRC 1999, EPA 2003).

The *National Residential Radon Survey* (EPA 1992), found that the average indoor radon level in the United States to be about 1.25 pCi/L. The risk assessments cited above generally assumed a lifetime exposure to this average indoor level. To reduce the risk of lung cancer, EPA has set a recommended "action level" of 4 pCi/L for homes. At that level, it is cost-effective for occupants to reduce their exposure by mitigating their home. In about 70% of cases, a properly installed mitigation system will reduce the indoor radon level to 2 pCi/L or less most of the time. Typically, a home is mitigated based on the average of two radon measurements for real estate transactions. A measurement to confirm the (lower) radon level and proper operation of the mitigation system is typically made following installation.

This indicator is based on: (1) the number of U.S. homes estimated to be at or above the EPA recommended radon action level of 4 pCi/L, i.e., homes with an elevated radon level based on Census data and EPA's National Radon Residential Survey (1992); and (2) the number of homes with operating radon mitigation system. The gap between the homes in (1) and in (2) is the number of homes that have not yet been mitigated (generally, homes are only mitigated if the EPA recommended radon action level of 4 pCi/L or more is measured). The number of homes above 4 pCi/L was derived from U.S. Census data to be consistent with the estimates originally developed in the (radon) *Technical Support Document* (TSD). The number of homes with an operating mitigation system (HOMS) was developed from radon vent fan (RVF) sales data provided voluntarily by fan manufacturers.

What the Data Show

There has been a 370 % increase in the number of homes with an operating mitigation system in 2004 compared to those mitigated in 1990, from 155,000 to 577,000 over 14 years (Figure 013-1). There has been a 126% increase in the estimated number of homes with radon levels greater than 4pCi/L, from about 5 million to 6.3 million over 14 years.

It has been reported anecdotally that radon vent fans/mitigation systems are also being used to control for soil gases/intrusion in homes in the vicinity of RCRA, Superfund, UST/AST and similar sites as an element of corrective action plans. While fans used in this way may provide a radon reduction benefit, they could be considered a subtraction from the number of homes with an operating mitigation system, thus reducing slightly the slope of the trend line.

Indicator Limitations

- The indicator presumes that radon vent fans are used for their intended purpose; the available information supports this premise.

- Homes where the vent fan has failed and has not been replaced have not been added back into the pool of elevated homes.

Data Sources

U.S. Environmental Protection Agency. *National Radon Residential Survey: Summary Report*, EPA 402-R-92-011. Washington, DC; US Environmental Protection Agency, Office of Air and Radiation, October 1992. (*Report is not available online*)

U.S. Environmental Protection Agency. *Technical Support Document*, EPA 400-R-92-011, Mat 1992.

U.S. Environmental Protection Agency. *Homes With Operating Mitigation Systems*, unpublished industry data; Indoor Environments Division, Washington DC; 2005.

References

S. Darby et al. 2005. Radon in Homes and Risk of Lung Cancer: Collaborative Analysis of Individual Data From 13 European Case-Control Studies. British Medical Journal, 330 (7485): 223.

D. Krewski, J.H. Lubin, J.M. Zeilinski, M. Alavanja, V.S. Catalan, R.W. Field, et al., 2005. Residential Radon and Risk of Lung Cancer: A Combined Analysis of 7 North American Case-Control Studies, Epidemiology (2):137-45.

National Research Council (NRC), 1999. *Health Effects Of Exposure To Radon: BEIR VI*, National Academy Press, (http://www.epa.gov/iaq/radon/beirvi.html)

U.S. Environmental Protection Agency. 1992. *National Radon Residential Survey: Summary Report*, EPA 402-R-92-011. Washington, DC; US Environmental Protection Agency, Office of Air and Radiation, October.

U.S. Environmental Protection Agency. 2003. *EPA Assessment of Risks from Radon in Homes*, EPA 402-R-03-003. Washington, DC; US Environmental Protection Agency, Office of Radiation and Indoor Air, (www.epa.gov/radiation/docs/assessment/402-r-03-003.pdf)

Graphics

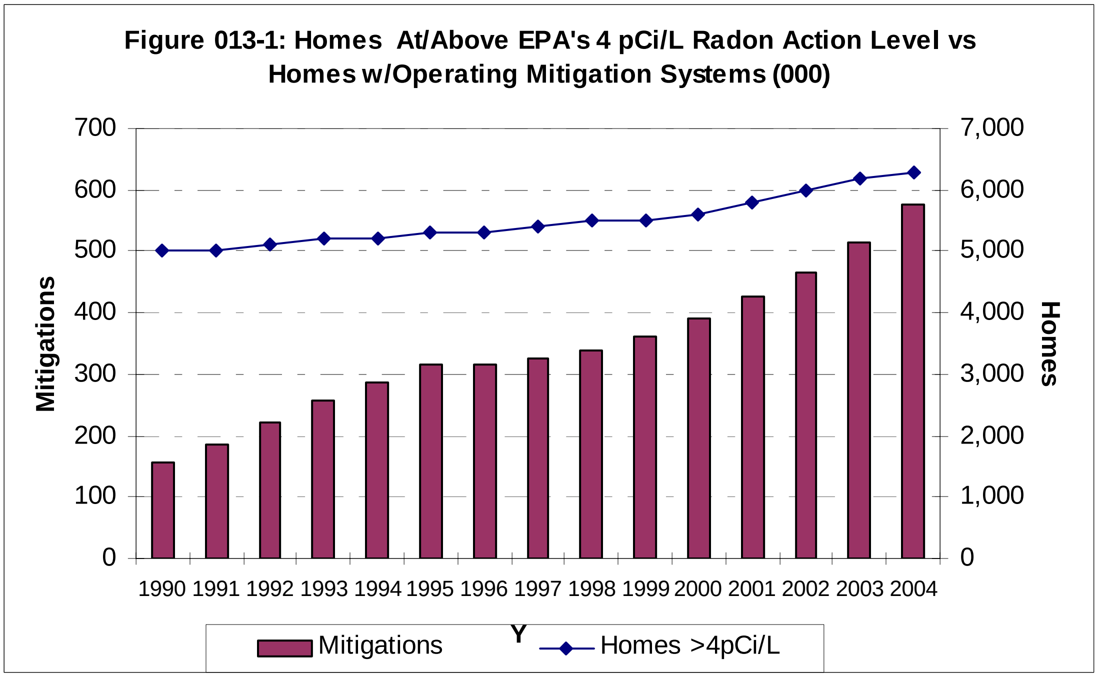


Figure 013-1: Homes At/Above EPA's 4 pCi/L Radon Action Level vs Homes w/Operating Mitigation Systems (000)
Mitigations
Homes
700
600
500
400
300
200
100
0
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004
Y
Mitigations
Homes >4pCi/L

R.O.E. Indicator QA/QC

Data Set Name: US HOMES ABOVE EPA'S RADON ACTION LEVEL
Indicator Number: 013 (118091)
Data Set Source:
Data Collection Date:
Data Collection Frequency:
Data Set Description: US Homes Above EPA's Radon Action Level
Primary ROE Question: What are the trends in indoor air quality and it's effects on human health?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

In making physical measurements of radon in air, the established radon measurement industry in the U.S., EPA believes, generally make them consistent with EPA, state and industry protocols and quality assurance guidance. Measuring radon (radiation) in homes is well understood and has been widely practiced since the mid-1980’s. (Protocols for Radon and Radon Decay Product Measurements in Homes, EPA 402-R-92-003, May 1993

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

There are two types of data at issue here. First, the data on the number of homes above the EPA action level was generated based on a template first used in the Technical Support Document (TSD)(EPA 402-R-92-011, May 1992) created to support development of EPA’s 1992 A Citizen’s Guide to Radon (EPA 402-K02-006, May 2004) and the Home Buyer’s and Seller’s Guide to Radon (EPA 402-R-00-008, July 2000). That template and subsequent application of it are based on U.S. Census housing/population data tables. The TSD (and its derivative documents) was extensively peer reviewed, including by the EPA Science Advisory Board (SAB) and stakeholders. Second, the data on the number of homes with operating mitigation systems is derived from radon vent fan sales data. The primary sources for this data are three radon vent fan manufacturers that are responsible for 99% of the market. Annual updates solicited by EPA from these manufacturers yield data on the number of radon vent fans sold, their potential non-radon application or use, and estimates of their useful life (the latter is also checked against similar information from practicing mitigation practitioners in the field). Individual company information is treated as confidential business information (CBA). Only homes that have had a radon measurement are mitigated. Following mitigation, a test confirming reduction of the radon level to less than 4 pCi/L is routinely made.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The approach (described in T1Q2) and the data have been peer-reviewed attendant to publication (web) of earlier versions of the Radon Progress Report, and other documents prepared for internal EPA use (e.g., briefings, fact sheets, etc., for use by management). Variations on this approach have been used by the Agency since the early-1990s. This indicator is as direct and unencumbered a measure of risk reduction as is currently available within the existing limitations.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

As a measure of public health and risk reduction this indicator is the most appropriate currently available.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

The most relevant reference points, thresholds and ranges of values ate these: (1) EPA's public action level of 4 pCi/L; (2) the average indoor radon level of 1.25 (1.3) pCi/L; (3) the effectiveness of radon mitigation, i.e., radon reductions to less than 2 pCi/L in 70% of residential mitigations; (4) Census data as the basis for estimating the number of homes above the action level (1); and (5) the range of homes estimated to have an operating mitigation system based on three data points reflecting the useful life of a radon vent fan (i.e., 8, 10 and 12 years). All of these values (data) were established through valid survey, assessment and study designs.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

This information is documented in the draft chapters Homes With Operating (Active) Mitigation Systems and the Scope of the Radon Risk in Homes from the (as yet) unpublished Radon Progress Report (Jalbert, et al., Draft 2005). An earlier version of this report is available on the IED website (http://www.epa.gov/iaq/radon/images/natl_radon_results_update.pdf). The base Census data is publicly available.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The complete data set for radon vent fan sales by year and by company is not available due to business confidentiality limitations imposed by the providers. (Phil Jalbert, 202-343-9431, jalbert.philip@epa.gov).

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. This information is contained in EPA program staff files and to a lesser (but sufficient) degree in the draft or published above cited reports.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The quality/integrity of the Census data is presumed adequate. The quality/integrity of the manufacturer provided data is presumed sufficiently accurate given that it is primary (unaltered) sales data.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Not Applicable.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. For one-half the indicator, i.e., the number of homes with an operating mitigation system (HOMS), a range (8-10-12 years) has been developed based on the estimated useful life of radon vent fans generally (see also T2Q3).

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Yes. However, IED's current preference is to use the central estimate in the range of a radon vent fan's useful life, i.e., 10 years (see also T2Q3, T4Q2). T4Q4. Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available? Currently there are none known or quantified. However, a potential limitation exists that IED is investigating, i.e., the use of radon vent fans/mitigation systems in non-radon applications. It has been reported anecdotally that radon vent fans/mitigation systems are being used to control for soil gases/intrusion in homes in the vicinity of RCRA, Superfund, UST/AST and similar sites as an element of corrective action plans.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Charge to the Peer Reviewers:
Water and Other Relevant Indicators
for the U.S. Environmental Protection Agency's
2007 *Report on the Environment* Technical Document
May 20, 2005

The U.S. Environmental Protection Agency (EPA) has asked that independent peer reviewers critically review the indicators that the Agency proposes to use for its 2007 *Report on the Environment*—Technical Document (ROE07 TD). The purpose of this peer review is to ensure that the proposed indicators are appropriate, adequate, and useful for evaluating our nation's waters in general; useful for answering the questions posed in ROE07; meet technical requirements (including the indicator definition and criteria); are properly documented; and are scientifically sound. Separate peer reviews will be conducted for the indicators proposed for each of the five main chapters in the ROE07. This charge provides background and instructions for peer review of the *water* indicators. It includes the following sections and attachments:

- Section 1: Background information on ROE07 TD
- Section 2: Indicator definition and criteria
- Section 3: Charge and materials for the individual pre-workshop review
- Section 4: The peer review meeting
- Attachment 1: Questions and Proposed Indicators for the ROE07 Technical Document
- Attachment 2: Comment Sheet for Group 1 Indicators
- Attachment 3: Comment Sheet for General Questions for Group 1 Indicators
- Attachment 4: Comment Sheet for Group 2 Indicator
- Attachment 5: List of and EPA Rationale for Withdrawn ROE03 Indicators (will be posted by 6/10/05)
- Attachment 6: Indicator Materials for Review (included as subsequent sections of this binder).

Section 1: Background

In 2003, EPA published its first draft *Report on the Environment* (ROE03). ROE03 is a set of two question-driven reports comprising:

- A Technical Document (TD), which provides the scientific foundation for the ROE.
- A shorter Public Document that distills information in the TD for a non-technical audience.

These two reports were intended to identify and present the best available national-level indicators to help answer broad questions about the state of the nation's environment in five topic areas (chapters): air, water, land, human health, and ecological condition. In addition to reporting what we know, the ROE03 was also intended to point out where current data and understanding fall short of fully answering the questions in terms of delivering national, consistent, comprehensive data about the state of the nation's air, water, land, human health, and ecological condition. The ROE03 also presented some contextual information from other scientific sources in order to provide background and explain indicator data gaps.

EPA's Administrator has requested that the generation of Reports on the Environment be continued into the future. Current plans are for future reports to be developed on an approximately 3-year reporting cycle. To support the next anticipated ROE release in 2007, EPA has compiled a set of proposed indicators to help answer the questions posed for the 2007 Technical Document. EPA proposes reporting on both national-level indicators, national-level indicators that are provided at the scale of EPA regions, as well as several region-level indicators. As with ROE03, the questions are organized into five topic areas: air, water, land, human health, and ecological condition. There will be a separate chapter in the ROE07 Technical Document for each topic area. Each chapter will describe the set of questions for the topic area and the indicators that answer those questions.

Many of the indicators proposed for ROE07 were presented in ROE03, but some are new and others have new data sources. In addition, after refining the indicator definition and criteria (see boxes on the following pages), and applying both more consistently to the proposed indicator list, EPA recommends that some indicators from ROE03 not be presented in 2007.

To ensure that the indicators presented in the ROE07 TD are supported by data that are technically sound, meet the established indicator definition and criteria, and help answer the questions posed in the ROE, EPA has contracted with ERG to organize an independent peer review of the proposed ROE07 indicators.

Reviewers for the water indicators are charged with four tasks:

1) Assess whether the proposed water indicators are appropriate, adequate, and useful for evaluating and establishing an overall picture of our nation's waters.

2) Evaluate the proposed indicators with respect to their importance in terms of their ability to respond to the question.

3) Evaluate the proposed water and related indicators and their underlying data with respect to the ROE indicator definition and criteria presented below.

4) Identify any additional ***national-level*** water indicators that currently exist which meet the ROE indicator definition and criteria, help to answer one of the ROE questions, and for which data are readily available such that text and graphics describing the indicator could be developed within a short time frame (approximately 6 weeks).

Section 2: Indicator Definition and Criteria

Each indicator in ROE07 should conform to the following definition.

Definition: Indicator

For purposes of the ROE, an “indicator” is ***a numerical value derived from actual measurements of a pressure, ambient condition, exposure, or human health or ecological condition*** *over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment*. Indicators and their underlying data must meet criteria (see box below) for data quality, comparability, representativeness, and adequate coverage in time and space. Note that indicators rely on an underlying database or set of databases, but the databases themselves are not indicators.

In the above definition, "derived from" means that trends in *actual environmental observations* (e.g., rather than estimates or projections) must serve as the principal driver for trends in the indicators.

EPA has defined six indicator levels, as follows. Note that levels 1 and 2 are administrative indicators that measure progress in implementing environmental programs, and compliance with or response to those programs. They are *not* the subject of ROE07. Levels 3 through 6 indicators reflect environmental results/condition and are the subject of ROE07.

Description of Indicator Levels

Level 1 (Administrative—not covered by ROE07): Government Regulations/Activities. Examples: policy leadership, statutes, regulations, guidance, information.

Level 2 (Administrative—not covered by ROE07): Actions/Responses by Regulated and Non-regulated Parties. Examples: Pollution prevention and control, recycling, changes in consumer behavior, best management practices.

Level 3 (Environmental): Changes in Pressure or Stressor Quantities. Examples: Pollutants entering media, habitats altered or destroyed, hydrologic alteration.

Level 4 (Environmental): Ambient Conditions. Examples: Pollutant concentrations in media, food and drinking water, solid wastes in landfills, radiation; temperature, habitat condition, hydrology.

Level 5 (Environmental): Exposure or Body Burden/Uptake. Examples: Biological markers of uptake in people, plants, animals, or microorganisms.

Level 6 (Environmental): Changes in Human Health or Ecological Condition. Examples: Morbidity, mortality, biotic structure, and ecological processes.

Each indicator in ROE07 should conform to the following criteria:

Indicator Criteria

1) The indicator makes an important contribution to answering a question for the ROE. (In this context, "important" means that the indicator answers a substantial portion of and/or a critical part of the question.)
2) The indicator is objective. It is developed and presented in an accurate, clear, complete, and unbiased manner.
3) The underlying data are characterized by sound collection methodologies, data management systems that protect their integrity, and quality assurance procedures.
4) Data are available to describe changes or trends, and the latest available data are timely.
5) The data are comparable across time and space, and representative of the target population. Trends depicted in this indicator accurately represent the underlying trends in the target population.
6) The indicator is transparent and reproducible. The specific data used and the specific assumptions, analytic methods, and statistical procedures employed are clearly stated.

Section 3: Charge and Materials for the Individual Pre-Workshop Review

Attachment 1 lists all the ***proposed questions*** and ***associated indicators*** for the 2007 ROE by topic area. Pages 3 to 5 list the indicators to be reviewed by water reviewers[1]. Note that, for review purposes, there are two groups of indicators:

- **Group 1: Proposed Water Indicators.** Indicators that are proposed to answer one of the seven questions posed in the water chapter *and* that will be *written up in that chapter*.

- **Group 2: One Relevant Indicator from the Land Chapter.** This indicator is *proposed to answer a question in the land chapter* and will be written up in that chapter, but peer-reviewed by water reviewers since it is related to water.

The materials and instructions for reviewing each group of indicators are described below. Please conduct the review in the sequence indicated. Forms are provided as Attachments 2 through 4 to this charge to structure your review. Attachment 5 provides background for Step 2, below. The materials to be reviewed are provided in Attachment 6.

Step 1: Review Group 1 Indicators

For each indicator in Group 1, Attachment 6 provides:

[1] A few indicators are listed in a light gray font and marked as "Indicators to be Provided by July 2." These indicators are still being developed and, if available in time for this review, will be provided to you by July 2.

- *Draft text* introducing the indicator, identifying the underlying data used to evaluate the indicator, and describing data interpretations. EPA proposes including this text in the ROE07 TD.

- *Draft graphic(s)/table(s)* to help readers visualize spatial and temporal trends in the indicator. EPA proposes including these graphics in the ROE07 TD.

- *An information quality review form* that presents detailed background information on the indicator and its supporting data (e.g., data quality, coverage, processing). EPA documents this information for the overall project record and to facilitate peer review of the indicators.

Collectively, these three items should adequately present each indicator and thoroughly document the information that EPA considered when evaluating the indicators for ROE07. For each indicator in this category, you should thoroughly review the draft text, draft graphics/tables, and information quality review forms provided. Then, document your review comments by filling out the "Comment Sheet" in Attachment 2 *for each indicator*.

This sheet asks you a series of questions about each indicator. For questions 1 through 4, you are asked to provide a numerical response on a scale of 1 to 4 and then a written explanation of the rationale for your numerical response. Question 5 asks about graphical presentation and question 6 asks you to provide any other comments, concerns, or suggestions about the indicator that you did not already cover in your responses to Questions 1 through 5. Question 7 asks you to state whether you think the indicator merits inclusion in ROE07.

Step 2: Consider General Questions for Group 1 Indicators

After completing your reviews for the individual Group 1 indicators, as described above, please use Attachment 3 to answer the following two questions for these indicators:

- **General Question 1:** Considering the Group 1 indicators collectively, do any of these indicators clearly seem to be more appropriate, adequate, or useful for evaluating our nation's waters or for establishing an overall picture of our nation's waters than others? Do any seem to be more important than the others for answering the question they are intended to answer? Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators or if it covers an area of diminishing interest environmentally.

- **General Question 2:** Are there any additional <u>*national-level*</u> indicators that currently exist, but were not proposed for ROE07, that you would recommend for ROE07? Proposed indicators should meet the ROE indicator definition and criteria, be national in scale, make an important contribution to answering one of the ROE questions in your topic area, be of a quality that likely would pass this type of peer review, and have data that are readily available (e.g., could be compiled within 6 weeks or less). For any new indicators proposed, provide detailed justification for their inclusion and list references or citations for the associated underlying data sources. As you consider this question, please read Attachment 5, which provides the list of water and other indicators presented in

ROE03 that EPA does not intend to carry forward to ROE07, along with EPA's rationale for withdrawing them. If you disagree with EPA's rationale and feel any of these indicators should be included in ROE07, please so indicate in your response to this question, along with your rationale for why they should be included. Note: The full text and graphics for the ROE03 indicators can be viewed on-line at: http://www.epa.gov/indicators/roe/html/tsd/tsdWater.htm

Step 3: Review One Group 2 Indicator

Group 2 comprises one indicator that is *proposed to answer a question in the land chapter* and will be written up in that chapter, but peer-reviewed by water reviewers since it is related to water. You are asked to review the Group 2 indicator in the same way you reviewed Group 1 indicators under Step 1. For the Group 2 indicator, Attachment 6 provides:

- *Draft text* introducing the indicator, identifying the underlying data used to evaluate the indicator, and describing data interpretations.

- *Draft graphic(s)/table(s)* to help readers visualize spatial and temporal trends in the indicator.

- *An information quality review form* that presents detailed background information on the indicator and its supporting data (e.g., data quality, coverage, processing).

Collectively, these three items should adequately present the indicator and thoroughly document the information that EPA considered when evaluating the indicator for ROE07.
For this indicator, you should thoroughly review the draft text, draft graphics/tables, and information quality review form provided in Attachment 6. Then, document your review comments by filling out the "Comment Sheet" in Attachment 4.

Preparing for the Peer Review Workshop

After receiving the reviewers' pre-meeting comments, ERG will compile these comments and distribute them to all peer reviewers. Please familiarize yourself with the pre-meeting comments of the other water peer reviewers prior to the peer review workshop.

Note that the pre-meeting comments are preliminary in nature and are intended to help initiate discussion at the peer review meeting. Reviewers may change their comments based on discussion at the peer review meeting.

Section 4: The Peer Review Meeting

Most of the peer review meeting will take place with the peer reviewers split into breakout groups by topic area. Within each group, reviewers will consider the same questions they answered individually in their pre-meeting comments:

- Reviewers will discuss the merits of the individual Group 1 and Group 2 indicators based on responses provided on the “Comment Sheets” and, where possible, agree on a composite score for each indicator.

- Then, considering the Group 1 indicators collectively, reviewers will identify any indicators that clearly do not seem to be on the same level of importance as the other indicators.

- Finally, reviewers will discuss and, where possible, reach agreement on any possible other national-level indicators they believe EPA should consider for the ROE07 TD.

ERG will prepare a summary report of the discussions at the peer review workshop. This report will document the peer reviewers’ final conclusions and recommendations regarding the indicators for ROE07 TD. You will have a chance to check ERG’s draft report of the meeting for accuracy and completeness before it is finalized.

Attachment 1:

Questions and Proposed Indicators for the ROE07 Technical Document

Attachment 2: Comment Sheet for Group 1 Indicators

Please fill out a separate sheet for each Group 1 indicator.

Your Name: ______________________________
Topic Area: **Water**
Indicator Name: ____

1) Please indicate the extent to which you think the proposed indicator is appropriate, adequate, and useful (AA&U) for evaluating our nation's waters and for contributing to an overall picture of our nation's waters.

1	2	3	4
Indicator is not AA&U	Indicator is of somewhat AA&U	Indicator is largely AA&U	Indicator is completely AA&U

Comments:

2) Please indicate the extent to which you think the proposed indicator makes an important contribution to answering the specific ROE question it is intended to answer (see Attachment 1 for list of questions). (Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators, or if it covers an area of less or diminishing importance environmentally.)

1	2	3	4
Indicator is not important	Indicator is of minor importance	Indicator is important	Indicator is critical

Comments:

3) To what extent do you think the indicator meets the following <u>indicator definition</u>:

An "indicator" is ***a numerical value derived from actual measurements of a pressure, ambient condition, exposure, or human health or ecological condition*** *over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment.*

1	2	3	4
Doesn't meet the definition	Only partly meets the definition	Largely meets the definition	Fully meets the definition

Please explain:

4) To what extent do you think the indicator meets each of the following <u>indicator criteria</u>:

a) The indicator makes an important contribution to answering a question for the ROE. (In this context, "important" means that the indicator answers a substantial portion of and/or a critical part of the question.)

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

b) The indicator is objective. It is developed and presented in an accurate, clear, complete, and unbiased manner.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

c) The underlying data are characterized by sound collection methodologies, data management systems that protect its integrity, and quality assurance procedures.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

d) Data are available to describe changes or trends, and the latest available data are timely.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

e) The data are comparable across time and space, and representative[2] of the target population. Trends depicted in this indicator accurately represent the underlying trends in the target population.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

f) The indicator is transparent and reproducible. The specific data used and the specific assumptions, analytic methods, and statistical procedures employed are clearly stated.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

Please explain:

[2] An indicator seeks to describe trends in an overall target "population" (e.g., land area, type of surface water, type of emissions, U.S. population), yet data often can only be sampled from a subset of this population. The validity of the trends described by the indicator will depend on the degree to which the sampled population is representative of the target population.

5) Do you have any suggestions for more effective graphic presentation of the data?
If yes, please describe.

6) Please provide any additional comments, suggestions, or concerns regarding the indicator that you have not already noted in Questions 1 through 5. In particular, note any limitations to the indicator that you have not already described in your responses to the preceding questions.

7) Overall, this indicator:

_____ Should be included in ROE07 TD.

_____ Should be included in ROE07 TD with the modifications identified above.

_____ Should *not* be included in ROE07 TD.

Attachment 3: Comment Sheet for General Questions for Group 1 Indicators

Your Name: ______________________________
Topic Area: **Water**

1) Considering the Group 1 indicators *collectively*, do any of these indicators clearly seem to be more appropriate, adequate, or useful for evaluating our nation's waters or for establishing an overall picture of our nation's waters than others? Do any seem to be more important than the others for answering the question(s) they are intended to answer? (Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators or if it covers an area of diminishing interest environmentally.)

2) Are there any additional *national-level* indicators that make an important contribution to answering one of the ROE questions in your topic area, but were not proposed for ROE07, that you would recommend? (Proposed indicators should meet the ROE indicator definition and criteria, be national in scale, be of a quality that likely would pass this type of peer review, and have data that are readily available. For any new indicators proposed, provide justification for their inclusion and list references or citations for the associated underlying data sources.)

   As you consider this question, ***please read Attachment 5***, which provides the list of water and other indicators presented in ROE03 that EPA does not intend to carry forward to ROE07, along with EPA's rationale for withdrawing them. If you disagree with EPA's rationale and feel any of these indicators should be included in ROE07, please so indicate in your response to this question, along with your rationale for why they should be included. Note: The full text and graphics for the ROE03 indicators can be viewed on-line at: http://www.epa.gov/indicators/roe/html/tsd/tsdWater.htm

Attachment 4: Comment Sheet for the Group 2 Indicator

Your Name: ______________________________
Topic Area: Land
Indicator Name: Contaminated Groundwater Under Control on Contaminated Lands

1) To what extent do you think the indicator meets the following <u>indicator definition</u>:

An "indicator" is ***a numerical value derived from actual measurements of a pressure, ambient condition, exposure, or human health or ecological condition*** *over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment*.

1	2	3	4
Doesn't meet the definition	Only partly meets the definition	Largely meets the definition	Fully meets the definition

Please explain:

2) To what extent do you think the indicator meets each of the following <u>indicator criteria</u>:

a) The indicator makes an important contribution to answering a question for the ROE. (In this context, "important" means that the indicator answers a substantial portion of and/or a critical part of the question.)

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

b) The indicator is objective. It is developed and presented in an accurate, clear, complete, and unbiased manner.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

c) The underlying data are characterized by sound collection methodologies, data management systems that protect its integrity, and quality assurance procedures.

1	2	3	4
Doesn’t meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

d) Data are available to describe changes or trends, and the latest available data are timely.

1	2	3	4
Doesn’t meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

e) The data are comparable across time and space, and representative[3] of the target population. Trends depicted in this indicator accurately represent the underlying trends in the target population.

1	2	3	4
Doesn’t meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

f) The indicator is transparent and reproducible. The specific data used and the specific assumptions, analytic methods, and statistical procedures employed are clearly stated.

1	2	3	4
Doesn’t meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

Please explain:

[3] An indicator seeks to describe trends in an overall target “population” (e.g., land area, type of surface water, type of emissions, U.S. population), yet data often can only be sampled from a subset of this population. The validity of the trends described by the indicator will depend on the degree to which the sampled population is representative of the target population.

3) Do you have any suggestions for more effective graphic presentation of the data? If yes, please describe.

4) Please provide any additional comments, suggestions, or concerns regarding the indicator that you have not already noted in Questions 1 through 3. In particular, note any limitations to the indicator that you have not already described in your responses to the preceding questions.

5) Overall, this indicator:

_____ Should be included in ROE07 TD.

_____ Should be included in ROE07 TD with the modifications identified above.

_____ Should *not* be included in ROE07 TD.

Attachment 5: List of and EPA Rationale for Withdrawn ROE03 Indicators

Background:
A number of indicators were included in EPA's 2003 Draft Report on the Environment (DROE03) that are not proposed to be included in ROE07. The general reasons for these changes are described below, followed by indicator-specific explanations.

> EPA's Science Advisory Board Committee review of the DROE03 recommended EPA develop and utilize a more precise definition of "indicator" than was used for DROE03.
>
> EPA developed a set of specific indicator criteria to provide a more precise conformance to Office of Management and Budget (OMB) and EPA Information Quality Guidelines.
>
> The ROE07 introduced a Regional Pilot Project and developed and implemented a relevant process. Sub-national or regional indicators that were included in DROE03 but did not go through this pilot are not recommended to be included in ROE07.

When screened against these factors, the ROE07 development team identified a small number of the indicators in DROE03 that did not appear to conform to one or more of these requirements. A group decision was made that developing indicator write-ups, quality forms, and graphics for these indicators was not the best use of team resources. Broadly speaking, the rationales for withdrawal fall into four categories, coded as follows:

> **(D) Definition** – The indicator fails to meet the improved indicator definition for ROE07 (most often because the indicator was a level 1 or 2 indicator, rather than a level 3, 4, 5, or 6 indicator).
>
> **(C) Criteria** – The indicator fails to meet one of the six indicator criteria that were established to conform with EPA Information Quality Guidelines.
>
> **(N) New indicator** – The indicator is replaced by a "new" and superior indicator that was not available for the DROE03.
>
> **(R) Regional –** The indicator is not national in scope and is not part of the ROE07 EPA Regional Pilot Project.

The following information briefly explains the rationale for excluding specific indicators from development for the ROE07 Indicator Peer Review. Each indicator is categorized as D, C, N, or R. The indicators are organized by general peer review topic.

Air

Production of Ozone Depleting Substances - C

This DROE03 indicator presents estimates of the amount of ODSs produced worldwide in 1986 and 1999, and annual U.S. production from 1958 to 1993. This indicator is being withdrawn because of issues concerning data reliability and relevance. Global ODC production data are not reliable with respect to comparability among reporting countries. The US estimates are more reliable because of legal reporting requirements and the small number of sources. However, the data set fails to account for imports, and annual production is not a good surrogate for emissions of ODCs into the environment because of the time between production and eventual entry into the environment is highly variable among the various products and recovery systems.

Number of People Living in Counties with Ambient Air Concentrations Above the NAAQS - C

This DROE03 indicator conveyed how many people (based on census) lived in counties where air pollutant levels at times were above the level of the NAAQS during the year stated. It was intended to give the reader some indication of the number of people potentially exposed to unhealthy air. Because of changing populations and air quality standards, however, this indicator masks actual trends in the levels of air pollutants. It is not a valid exposure indicator because it is not based on measurement of an actual marker of exposure measured on individuals.

Percent of Population Living in Homes Where Someone Smokes Regularly Inside the Home - D

This DROE indicator portrayed the percentage of homes in the U.S. in which young children were exposed to tobacco smoke in 1998 versus 1957. The survey is based on a questionnaire (do children live in the home, and does someone who smokes regularly live in the home), rather than on actual measurements of the amount of smoke actually present or the degree to which children are exposed to the resulting smoke. This indicator violates the ROE indicator definition, requiring that indicators be based on actual measurements, and blood cotenine (Indicator 102) provides a better indicator of children’s exposure to smoke.

Water

Altered Fresh Water Ecosystems – C
Percent Urban Land Cover in Riparian Areas – C
Agricultural Lands in Riparian Areas - C

These DROE03 indicators are based on the percentage of land within 30 m of the edge of a stream or lake that is classified as urban or agriculture based on 1991 satellite data (NLCD). Baseline data are incomplete, and there are no reference points for the appropriate percentage of such cover, and it is not clear that the indicators could be reproduced with newer satellite data. There are no data for other alterations such as damming, channelization, etc.

Number of Watersheds Exceeding Criteria for Mercury, PCBs, & Dioxin – C

This DROE03 indicator is based on voluntary reporting of Hg contamination using data that has not undergone formal QA/QC review. It is not representative of the nation, or suitable for trend monitoring.

Lake Trophic State Index – R, C

This DROE03 indicator is based on phosphorous data collected in a one-time a statistical sample of lakes in the Northeast US during 1991-94. It is not included in the ROE07 Regional Pilot Project.

Sedimentation Index – R, C

This DROE03 indicator is based on data collected on freshwater streams in the Mid Atlantic Highlands Region during a one-time 1993-94 statistical survey. It is not included in the ROE07 Regional Pilot Project.

Contaminants in Fresh Water Fish (NAWQA) – C

This DROE03 indicator is based on reported concentrations of contaminants in fish collected by the US Geological Survey NAWQA program. While the data are collected from a large number of streams and are of high and consistent quality, the sample is not statistically representative of the nation, there are no national guidelines to serve as reference values for tissue concentrations, and Cycle II of NAWQA will not include comparable routine monitoring of trace organics and trace elements in fish tissues at sampling sites across the Nation.

Fish Index of Biotic Integrity – R, C

This DROE03 indicator is based on fish community data collected on freshwater fish in the Mid Atlantic Highlands Region during a one-time1993-96 statistical survey. Condition cannot be assessed in streams where no fish were caught, because data were insufficient to indicate whether the stream had poor quality or simply no fish. It is not included in the ROE07 Regional Pilot Project.

Macroinvertebrate IBI (MAIA) – R, C

This DROE03 indicator is based on benthic macroinvertebrate community data collected in freshwater streams in the Mid Atlantic Highlands Region during a one-time 1993-96 statistical survey. It is not included in the ROE07 Regional Pilot Project.

Beach Days Open – D
Waters with Fish Consumption Advisories - D

These DROE03 indicators are based on the frequency of beach closures or fish consumption advisories as reported to EPA voluntarilyby states and local government organizations. The data are not nationally or temporally consistent because of different and changing criteria for closing beaches or issuing fish consumption advisories in the different states, many of which do not involve actual water quality measurements. They are therefore level 1 indicators and fail to meet the definition for ROE indicators.

Contaminated Sediments in Fresh Water - C

This DROE03 indicator is based on reported concentrations of sediment contaminants collected by a large number of organizations focusing particularly on places where sediment contamination is perceived to be a problem (the EPA National Sediment Inventory). The database suffers from a number of limitations: the data are heavily biased toward sites at which there is a known or suspected toxicity problem and to particular geographic areas (non-representative of the nation), the data cover different dates in different locations- making estimation of trends difficult, and the data and procedures used to assign sites to a toxicity category are not uniform from watershed to watershed. It is unsuitable for trend estimation.

Chemical Contamination in Streams and Groundwater – C

This DROE03 indicator is based on data from a large number of NAWQA watersheds. The sampling and analytical protocols (including the analytes measured) are not comparable across all NAWQA watersheds.

Nitrate in Farmland, Forested and Urban Streams and Groundwater
Phosphorus in Farmland, Forested, and Urban Streams – N

These DROE03 indicators are being replaced by two new indicators, "Nitrate, Phosphorus, and Pesticides in Streams in Agricultural Watersheds" and "Nitrate and Pesticides in Groundwater in Agricultural Watersheds." The NAWQA streams in forested and urban watersheds were based on a small sample size, and may not be representative of forested and urban streams in general.

Phosphorus in Large Rivers - C

The indicator is based on phosphorus concentrations in large rivers sampled periodically by the USGS National Stream Quality Accounting Network (NASQAN). Monitoring at many of the large river NASQAN sites has been discontinued.

Chemicals

Sediment Runoff Potential from Croplands and Pasturelands - C

This DROE03 indicator represents the estimated sediment runoff potential for croplands and pasturelands based on topography, weather patterns, soil characteristics, and land-use land cover and cropping patterns for the U.S. and the Universal Soil Loss equation www.brc.tamus.edu/swat. The indicator addresses "potential" and not actual/current condition, and relies on a model to predict ambient characteristics (level 4 indicators) based on level 3 measurements, which violates a fundamental ROE protocol on the use of models in indicators. Trends in this indicator would likely be associated only with trends in land cover, cropping practices, and weather (topography and soil type are unlikely to change). No reliable spatial trend data at the appropriate scale exist for either cropping practices or land cover, and consequently trends in this indicator would be difficult to calculate.

Potential Pesticide Runoff from Fields - C
Pesticide Leaching Potential - C

These DROE03 indicators represent the potential movement of agricultural pesticides from the site of application to ground and surface waters, based on estimates of pesticide leaching and runoff losses derived from soil properties, field characteristics, management practices, pesticide properties, and climate for 243 pesticides applied to 120 specific soils in growing 13 major agronomic crops. The indicators address "potential" and not actual/current condition, and rely on models to predict ambient characteristics (level 4 indicators) based on level 3 measurements, which violates a fundamental ROE protocol on the use of models in indicators.

Risk of Nitrogen Export - C
Risk of Phosphorus Export - C

These DROE03 indicators represent the potential movement of N and P from the site of application to surface waters, based on a large empirical dataset relating land use to N and P observed in receiving streams over several decades at a variety of locations. The indicators address "potential" and not actual/current conditions, and rely on statistical models to predict ambient characteristics (level 4 indicators) based on level 3 measurements, which violates a fundamental ROE protocol on the use of models in indicators.

Pesticide Use - C

Agricultural pesticide usage data, measured at the national aggregate level for all pesticides is very difficult to interpret, given the wide year to year changes in the types of pests being controlled for and changes in agricultural production/chemical usage from year to year. From one time period to another the mix of pesticides changes, pest pressures change, agricultural practices change, agricultural acreage changes, regulatory status of key uses changes, and many other important variables change. Moreover, the effects of pesticide usage are encountered at three levels of the product's life cycle: production, usage, and residues on foods. The geographic distribution of those effects renders difficult the interpretation of national usage levels for all pesticides, taken as a group. While it is of course possible to compare magnitudes of aggregates at different times, the real significance for the environment is in the differences in the content and geographic distribution of the aggregates, not in the magnitude of the aggregate.

Contaminated Lands

Number and Location of Superfund NPL Sites - D

This DROE03 indicator is a category 1 indicator (it represents an administrative decision to force a cleanup, rather than an amount of waste present or removed), and therefore does not meet the ROE07 indicator definition.

Number of RCRA Corrective Action Sites - D

This DROE03 indicator, by itself, is a category 1 indicator (it represents an administrative decision to force a cleanup, rather than an amount of waste present or removed), and therefore does not meet the ROE07 indicator definition. The data are being combined into a new indicator, Quantity of RCRA Hazardous Waste Generated and Managed (which combines information from several DROE03 indicators).

Radioactive Waste Storage and Disposal - C

This DROE03 indicator is based on production and inventory data collected by the Department of Energy. Although the data continue to be collected, they are no longer publicly available post-September 11, 2001; therefore ongoing data trends are not and will not in the future be available for this indicator. Moreover, the earlier data reflected two distinct periods in the history of waste generation in the nuclear weapons complex. The first reflected a period during which wastes and other materials were being generated as an integral part of the production of weapons grade nuclear materials and components. The period after 1989 reflected the cessation of large-scale production of such materials and the initiation of clean-up activities and wastes from those initiatives. Thus, even before the truncation of data in the post 9/11 period, there were significant issues with the comparability of the data over time.

Human Health

Cardiovascular Disease Prevalence - C

This DROE03 indicator was based on data from NHANES III (1988-1994). Currently, no national trend data are available on cardiovascular disease (CVD) prevalence.

Blood VOC – C

This DROE03 indicator was based on a convenience sample whose representativeness cannot be determined or necessarily used as a baseline for future sampling. The indicator is based on detects only, so there is no reference level, and VOCs are cleared from the bloodstream rapidly (~ 1hr), so there is a significant possibility of false negatives, considering that exposures tends to be associated with occupational and indoor settings.

Urinary Arsenic - R
This DROE03 indicator was based on data from EPA Region 5 only, and is not part of the ROE07 Regional Pilot.

Ecological Condition

The Farmland Landscape - C
This DROE03 indicator represents croplands and the forests or woodlots, wetlands, grasslands and shrublands, that surround or are intermingled with them, and the degree to which croplands dominate the landscape http://www.heinzctr.org/ecosystems/farm/lndscps.shtml. The indicator relies on data generated using early 1990's satellite data, and it is unclear whether the definition of "farmland landscape" is sufficiently precise to be replicated independently, especially with respect to any future satellite data availability.

Extent of Estuaries and Coastline – C
This DROE03 indicator is based on remote sensing data, but is unlikely to show trends unrelated to sea level rise and changing tides, so it is not a very useful indicator for trends.

Coastal Living Habitats - C
This DROE03 indicator is based on remote sensing data of coastal wetlands, mudflats, sea-grass beds, etc., but the only system for which a national indicator has been developed is coastal vegetated wetlands, which already is covered in another indicator.

Shoreline Types - C
This DROE03 indicator is based on NOAA's Environmental Sensitivity Index. The index is based on a standardized mapping approach, but coverage is not complete for large parts of the coastline and the data in some of the atlases are more than 15 years old. Consequently, this indicator is not appropriate for measurement of representative, national trends.

Extent of Ponds, Lakes, and Reservoirs – C
This DROE03 indicator is based on data from the USGS National Wetlands Inventory. While these data are based on a valid statistical sampling design, the total amount of surface water is less than half of the area of lakes, reservoirs and ponds greater than 6 acres in size in the USGS National Hydrography Data Set. Until this discrepancy is resolved, the indicator may not satisfy the ROE criteria.

At-Risk Native Species – C
At-Risk Native Grassland and Shrubland Species – C
At-Risk Native Forest Species – C
Populations of Representative Forest Species – C
Non-Native Fresh Water Species – C
At-Risk Fresh Water Plant Communities – C
The Ecological Condition chapter is being restructured from the DROE03 organization per the recommendation of EPA's Science Advisory Board and numerous stakeholders. As such, the chapter

no longer requires that the above indicators be broken out by ecosystem. In addition, the ability to track trends of many of these indicators is currently in question.

Population of Invasive and Non-invasive Bird Species – R

This DROE03 indicator is based on an analysis of USGS Breeding Bird Survey data in grassland and shrubland ecosystems for 5 year periods ranging from the late 1960s to 2000. Because the ecological condition questions are no longer directed at specific ecosystems types, this appears to be a regional indicator. It is not clear at this time that this indicator will be updated.

Bird Community Index – R

This DROE03 indicator is not national in scope or part of the ROE EPA Regional Pilot.

Fish Diversity – R

This DROE03 indicator is based on a statistical sample of fish trawls in Mid-Atlantic estuaries during 1997-98. This indicator is not part of the ROE07 Regional Pilot project, and EMAP is no longer collecting fish samples to support this indicator.

Fish Abnormalities - C

This DROE03 indicator is based on a statistical sample of fish trawls in estuaries in the Atlantic and Gulf, but the data are no longer being collected by EMAP to support this indicator.

Unusual Marine Mortalities – C

This DROE03 indicator is based on voluntary reporting of unusual mortality events to NOAA. Because there is no systematic requirement to report, these data are not suitable to support national trends in the indicator.

Animal Deaths and Deformities – C

This DROE03 indicator is based on data reported by a number of different organizations to USGS on incidences of death or deformities in waterfowl, fish, amphibians, and mammals. Trends are available only for waterfowl, and because data reporting is voluntary rather than systematic, the data are not adequate to determine actual trends versus trends in reporting.

Tree Condition – C

This DROE03 indicator is based on an ongoing statistical sample of forests across the conterminous US and comprises components that relate to crown (tree canopy condition), the ratio of dead to live wood, and the fire class. This indicator likely relates more to forest management practices than to environmental condition, and for this reason has low relevance value to EPA.

Processes Beyond the Range of Historic Variation – C

This DROE03 indicator is based on an analysis of recent Forest Inventory and Analysis data on climate events, fire frequency, and forest insect and disease outbreaks, which were then compared to anecdotal data for the period 1800-1850. Because the early data are anecdotal, and because the data mostly relate to forest management practices, etc., it is proposed that this indicator has low relevance and that trend data are of questionable utility as an ROE indicator.

Soil Compaction – C
Soil Erosion – C

These DROE03 indicator are based on an ongoing statistical sample of soils in forests across the conterminous US, but the actual indicators are based on models rather than measurement, and they likely relate more to forest management practices than to environmental condition, and for this reason have low relevance value to EPA.

Soil Quality Index - R

This DROE03 indicator was based on a survey of soils in the Mid Atlantic region during the 1990s, and was neither repeated and is not part of the Regional Pilot Project for ROE07.

Chemical Contamination – C

This DROE03 indicator combines data from the USGS NAWQA program that are not consistent in terms of sampling frequency or analytical protocols.

Attachment 6: Indicator Materials for Review

NOTE: ATTACHMENT 6 COMPRISES THE SUBSEQUENT SECTIONS OF THIS BINDER

Indicator: Benthic Macroinvertebrates in Wadeable Streams (341)

Freshwater benthic macroinvertebrate communities are composed primarily of insect larvae, mollusks, and worms. They are an essential link in the aquatic food web, providing food for fish and consuming algae and aquatic vegetation (Karr et al.1997). The presence and distribution of macroinvertebrates can vary across geographic locations based on the elevation, stream gradient, and substrate (Barbour et al 1999).These organisms are sensitive to disturbances in stream chemistry and physical habitat, both in the stream channel and along the riparian zone, and alterations to the physical habitat or water chemistry of the stream can have direct and indirect impacts on their community structure. Each species has specific tolerance values to stressors. Because of their relatively long life cycles (approximately one year) and limited migration, they are particularly susceptible to site-specific stressors (Barbour et al. 1999).

Information about benthic macroinvertebrate communities often are captured using an index that reduces complex information about community structure into a simple numerical value. This indicator relies on a Multi Metric Index (MMI) , which is based on measures of taxonomic richness (number of taxa); taxonomic composition (e.g., insects vs. non-insects); taxonomic diversity; feeding groups (e.g., presence and abundance of shredders, scrapers or predators); habits (e.g., presence of burrowing, clinging or climbing taxa); and tolerance. Different specific metrics are used for each of these categories in different regions of the U.S., and the ones with the greatest ability to discriminate between streams are used to construct the MMI. Each metric is scaled against the 5th-95th percentiles for streams in each region to create an overall MMI, whose values range from 0 to 100.

This indicator is based on data collected for the U.S. EPA's Wadeable Streams Assessment (WSA) (in draft). Wadeable streams are streams, creeks and small rivers that are shallow enough to be sampled using methods that involve wading into the water. They typically include waters classified as 1st through 4th order in the Strahler Stream Order classification system (based on the number of tributaries upstream). The WSA is based on a probability design, so the results from representative sample sites can be used to make a statistically valid statement about the condition of the nation's waters. Using standardized methods, crews sampled 748 sites, including reference and repeat visits in the eastern and central U.S. in 2004. Between 1999 and 2004, 839 sites were sampled in the western U.S. using the same methods. All sites were sampled between late April and mid- November. At each site, a composite bottom sample was collected from eleven equally spaced transects within the sample reach. Detailed field methodologies and project information can be found at ttp://www.epa.gov/owow/monitoring/wsa/index.html. This is the first time that a survey on this broad scale has been conducted, and will serve as a baseline for future surveys.

What the Data Show

The benthic macroinvertebrate IBI in wadeable streams in the U.S. was found to vary from less than 10 to more than 95, with higher values (more diversity) much more common than lower values (Figure 341-1). The percentage of wadeable stream miles for any particular IBI score can be read off the left hand y axis, and the total wadeable stream miles off the right hand y axis. The cumulative frequency distribution in the figure represents the national distribution of the data. Thresholds for favorable or unfavorable biological condition vary from one part of the country to another.

Indicator Limitations

- Samples were taken one time from each sampling location during the index period (June – October). Although the probability sampling design results in unbiased estimates for the MMI in wadeable streams during the study period, values of the index may be different during other seasons and years because of variations in hydrology.

- Reference levels for the MMI (i.e., levels that would allow streams to be classified as to least disturbed, moderately disturbed, and most disturbed based on regional reference sites) vary from region to region; these reference levels will be available from the WSA to provide such a classification of streams nationally, but they are not available at this time.
- This is the first time that a survey on this broad scale has been conducted. The data will serve as a baseline for future surveys, but the sampling design for the current WSA design does not allow trends to be calculated over the period 1999-2004.

Data Sources

Data for this indicator were collected for the Environmental Protection Agency's (EPA) Wadeable Streams Assessment (WSA) in 2004 for the central and eastern states and from 1999-2004 for the western states. Information about the WSA can be found at http://www.epa.gov/owow/monitoring/wsa/index.html.

References

Barbour, M.T., J Gerritson, B.D. Snyder, J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water. Washington D.C.

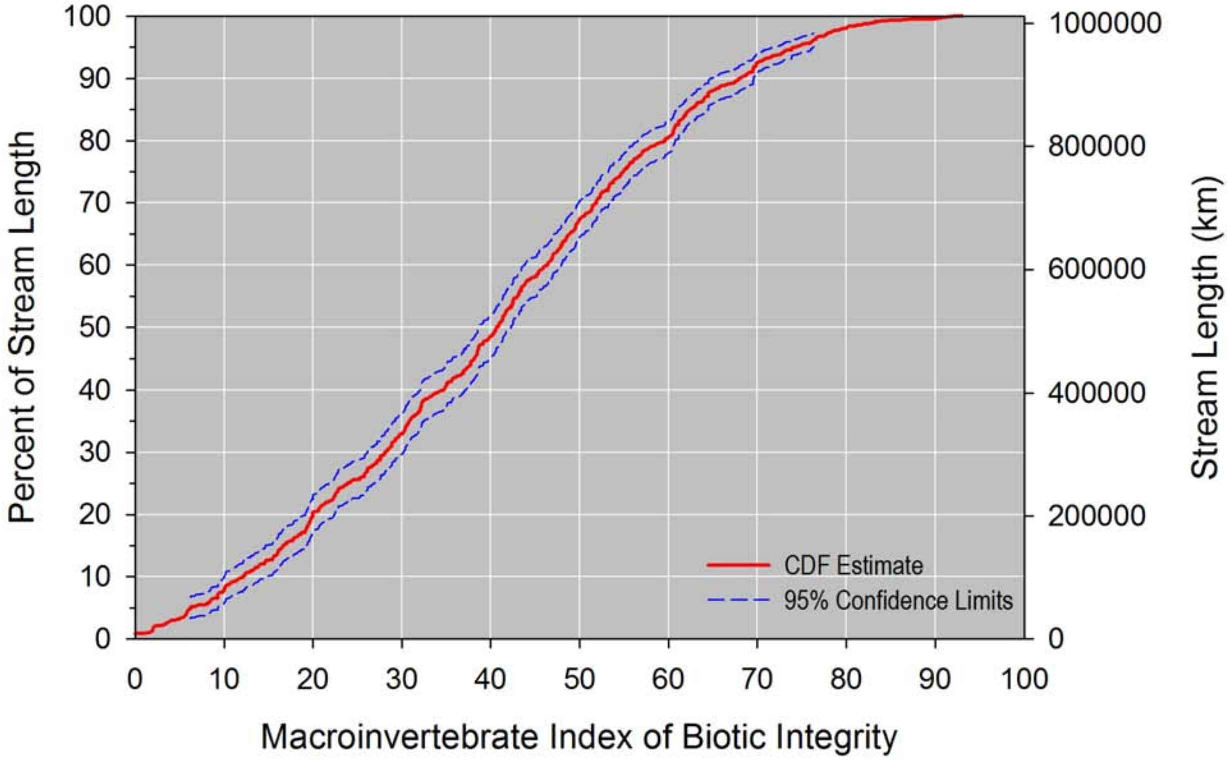
U.S. EPA. 2004. Wadeable Streams Assessment: Benthic Laboratory Methods. U.S. Environmental Protection Agency; Office of Water, Washington D.C. EPA841-B-04-007

U.S. EPA. 2004. Wadeable Streams Assessment: Benthic Laboratory Methods. U.S. Environmental Protection Agency; Office of Water, Washington D.C. EPA841-B-04-008

Karr, J.R., and D.R. Dudley. 1981. Ecological Perspective on water quality goals. Environmental Management 5:55-68

Graphics

Fig 341-1: Cumulative distribution function for macroinvertebrate Index of Biotic Integrity in wadeable streams in the United States



R.O.E. Indicator QA/QC

Data Set Name: BENTHIC MACROINVERTEBRATES IN WADEABLE STREAMS
Indicator Number: 341 (89189)
Data Set Source:
Data Collection Date: UNKNOWN
Data Collection Frequency:
Data Set Description: Benthic Macroinvertebrates in Wadeable Streams
Primary ROE Question: What are the trends in extent and condition of fresh surface waters?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

The field methods used to collect the benthic macroinvertebrate data were published in the Wadeable Streams Assessment (WSA) Field Operations Manual (2004 EPA841-B-04-008) in 2004. The protocols used were initially established and published in the Environmental Assessment and Monitoring Program (EMAP) http://www.epa.gov/nheerl/arm/index.html. They outline the collection technique, equipment, and field processing for all samples. Trained field crews collected composite samples from each site, following the detailed process laid out in the Field Operations Manual. Laboratory methods for identifying and sorting the macroinvertebrate data are published in the Wadeable Streams Assessment Benthic Laboratory Methods (2004 EPA 841-B-04-007). As with the field collection methods, laboratory sorting and identification techniques mirrored those described in the EMAP program. The standard identification process and associated QC process ensure a high level of accuracy. All laboratories used were given a target levels of identification for each organism (primarily genus), and all laboratories had a thorough QC process to document the accuracy and repeatability of the identification. U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Field Operations Manual. US Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-004. U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Benthic Laboratory Methods. US Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-007.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

The indicator is based on data collected by the EPA's WSA. The WSA is based on a probabilistic survey design used to make a statically valid statement about the ecological condition of the wadeable streams through the United States. Information about this probabilistic survey design and implementation can be found on the U.S. EPA website http://www.epa.gov/nheerl/arm/index.html. Numerous publications and journal articles can be accessed through this site. Diaz-Ramos, S. , Stevens, D.L., Jr and Olsen, A.R. 1996. EMAP Statistical Methods Manual. EPA620-R-96-002, US Environmental Protection Agency, Office of Research and Development, NHEERL-WED, Corvallis, Oregon. Stevens, D.L., Jr, and Olsen, A.R. 1999. Spatially restricted surveys over time for aquatic resources. Journal of Agriculture, Biological and Environmental Statistics, 4, 415-28.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Two data analysis approaches were used on the benthic macroinvertebrate data. Both approaches are frequently used by federal agencies, states and research organizations to assess the data from benthic macroinvertebrate communities. A Multimetric Index (MMI) was developed on a national and ecoregional scale to evaluate the data. This approach integrates aspects of the biological assemblage, metrics, and evaluates them with the biological abundance and diversity at each site to generate and indicator. The second approach used was the development of a predictive O/E model. This model compares the Observed number of taxa found at each site to the Expected taxa for that site. Expected condition is derived from the taxa found at reference sites, and the geographic characteristics of the site. The result is measure of how far the site is from reference. Karr, J.R., K.D. Fausch, P.L. Angermeier, P.R. Yant, and I.J. Schlosser. 1986. Assessing biological Integrity in running waters: A method and its rationale. Special publication 5. Illinois Natural History Survey. Wright, J.F., M.T. Furse, and P.D. Armitage. 1993. RIVPACS: a Technique for evaluating the biological quality of rivers in the UK. European Water Pollution Control 3(4):15-25. Yoder, C.O. and E.T. Rankin 1995 (b) Biological response signatures and the area of degradation value: new tools for interpreting multimetric data. In Biological assessment and criteria: tools for water resource planning and decision making. Pp. 263-286 Lewis Publishers. Barbour, M.T., J.B. Stribling, and J.R. Karr. 1995. Multimetric approach for establishing biocriteria and measuring biological condition, In Biological assessment and criteria: tools for water resource planning and decision making. pp. 63-77. Lewis Publishers. Haskins, C.P., and D.M. Carlisle. 2001. Use of Predictive Models for Assessing the biological Integrity of Wetlands and Other aquatic habitats. In Bioassessment and Management of North American Freshwater Wetlands. pp. 59-84. John Wiley and Sons.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The spatial and temporal aspects of this indicator are appropriate for reporting on the condition of the nation's freshwater stream resource. The 1500 sites that were sampled and used in the report were chosen through a design specifically to answer this question. Sites throughout the conterminous United States were sampled that represent a diverse selection of streams that vary in size, flow and type of disturbance. Because of the statistical approach to selecting these sites, the aggregated results can be extrapolated to make a statement about the target population.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The statistically valid survey ensures spatial dispersion within the target population. All types of natural streams, and associated ecosystem characteristics, have a known probability of being included in the sample. Within each reach length, crews collected and composite samples at eleven equally spaced transects to increase the chance of including all ecosystems within the survey. Highly sensitive or unique ecosystems do have a lower probability of being sampled due to the sparse nature of there location and the broad geographic scale of the sampling design.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Selection of reference sites was a key aspect to the analysis of the WSA data. Approximately 20 reference sites per ecoregions were selected a priori to be sampled with the same methods as the randomized sites. States and cooperators were asked to contribute their 10 best reference sites for inclusion in this pool. Additionally, the U.S Geological Survey North American Water Quality Assessment (NAQWA) identified a number of predefined reference sites from their Status and Trends Program and Hydrologic Benchmark Network to be sampled with WSA methods for this survey. Additional reference sites were contributed by the Chuck Hawkins in his STAR grant program for the Western states. The data on the indicator at these sites was analyzed with both the MMI and used to create the O/E model to establish the reference condition the randomized sites were analyzed against.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

All sampling methodologies can be found in the U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Field Operations Manual. US Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-004. Laboratory methods used to examine this indicator can be found in the U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Benthic Laboratory Methods. US Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-007. Detailed analytical procedures can be found in the Data Analysis Plan accompanying the Wadeable Streams Assessment Final Report. A description of how the data are interpreted is available in Stoddard et al, Environmental Monitoring and Assessment Program Western Streams and Rivers Statistical Summary, June 2005. Documents are available on the web at http://www.epa.gov/owow/monitoring/wsa/index.html

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

All data, including metadata, from the Wadeable Streams Assessment will be available for the public through the Storage and Retrieval (STORET) System. Information on STORET, including data downloads, can be found at http://www.epa.gov/storet/.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The description of the study design, methods to select and sample sites, and the laboratory analysis are all fully documented and available for the public (http://www.epa.gov/owow/monitoring/wsa/index.html http://www.epa.gov/nheerl/arm/index.html). Following these documents and associated references, the study design could be replicated. Analytical methods used to examine the data are also fully documented and will be available in the final report. Using the data publicly available on the STORET warehouse, analytical procedures could also be replicated.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

An extensive Quality Assurance/Quality Control procedure was an integral part of the WSA. Full documentation of the QA/QC procedures can be found in U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Quality Assurance Project Plan. U.S. Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-005. It is available to the public on the EPA's website. http://www.epa.gov/owow/monitoring/wsa/QAPP-August18.pdf. The QAPP was reviewed by an independent EPA team with members from ORD, OW and OEI. In the field QA/QC included training all crew members in WSA methods, conducting a thorough field audit of all crews, and extensive chain of custody documentation. Laboratory QA/QC included training for sorters, a laboratory audit, and 10 percent re-identification of samples for all labs.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

The WSA is based on a probability sampling design where the results from the sampled population can be used to make a statistically valid statement about the entire population. Details about the statistical design and implementation of this approach can be found the EPA website dedicated to this topic. http://www.epa.gov/nheerl/arm/index.htm

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Measurements of uncertainty are associated with the dataset and can be found in the WSA Report (in draft). Actions were taken throughout the study to reduce the level of uncertainty throughout the dataset. The Quality Assurance Project Plan (QAPP) for the WSA has Measurement Quality Objectives (MQOs) and Data Quality Objectives (DQOs) specified for each indicator. U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Quality Assurance Project Plan. U.S. Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-005.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

The conclusions are not impacted by variability around the indicator. Actions were taken throughout the study to reduce the level of uncertainty and increase repeatability throughout the dataset. Taxonomic re-identification of 10 percent of the samples by an independent taxonomist was conducted to ensure all labs met the MQO's established in the QAPP. Information about all the QA procedures can be found at http://www.epa.gov/owow/monitoring/wsa/QAPP-August18.pdf. The extensive QC process throughout all aspects of the project ensures high quality data with low levels of uncertainty.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

This is the first time a national, statistically valid survey has been conducted for stream resources. Results from this survey will serve as a baseline to compare future surveys. Trends over time using this indicator cannot be assessed at this time.

Indicator: Chesapeake Bay Blue Crabs: Mature Females - Spawning Stock Abundance (320R)

The blue crab represents a valuable commercial fishery across much of the eastern coast of the U.S. fishery. In Chesapeake Bay, harvest pressure on the species and the loss of the submerged aquatic vegetation habitat that young crabs require for shelter and food during their development, have led directly to the decline in the blue crab's numbers (*1997 Chesapeake Bay Blue Crab Fishery Management Plan;Blue Crab 2003, Status of the Chesapeake Population and its Fisheries; Blue Crab; Blue Crabs in the Chesapeake, About Blue Crabs).* Spawning stock abundance of female blue crabs is a key determinant of the status of this important fishery.

This indicator reflects trends in the spawning stock abundance of female blue crabs based on four fishery-independent surveys used to determine stock status: the Virginia trawl survey, the Maryland summer trawl survey, the Calvert Cliffs crab pot survey, and the Bay wide winter dredge survey. Data from the two trawl surveys and the Calvert Cliffs pot survey are based on calendar year collections through 2003. The winter dredge survey data represent seasonal collections from December 2003 through March 2004. Indices from the winter dredge survey are expressed as estimates of the number of crabs per unit area; all other indices are expressed as the geometric mean catch per unit effort. Modified and standardized width-age cutoff values are used to differentiate age classes for three of the four surveys (Maryland and Virginia trawl and Calvert Cliffs pot survey) used to derive the abundance indices (*2004 Chesapeake Bay Blue Crab Advisory Report).*

What the Data Show

Based on a standardized, transformed index of mature females, spawning stock biomass trended upwards 2001 through 2003 after hitting a historic low in 2000, but has been below the long-term average in all years since 1992, with the exceptions of 1996 and 1997 (Figure 320R-1). (*2004 Chesapeake Bay Blue Crab Advisory Report).*

Indicator Limitations

- A comprehensive update of the blue crab stock assessment is underway and the new assessment will use updated data treatments and methodologies that will likely alter the trend patterns presented in this indicator

Data Sources

Chesapeake Bay, Trends and Indicators, http://www.chesapeakebay.net/pubs/statustrends/75-data-2002.xls Derek Orner, NOAA Chesapeake Bay Office (derek.orner@noaa.gov)

References:

1997 Chesapeake Bay Blue Crab Fishery Management Plan. Chesapeake Bay Program. June 1997. EPA 903-r-97-015 CBP/TRS 175/97

Blue Crab 2003, Status of the Chesapeake Population and its Fisheries. Chesapeake Bay Commission Blue Crab Technical Workgroup. November 2003. (http://www.chesbay.state.va.us/CBC%20018%20crab%20report.pdf)

Blue Crab. Chesapeake Bay Program website. December 10, 2004. (http://www.chesapeakebay.net/blue_crab.htm)

Blue Crabs in the Chesapeake, About Blue Crabs. Maryland Sea Grant, University System of Maryland, November 19, 2002. (http://www.mdsg.umd.edu/crabs/about.html)

2004 Chesapeake Bay Blue Crab Advisory Report. Chesapeake Bay Stock Assessment Committee. June 2, 2004. (http://noaa.chesapeakebay.net/fish/BCAR2004.pdf)

Graphics

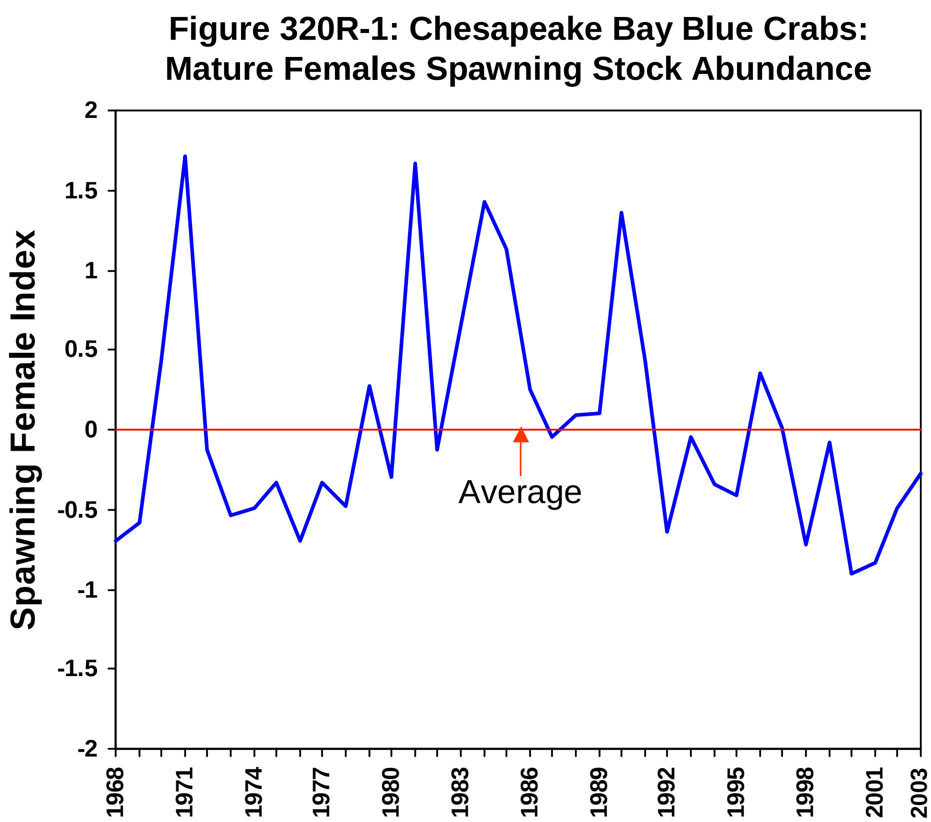


Figure 320R-1: Chesapeake Bay Blue Crabs:
Mature Females Spawning Stock Abundance
Spawning Female Index
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
Average
1968
1971
1974
1977
1980
1983
1986
1989
1992
1995
1998
2001
2003

R.O.E. Indicator QA/QC

Data Set Name: CHESAPEAKE BAY BLUE CRABS: MATURE FEMALES - SPAWNING STOCK ABUNDANCE
Indicator Number: 320R (89154)
Data Set Source: NOAA Chesapeake Bay Office
Data Collection Date: 1986-2003
Data Collection Frequency: 1 yr
Data Set Description: Chesapeake Bay Blue Crabs: Mature Females
Primary ROE Question: What are the trends in extent and condition of coastal waters

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. Very good quality and Bay coverage is provided in the data set. Mature female data set is a combination of several different fishery-independent surveys. The MD Trawl Survey which samples the major tributaries in MD; VA Trawl survey providing information for the mainstem and tributaries in VA; Calvert Cliffs pot survey which is a small spatial scale survey in the mid-portion of Chesapeake Bay; and the Baywide winter dredge survey which samples over 1500 stations Baywide. For additional information refer to the 2004 Chesapeake Bay Blue Crab Advisory Report Prepared by the Chesapeake Bay Stock Assessment Committee: June 2, 2004, at http://noaa.chesapeakebay.net/fish/BCAR2004.pdf. Report results and recommendations are developed by a Committee consisting of scientists from MD and VA academic and management agencies as well as the National Marine Fisheries Service. The methods have been introduced at various times in various peer reviewed journal entries. Contact Derek Orner, NOAA Chesapeake Bay Office (derek.orner@noaa.gov).

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. Individual sampling designs/monitoring plans are in effect for each state. The winter dredge survey was designed with a Baywide comprehensive sampling frame in mind. Maryland DNR runs the MD trawl program. Virginia Institute of Marine Science (VIMS) oversees the VA trawl survey. The Academy of Natural Sciences runs the Calvert Cliffs survey and the NOAA Chesapeake Bay office coordinates the winter dredge survey between Maryland DNR and VIMS. **MD trawl survey began in 1977 (Maryland Summer Trawl Survey runs May-November; Chester, Choptank, Patuxent, Tangier, Pocomoke; 1/4" mesh, 16' net; 6 minute tow; measures crabs per tow) **Calvert Cliffs survey began in 1968 (Calvert Cliffs Pot Survey runs April-November; 3 locations, 60 pots total; 1" pot mesh; measures crabs per pot.) **Virginia trawl survey began in 1955 (Virginia Trawl Survey runs January-December; most Virginia inland waters;130 stations per month; 1/4" mesh, 30' net; 5 minute tow; measures crabs per tow) **Winter dredge survey began in 1990 (Winter dredge Survey runs December-March; Baywide; ~ 1500 stations; 1/2" mesh, 6' dredge; 100m tow; measures crabs/1000sq. meters) The surveys have all been collecting data for the benefit of making resource management decisions. None of the surveys are currently mandated however, all provide critical information in maintaining the status of the blue crab resource. For additional information refer to the 2004 Chesapeake Bay Blue Crab Advisory Report Prepared by the Chesapeake Bay Stock Assessment Committee: June 2, 2004, at http://noaa.chesapeakebay.net/fish/BCAR2004.pdf. Contact Derek Orner, NOAA Chesapeake Bay Office (derek.orner@noaa.gov).

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. This indicator has undergone extensive technical and peer review by state, Federal and non-government organization partner members of the Chesapeake Bay Stock Assessment Committee (CBSAC) and the Living Resources subcommittee. Data collection, data analysis and QA/QC is conducted by the principal investigators/scientists. The data are peer reviewed by scientists on the CBSAC. Data selection and interpretation, the presentation of the indicator, along with all information and messages that accompany it is arrived at via consensus by the scientists in collaboration with the resource manager members of the CBSAC. The CBSAC presents the indicator to the subcommittee where extensive peer review by Bay Program managers occurs. The indicator is published at http://www.chesapeakebay.net/status.cfm?sid=75. The data used to construct the chart are located at http://www.chesapeakebay.net/pubs/statustrends/75-data-2002.xls. For additional information refer to the 2004 Chesapeake Bay Blue Crab Advisory Report Prepared by the Chesapeake Bay Stock Assessment Committee: June 2, 2004, at http://noaa.chesapeakebay.net/fish/BCAR2004.pdf. Contact Derek Orner, NOAA Chesapeake Bay Office (derek.orner@noaa.gov).

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

These surveys are used to determine trends in extent and conditions of blue crabs in coastal waters in the Chesapeake Bay region. MD Trawl survey data were initially collected for various fish species but not until 1977 was blue crab catch information added to the survey. The VA trawl survey has been collecting information since 1955 and again is not a blue crab targeted survey but does collect information required for analyses. Calvert Cliffs pot survey was initially began in 1968 to provide information for the construction of Calvert Cliffs nuclear power plant. The lead scientist for the project has continued to collect information over the timeframe in a consistent manner. The winter dredge survey was designed in 1990 and was designed specifically to garner information on a Baywide scale on the population of blue crab in Chesapeake Bay. By far, this is the most comprehensive blue crab survey. For additional information refer to the 2004 Chesapeake Bay Blue Crab Advisory Report Prepared by the Chesapeake Bay Stock Assessment Committee: June 2, 2004, at http://noaa.chesapeakebay.net/fish/BCAR2004.pdf. Contact Derek Orner, NOAA Chesapeake Bay Office (derek.orner@noaa.gov).

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Clearly shows the status of the mature female (or spawning stock abundance) for blue crab in Chesapeake Bay.The blue crab represents a valuable commercial fishery across much of the eastern coast of the U.S. fishery. In Chesapeake Bay, harvest pressure on the species and the loss of the submerged aquatic vegetation habitat that young crabs require for shelter and food during their development, have led directly to the decline in the blue crab's numbers. Spawning stock abundance of female blue crabs is a key determinant of the status of this important fishery.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Yes - The long term average of all four surveys combined is used for comparing recent status and trends. Refer to the 2004 Chesapeake Bay Blue Crab Advisory Report Prepared by the Chesapeake Bay Stock Assessment Committee: June 2, 2004, at http://noaa.chesapeakebay.net/fish/BCAR2004.pdf. Contact Derek Orner, NOAA Chesapeake Bay Office (derek.orner@noaa.gov).

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Refer to the 2004 Chesapeake Bay Blue Crab Advisory Report Prepared by the Chesapeake Bay Stock Assessment Committee: June 2, 2004, at http://noaa.chesapeakebay.net/fish/BCAR2004.pdf. Contact Derek Orner, NOAA Chesapeake Bay Office (derek.orner@noaa.gov).

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. Refer to the 2004 Chesapeake Bay Blue Crab Advisory Report Prepared by the Chesapeake Bay Stock Assessment Committee: June 2, 2004, at http://noaa.chesapeakebay.net/fish/BCAR2004.pdf. For data and information about the Winter Drege Survey go to http://www.dnr.state.md.us/fisheries/crab/winter_dredge.html For original Winter Dredge Survey data, go to http://noaa.chesapeakebay.net/fisheries/surveys.htm. For original VA Trawl Survey data go to http://www.fisheries.vims.edu/trawlseine/mainpage.htm. MD trawl and Calvert Cliffs survey data and information resides with the NOAA Chesapeake Bay Office. Contact Derek Orner, NOAA Chesapeake Bay Office (derek.orner@noaa.gov).

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. Refer to the 2004 Chesapeake Bay Blue Crab Advisory Report Prepared by the Chesapeake Bay Stock Assessment Committee: June 2, 2004, at http://noaa.chesapeakebay.net/fish/BCAR2004.pdf. Contact Derek Orner, NOAA Chesapeake Bay Office (derek.orner@noaa.gov).

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The quality of the data for the Baywide winter dredge survey is by far the most comprehensive. Calvert Cliffs pot survey information has been collected in the same manner over all years of the survey but is limited to fishing season and fishing regulations. The two state trawl surveys have been collecting data and reporting results annually throughout the survey durations. For information about the Winter Drege Survey go to http://www.dnr.state.md.us/fisheries/crab/winter_dredge.html For VA Trawl Survey information go to http://www.fisheries.vims.edu/trawlseine/mainpage.htm. MD trawl and Calvert Cliffs survey inforamtion resides with the NOAA Chesapeake Bay Office. Contact Derek Orner, NOAA Chesapeake Bay Office (derek.orner@noaa.gov). For additional information refer to the 2004 Chesapeake Bay Blue Crab Advisory Report Prepared by the Chesapeake Bay Stock Assessment Committee: June 2, 2004, at http://noaa.chesapeakebay.net/fish/BCAR2004.pdf.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. Values are interpreted using a statistical average or standard score (Z-score) allowing for averaging of various data sets. Results are provided as an overall average as it moves above or below an average 0. (Positive numbers [above the 0 line] are better than average). Raw data are used to generate a standard score for each survey and averaged together to obtain an unweighted average Z-score estimate. For additional information refer to the 2004 Chesapeake Bay Blue Crab Advisory Report Prepared by the Chesapeake Bay Stock Assessment Committee: June 2, 2004, at http://noaa.chesapeakebay.net/fish/BCAR2004.pdf. Contact Derek Orner, NOAA Chesapeake Bay Office (derek.orner@noaa.gov).

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No. N/A

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No. N/A

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

No - the limitations in the survey will not mislead the user. MD trawl survey samples on in major tributaries of Maryland waters of Chesapeake Bay and the Calvert Cliffs survey was a spatially limited to the waters surrounding the power plant in Calvert County, MD. The VA trawl survey samples both tributaries and the mainstem Bay in VA and the winter dredge survey is Baywide, Contact Derek Orner, NOAA Chesapeake Bay Office (derek.orner@noaa.gov).

Indicator: Coastal Benthic Index (048)

Benthic communities are largely composed of macroinvertebrates, such as annelids, mollusks, and crustaceans, that inhabit the bottom substrates of estuaries and play a vital role in maintaining sediment and water quality. They also are an important food source for bottom-feeding fish, invertebrates, ducks, and birds. Communities of benthic organisms are sensitive to pollutant exposure (Holland, et al., 1987) and as a result are important indicators of environmental stress. Sediments can accumulate environmental contaminants over time, and because benthic organisms are relatively immobile, they receive prolonged exposure to any such contaminants (Sanders et. al., 1980; Nixon et al., 1986)

This benthic index for each site is based on a multi-metric benthic diversity index that reflects overall species diversity (adjusted for salinity, if necessary) and, for some regions, the presence of pollution-tolerant and pollution-sensitive species (e.g., Weisberg et al, 1997; Engle and Summers 1999, EPA 2004). The benthic community at each site is given a high score if the index exceeds a particular threshold (e.g., a community with high diversity, many pollution-sensitive species, and few pollution tolerant species), a low score if it falls below a certain threshold, and a medium score if it falls in between. The exact structure of the index and the threshold values vary from one region to another, but comparisons between predicted and observed scores based on expert judgment are used to insure that the classifications of sites from one region to another are consistent (see EPA 2004, p. 15). Data for the estuaries were collected using probability samples, so the results from the sampling sites produce representative samples of the entire region. No data are available for the Great Lakes.

The sediment quality index for the each region was rated high (1) if less than 10% of the sediments had a low index score and more than 50% had a high score; moderate (3) if 10-15% of the sediments had a low index score, or fewer than 50% had a high index score; and low (5) if more than 20% of sites had a low index score. These values are based on the professional judgment of water quality managers in each region.

What the Data Show

Benthic condition in the nation's estuaries overall were observed to be in moderate to low condition (Rank Score = 2.0), with 17 percent of the estuarine area rated as low (Figure 048-1). Of that 17%, 71% also exhibited degraded sediment quality and 42% exhibited degraded water quality (see indicators xxx and yyy).

EPA Regions 9 and 10 had high benthic index scores, and Region 6 was high-moderate (Figure 048-1). Region 3 had a low benthic score, and Regions 1 and 2 and the Great Lakes were rated as low-moderate. More than 75% of the estuarine bottom had high benthic index scores in Regions 1, 9, and 10. Only one Region (3) had a low benthic diversity score for more than 25% of the bottom area.

Indicator Limitations

- The coastal areas of Alaska and Hawaii have been sampled, but not yet assessed.
- Benthic indices for the Northeast, West, and Puerto Rico do not yet include measures of pollution-tolerant or pollution-sensitive species; although species diversity has the largest impact on index scores in the other regions, index values could change in the future as these components are added to the index values for these regions.
- Samples are collected during an index period from July-September, and the indicator is only representative of this time period.

Data Sources

The data source for this indicator is the National Coastal Condition Report II, U.S. Environmental Protection Agency, 2004. http://www.epa.gov/owow/oceans/nccr/2005/downloads.html

References

Engle, V.D., and J.K. Summers. 1999. Refinement, validation, and application of a benthic condition index for northern Gulf of Mexico estuaries. *Estuaries 22*(3A):624–635.

EPA. 2004. National Coastal Condition Report II, EPA-620/R-03/002. U.S. Environmental Protection Agency, Washington, DC.

Holland, A.F., A. Shaughnessey, and M.H. Heigel. 1987. Long-term variation in mesohaline Chesapeake Bay benthos: spatial and temporal patterns. *Estuaries* 10: 227-245 (

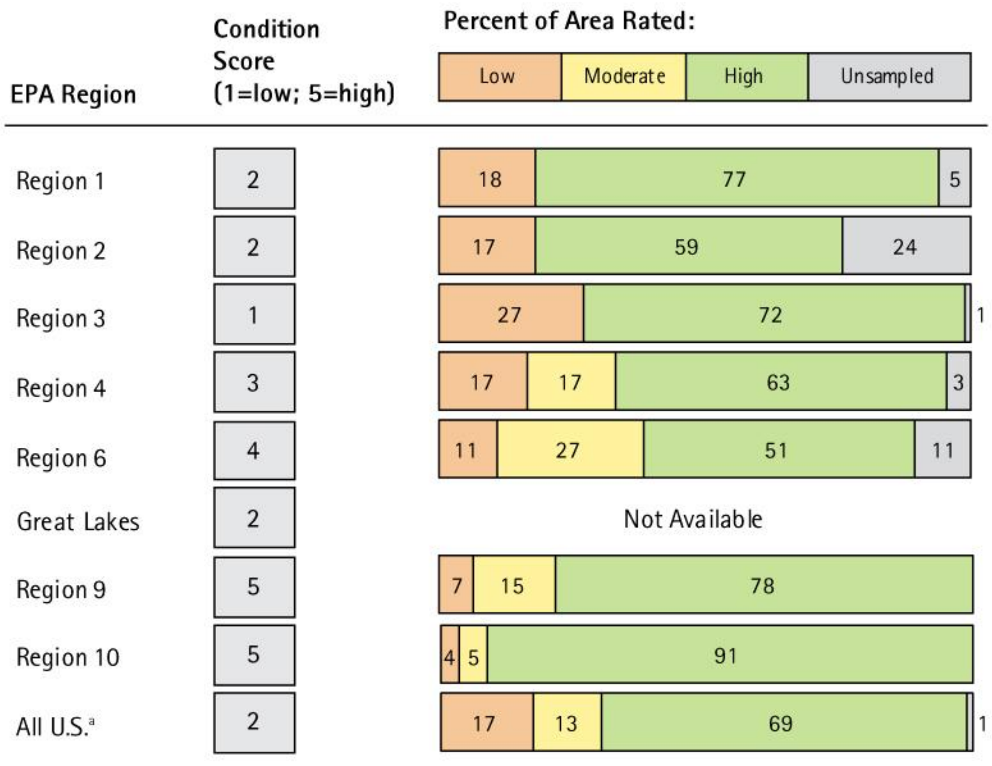
Nixon, S.W., Hunt, C.D., and Nowicki, B.L. 1986. "The retention of nutrients (C, N, P), heavy metals (Mn, Cd, Pb, Cu), and petroleum hydrocarbons by Narragansett Bay." In P. Lasserre and J.M. Martin (eds.), *Biogeochemical Processes at the Land-Sea Boundary*, New York, NY: Elsevier 99-1122.

Sanders, H.L., J.F. Grassle, G.R. Hampson, L.S. Morse, S. Gerner-Price, and C.C. Jones. 1980. Anatomy of an oil spill: long-term effects from the grounding of the barge Florida off West Falmouth, Massachusetts. *Journal of Marine Research* 38: 265-380.

Weisberg, S.B., J.A. Ranasinghe, D.D. Dauer, L.C. Schnaffer, R.J. Diaz, and J.B. Frithsen. 1997. An estuarine benthic index of biotic integrity (B-IBI) for Chesapeake Bay. *Estuaries 20*(1):149–158.

Graphics

Figure 048 - 1. Summary of Condition Based on the Benthic Index



Source: National Coastal Condition Report II, U.S. EPA, 2004.

[a]The national score is based on an aerially weighted mean of the regional scores.

R.O.E. Indicator QA/QC

Data Set Name: COASTAL BENTHIC INDEX
Indicator Number: 048 (89177)
Data Set Source: EPA/EMAP/NCA
Data Collection Date: 1999-2000
Data Collection Frequency: annually
Data Set Description: This index reflects changes in benthic community diversity and abundance of pollution-tolerant and pollution-sensitive species. It is capable of distinguishing between degraded and undegraded benthic habitats.
Primary ROE Question: What are the trends in extent and condition of coastal waters

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Methods described for this survey represent a combination of standard, scientifically accepted sampling and analytical methodologies. They are described in ; US EPA 2001. National Coastal Assessment: Field Operations Manual. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA 620/R-01/003. pp72. U.S. EPA. 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual-Estuaries, Volume 1: Biological and Physical Analyses. U.S. Environmental Protection Agency, Office of Research and Development , Narragansett, RI. EPA/620/R-95/008.
http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

There is an entire portion of the EMAP website dedicated to principles and implementation of the NCA monitoring design and analysis.
http://www.epa.gov/nheerl/arm/index.htm Diaz-Ramos, S., Stevens, D.L., Jr and Olsen, A.R. (1996) EMAP Statistical Methods Manual. Rep. EPA/620/R-96/002, U.S. Environmental Protection Agency, Office of Research and Development, NHEERL-WED, Corvallis, Oregon. Olsen, A.R., Stevens, D.L., Jr. and White, D. (1998) Application of global grids in environmental sampling. Computing Science and Statistics, 30, 279-84. Stevens, D.L., Jr. (1997) Variable density grid-based sampling designs for continuous spatial populations. Environmetrics, 8, 167-95. Stevens, D.L., Jr. and Olsen, A.R. (1999) Spatially restricted surveys over time for aquatic resources. Journal of Agricultural, Biological, and Environmental Statistics, 4, 415-28. Stevens, D.L., Jr. and Urquhart, N.S. (1999) Response designs and support regions in sampling continuous domains. Environmetrics, 11, 13-41. Stevens, D. L., Jr. and Olsen, A. R. Variance Estimation for Spatially Balanced Samples of Environmental Resources. Environmetrics

14:593-610. Stevens, D. L., Jr. and A. R. Olsen (2004). "Spatially-balanced sampling of natural resources." Journal of American Statistical Association 99(465): 262-278.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Benthic indices were developed utilizing a stepwise regression analysis of variables from each site with the benthic abundance and diversity data. The indices were validated against sites with known benthic quality. Benthic community diversity was used as a surrogate for areas where a benthic index has yet to be developed. Engle, V.D., J.K. Summers, and G.R. Gaston. 1994. A benthic index of environmental condition of the Gulf of Mexico Estuaries. Estuaries 17: 372-384. Engle, V.D., and J.K. Summers. 1999. Refinement, validation, and application of a benthic index for northern Gulf of Mexico estuaries. Estuaries 22(3A):624-635. Van Dolah, R.F., J.L. Hyland, A.F. Holland, J.S. Rosen, and T.T. Snoots. 1999. A benthic index of biological integrity for assessing habitat quality in estuaries of the southeastern USA. Marine Environmental Research 48:(4-5): 269-283.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Sampling for the indicator presents available information on a national scale for the conterminous 48 states and Puerto Rico. There are 50 sites sampled each year for each of the states or territory. Data collection began in 1999 and is ongoing in 2004.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Sensitive populations or ecosystems are represented to a limited extent. The monitoring design at the scale presented is to characterize condition on a regional scale, not specific areas.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Threshold values for benthic indices were established in the development of each index used. The values are different for each index, but reflect the same thresholds for condition. In the absence of an index the relationship of community diversity to natural gradients within the region were used. The application of the results from the indices was applied consistently across the geographical area.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

U.S. EPA. 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual-Estuaries, Volume 1: Biological and Physical Analyses. U.S. Environmental Protection Agency, Office of Research and Development , Narragansett, RI. EPA/620/R-95/008. U.S. EPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Project Plan. . U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/002. U.S. EPA. 2001. National Coastal Assessment Field Operations Manual. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/003. http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

http://www.epa.gov/emap/nca/html/data/index.html Stephen Hale, U.S. EPA, Atlantic Ecology Division, (401) 782-3048

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes, Using the documentation provided for the design can be reproduced by a competent statistician. All of the field sampling and analytical methods are also well documented.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

U.S. EPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Project Plan. . U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/002 Hale, S., J. Rosen, D. Scott, J. Paul, and M. Hughes. 1999. EMAP Information Management Plan: 1998-2001. U.S. Environmental Protection Agency, Office of Research and Development , Narragansett, RI. http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

There is an entire portion of the EMAP website dedicated to principles and implementation of the NCA monitoring design and analysis. http://www.epa.gov/nheerl/arm/index.htm Diaz-Ramos, S., Stevens, D.L., Jr and Olsen, A.R. (1996). See T1Q2.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes, measurements of uncertainty are provided with each indicator.
http://www.epa.gov/nheerl/arm/index.htm

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Inconsistency in application of the design, sample collection, or sample analysis. These are controlled through standardization of methodologies, publication of operational manuals, and training of personnel involved. It is monitored through quality assurance requirements and audits.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The only data gaps would be from missing or lost samples. In this event The analyses is performed without those sites. Any error associated with the index may only increase slightly, but would be controlled by the number of sites and the survey design.

Indicator: Index of Overall Condition of the Nation's Coastal Waters (350)

The nation's coastal waters, which include estuaries, wetlands, coral reefs, mangrove forests, and upwelling areas, provide an important interface between land and sea, as well as between fresh water and saline environments. Coastal waters provide unique and critical habitats, spawning grounds, food, and shelter for fish, birds, and other wildlife. Coastal resources support 85 percent of waterfowl and other migratory birds in the nation, and estuaries support commercial and recreational activities that are vital to the nation's economy (EPA 2004).

This indicator is based on the National Coastal Condition Report, which provides a characterization of the overall condition of the nation's coastal waters (EPA 2004). It is based on five indices constructed from combined survey data: water quality, sediment quality, benthic condition, coastal habitat, and fish tissue contaminants. The water quality index is based on five sub-indicators that include dissolved oxygen, nutrients (nitrogen and phosphorous), chlorophyll *a*, and water clarity. The sediment quality index is based on sediment toxicity, sediment contaminant concentration, and total organic carbon (TOC). The benthic condition index includes measures of benthic community diversity and, in some regions, the presence of pollution-tolerant or pollution-intolerant organisms. The coastal habitat index is based on wetland loss data, except for the Great Lakes. The fish tissue index is based on levels of chemical contamination in certain fish and shellfish species.

The five indices were each assigned ratings on a scale of 1 (a low condition rating) to five (a high condition rating) for each of the nation's coastal regions. The numeric rating scale translates into low (<2), moderate (2-4) and high (>4). The five index ratings were averaged to create an overall score for each coastal region. Regional scores were averaged to create a national score. The percentage area of each region classified as high is based on the stations at which none of the five indices showed a score below high; the percentage classified as low is based on stations that had a poor rating for at least one index. The national average is based on the weighted average of the areas for each region.

Data for this indicator are based on probabilistic surveys conducted on each of these measures in all estuarine waters of the conterminous 48 states and Puerto Rico by the NCA. For the Great Lakes, available non-probabilistic data were used. Wetland loss data used in the coastal habitat index derives from special study by the National Wetland Inventory, and alternative measurement approaches were used for the Great Lakes, where assessments include amphibian abundance and diversity, wetland-dependent diversity and abundance, coastal wetland area by type, and the effects of water level fluctuations.

What the Data Show

On the whole, the nation's coastal waters are in moderate condition, as the majority of regions received scores ranging from 2 to 4 (Figure 350-1). Regions 2, 3, and 6 received low ratings (below 2).

Over the entire U.S., 35% of the coastal area excluding the Great Lakes received low condition scores (ranging from 21% in Region 10 to 55% in Region 9), while 21% received high scores (ranging from 4% in Region 3 to 31% in Region 4).

Indicator Limitations

- The coastal areas of Alaska and Hawaii have been sampled, but not yet assessed. Data are not available for the U.S. Virgin Islands and the Pacific territories.

- There is insufficient information to compare National Coastal Condition Reports I and II for trend data. In some cases, indicators were changed in NCCR II to improve the assessment. In addition, reference conditions for some of the indicators were modified to reflect regional differences.

Data Sources

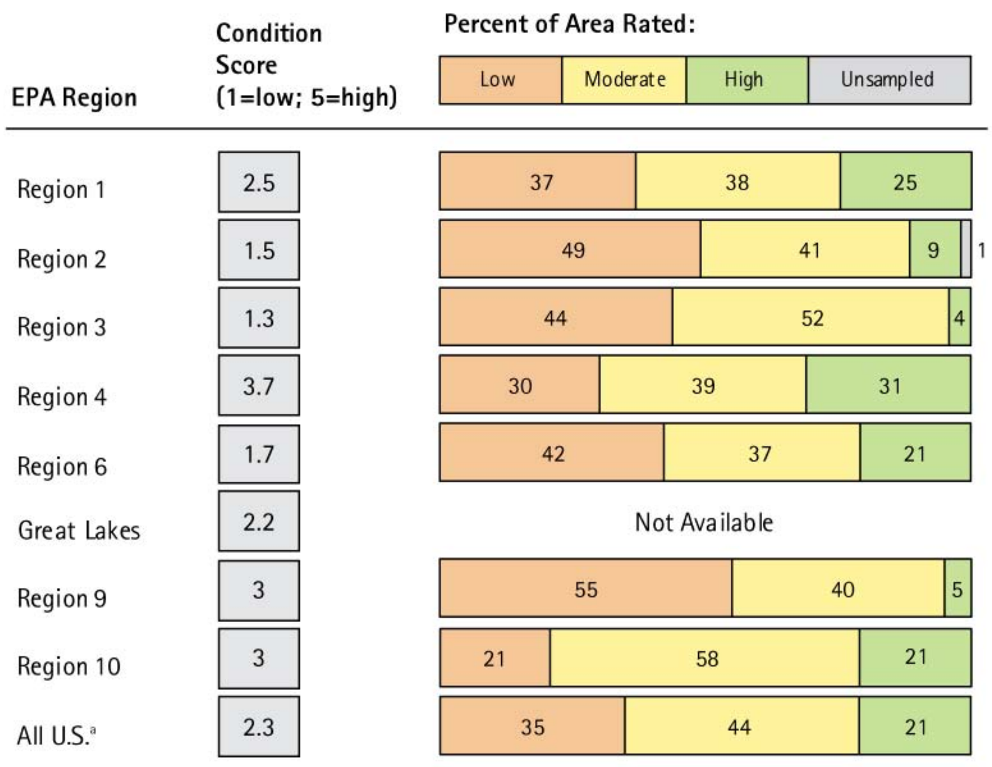
The data source for this indicator is the National Coastal Condition Report II, U.S. Environmental Protection Agency, 2004.
http://www.epa.gov/owow/oceans/nccr/2005/downloads.html

References

EPA. 2004. National Coastal Condition Report II, EPA-620/R-03/002. U.S. Environmental Protection Agency, Washington, DC.

Graphics

Figure 350-1: Summary of the US Overall Coastal Condition Based on Water Quality, Sediment Quality, Benthic, Coastal Habitat, and Fish Contaminant Indices[b]



Source: National Coastal Condition Report II, US EPA, 2004.

Notes: [a] The national score is based on an aerially weighted mean of the regional scores.

[b] The overall percentage is based on the overlap of the five indicators and includes estuarine area for all of the conterminous 48 states (by region and total) and Puerto Rico.

R.O.E. Indicator QA/QC

Data Set Name: COASTAL CONDITION INDEX
Indicator Number: 350 (113416)
Data Set Source: EPA/EMAP/NCA
Data Collection Date: 1999-2000
Data Collection Frequency: annually
Data Set Description: An indicator which combines the results of the individual assessment indicators into a summary for the geographic area of interest.
Primary ROE Question: What are the trends in extent and condition of coastal waters

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Methods described for this survey represent a combination of standard, scientifically accepted sampling and analytical methodologies. They are described in ; US EPA 2001. National Coastal Assessment: Field Operations Manual. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA 620/R-01/003. pp72. U.S. EPA. 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual-Estuaries, Volume 1: Biological and Physical Analyses. U.S. Environmental Protection Agency, Office of Research and Development , Narragansett, RI. EPA/620/R-95/008. http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

There is an entire portion of the EMAP website dedicated to principles and implementation of the NCA monitoring design and analysis. http://www.epa.gov/nheerl/arm/index.htm Diaz-Ramos, S., Stevens, D.L., Jr and Olsen, A.R. (1996) EMAP Statistical Methods Manual. Rep. EPA/620/R-96/002, U.S. Environmental Protection Agency, Office of Research and Development, NHEERL-WED, Corvallis, Oregon. Olsen, A.R., Stevens, D.L., Jr. and White, D. (1998) Application of global grids in environmental sampling. Computing Science and Statistics, 30, 279-84. Stevens, D.L., Jr. (1997) Variable density grid-based sampling designs for continuous spatial populations. Environmetrics, 8, 167-95. Stevens, D.L., Jr. and Olsen, A.R. (1999) Spatially restricted surveys over time for aquatic resources. Journal of Agricultural, Biological, and Environmental Statistics, 4, 415-28. Stevens, D.L., Jr. and Urquhart, N.S. (1999) Response designs and support regions in sampling continuous domains. Environmetrics, 11, 13-41. Stevens, D. L., Jr. and Olsen, A. R. Variance Estimation for Spatially Balanced Samples of Environmental Resources. Environmetrics 14:593-610. Stevens, D. L., Jr. and A. R. Olsen (2004). "Spatially-balanced sampling of natural resources." Journal of American Statistical Association 99(465): 262-278.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The five assessment indicators used by NCA were combined into a single indicator in response to the requirements of section 305(b) of the CWA. National indicators were created by calculating a weighted average of each of the five separate indicators. The indicators are weighted by the percentage of total area of estuaries contributed by each geographic area. The overall national score was calculated by summing each national indicator score and dividing by five.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Sampling for the indicator presents available information on a national scale for the conterminous 48 states and Puerto Rico. There are 50 sites sampled each year for each of the states or territory. Data collection began in 1999 and is ongoing in 2004.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Sensitive populations or ecosystems are represented to a limited extent. The monitoring design at the scale presented is to characterize condition on a regional scale, not specific areas.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Regional overall condition was calculated by summing the scores from each of available indicators and dividing by the number of indicators used. Numerical scores (1-5) were assigned based on the rating given to each indicator for the region, with the lower numbers representing a lesser condition value. Regional scores were then aerially weighted to calculate the value for overall national condition.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

U.S. EPA. 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual-Estuaries, Volume 1: Biological and Physical Analyses. U.S. Environmental Protection Agency, Office of Research and Development , Narragansett, RI. EPA/620/R-95/008. U.S. EPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Project Plan. . U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/002. U.S. EPA. 2001. National Coastal Assessment Field Operations Manual. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/003.
http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

http://www.epa.gov/emap/nca/html/data/index.html Stephen Hale, U.S. EPA, Atlantic Ecology Division, (401) 782-3048

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes, Using the documentation provided for the design can be reproduced by a competent statistician. All of the field sampling and analytical methods are also well documented.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

U.S. EPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Project Plan. . U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/002 Hale, S., J. Rosen, D. Scott, J. Paul, and M. Hughes. 1999. EMAP Information Management Plan: 1998-2001. U.S. Environmental Protection Agency, Office of Research and Development , Narragansett, RI. http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Not Applicable

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Uncertainty has been established by each of the indicators that were summarized to generate the overall condition indicator. Additional calculations cannot be performed.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Inconsistency in application of the design, sample collection, or sample analysis. These are controlled through standardization of methodologies, publication of operational manuals, and training of personnel involved. It is monitored through quality assurance requirements and audits.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The survey design dealt with data limitations and gaps at the level of each individual assessment

Coastal Habitat Index (334)

Coastal wetlands are vegetated interfaces between the aquatic and terrestrial components of estuarine ecosystems. They are a unique and valuable resource that provides habitat for a wide variety of plant and animal species. An estimated 95% of commercial fish and 85% of sport fish spend a portion of their life cycles in coastal wetland and estuarine habitats. Adult stocks of commercially harvested shrimp, blue crabs, oysters, and other species throughout the United States are directly related to wetland quality and quantity (Turner and Boesch, 1988). This irreplaceable resource has been diminishing over the years largely due to urban and rural development (Dahl, 2000).

In this indicator, for all regions except the Great Lakes, coastal habitat was assessed by measuring coastal wetland loss using data based on a special study by the National Wetlands Inventory Status and Trends Survey (NWI). For the Great Lakes, the index is based on an assessment that includes amphibian abundance and diversity, wetland-dependent diversity and abundance, coastal wetland area by type, and the effects of water level fluctuations. Wetland loss was measured in acres and assessed by taking an average of the mean long-term decadal loss rate (1780-1990) and the present decadal loss rate (1990-2000). Regions were assigned scores based on this average. Condition ratings were assigned as follows: high (score >4) if the coastal habitat index value was less than 1.0; moderate (score between 2-4) if the index value was between 1.0 and 1.25; and low (score <2) if the index value was greater than 1.25.

What the Data Show

Overall, the nation's coastal wetlands received a score of 1.26 on the coastal habitat index and alow condition rating (score = 1.0) (Figure 334-1). This rating was determined by averaging the 0.2 percent recent rate of decadal loss and the mean long-term decadal loss rate of 2.3 percent. The highest regional index values (translates to lowest condition rating scores) were observed in West Coast estuaries (index score 1.9 and condition score 1.0) and in Gulf Coast estuaries (index score 1.30 and condition score 1.0) where the majority of the nation's wetlands exist. The best condition was seen in the Northeast estuaries where the habitat index was 1.0 and the condition score 4.0. This data cannot be analyzed by EPA Region.

Indicator Limitations

- Data for Alaska, Hawaii, and Puerto Rico were not included in this analysis. Approximately 75 percent of the nation's estuaries are located in Alaska.
- There is insufficient information to compare National Coastal Condition Reports I and II for trend data. NCCR I presented an index based on 1780 to 1990; NCCR II presented the index based on 1780-2000.
- NWI maps do not show all wetlands since the maps are derived from aerial photointerpretation with varying limitations due to scale, photo quality, inventory techniques, and other factors.

Data Sources

Data for this indicator were provided from a special study by the National Wetlands Inventory to be compiled and presented in the National Coastal Condition Report II, U.S. Environmental Protection Agency, 2004. This report was prepared by EPA's Offices of Water and Research and Development.

Dahl. T.E. 1990. *Wetlands – Losses in the United States 1780's to 1980's*. U.S. Department of the Interior, U.S. Fish and Wildlife Service, Report to Congress, Washington, D.C.
http://www.npwrc.usgs.gov/resource/othrdata/wetloss/wetloss.htm

Dahl, T.E. 2003. Results of the 2000 National Wetlands Inventory. U.S. Department of the Interior, U.S. Fish and Wildlife Service, Washington, D.C. Unpublished draft.

References

Turner, R.E. and D.F. Boesch. 1988. Aquatic animal protection and wetland relationships: Insights gleaned following wetland loss or gain. In *The Ecology and Management of Wetlands*. Volume 1: Ecology of Wetlands, D.D. Hook, W.H. McKee, Jr., H.K. Smith, J. Gregory, V.G. Burrell, M.R. Devoe, R.E. Sojka, S. Gilbert, R. Banks, L.H. Stolzy, C. Brooks, T. D. Matthews, and T. H. Shear (eds). Portland, OR: Timber Press.

Dahl, T.E. *Status and Trends of Wetlands in the Conterminous United States 1986 to 1997*, Washington, D.C.: U.S. Department of the Interior, U.S. Fish and Wildlife Service, 2000. http://wetlands.fws.gov/bha/SandT/SandTReport.html

Graphics

Table 334-1. Summary of Condition Based on the Coastal Habitat Index[a]

Coastal Region	Condition Score (1=low; 5=high)	Coastal Habitat Index Value
Northeast	4	1.00
Southeast	3	1.06
Gulf	1	1.3
West	1	1.9
Great Lakes	2	Not available
All U.S.[b]	1.7	1.26

Source: National Coastal Condition Report II, U.S. EPA, 2004.
[a]The coastal habitat index is based on the average of the mean long-term decadal wetland loss rate (1780-1990) and the present decadal wetland loss rate (1990-2000).
[b]The national score is based on an aerially weighted mean of the regional scores.

R.O.E. Indicator QA/QC

Data Set Name: COASTAL HABITAT INDEX
Indicator Number: 334 (89134)
Data Set Source: NWI (2002)
Data Collection Date: 1999-2000
Data Collection Frequency: Every ten years
Data Set Description: An indicator of the proportional change in regional coastal wetlands over a 10 year period combined with the long-term decadal losses.
Primary ROE Question: What are the trends in extent and condition of coastal waters

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. Source imagery, data and data review processes were converted to a digital process for the 2000 dataset were converted to a digital procedure and were revised per the following technical manuals: USFWS, 2004. Technical Procedure for Wetlands Status and Trends. U.S. Dept of the Interior, Fish and Wildlife Service, Branch of Habitat Assessment, Arlington, VA. 62 pp.USFWS, 2004. National Standards and Quality Components for Wetlands, Deepwater and Related Habitat Mapping. U.S. Dept of the Interior, Fish and Wildlife Service, Branch of Habitat Assessment, Arlington, VA. 19 pp.Data collection methods for the 1990 survey are described in the references listed below. Dahl. T.E. 1990. Wetlands Losses in the United States, 1780 s to 1980 s. U.S. Dept of the Interior, Fish and Wildlife Service, Report to congress, Washington, DC. http://www.npwrc.usgs.gov/resource/othrdata/wetloss/wetloss.htm NWI (National Wetlands Inventory). 2002. Results of the 2000 wetlands inventory. http://wetlands.fws.gov/

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The sampling design for the coastal indicator was developed by an interagency group of spatial sampling experts specifically to monitor wetland changes. It can be used to monitor conversions between ecologically different wetland types, as well as, measure wetland gains and losses. This sample design has been used successfully by several researchers (Hefner et al. 1994; Moulton et al. 1997; Dahl 1999; and others), to monitor wetland change over time. The NWI status and trends dataset from 1986 to 1997 did not have the required data for developing the coastal indicator. Where statistical estimates were lacking or outdated, estimates of wetland extent were supplemented with updated map data from 1990 and 2000. These include data on West Coast intertidal wetlands. These products were produced using standardized, accepted techniques. Components of data quality for wetlands and deepwater habitat maps are specified in: USFWS, 2004. National Standards and Quality Components for Wetlands, Deepwater and Related Habitat Mapping. U.S. Dept of the Interior, Fish and Wildlife Service, Branch of Habitat Assessment, Arlington, VA. 19 pp.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The scientific integrity of the Wetlands Status and Trends is unchallenged as it represents the most comprehensive and contemporary effort to track wetlands resources on a national scale. The Fish and Wildlife Service strives to present information on wetlands, deepwater and related habitats in an accurate, clear, complete and unbiased manner. To ensure the effectiveness and reliability of wetland status and trends data, the Service has established these procedural guidelines and adheres to the various quality assurance and quality control measures described. The goal of these guidelines and protocols is to ensure that the data collection, analysis, verification and reporting methods used produce information suitable to support decisions for which the data was intended.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The Wetlands Status and Trends sample was designed to be a quantitative estimate of the areal extent of all coastal wetlands in the conterminous United States. Wetlands mapping efforts encompasses all wetlands of the conterminous 48 states and Puerto Rico, including coastal wetlands. Only data related to the coastal wetlands from the 23 coastal states and territories were included in the development of this index.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The sampling design targets wetlands which are considered to be sensitive ecosystems.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

The national value of the coastal habitat index is a weighted mean that reflects the extent of wetlands in each region. The calculated index scores range from 1.0 representing acceptable condition to greater than 1.25, representing less than acceptable condition. The use of this rating was consistent across all geographic areas.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

http://policy.fws.gov/905fw1.html This chapter provides guidance for conducting habitat mapping by the National Wetlands Inventory.Also see: USFWS, 2004. Technical Procedure for Wetlands Status and Trends. U.S. Dept of the Interior, Fish and Wildlife Service, Branch of Habitat Assessment, Arlington, VA. 62 pp.USFWS, 2004. National Standards and Quality Components for Wetlands, Deepwater and Related Habitat Mapping. U.S. Dept of the Interior, Fish and Wildlife Service, Branch of Habitat Assessment, Arlington, VA. 19 pp.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

See: http://wetlandsfws.er.usgs.gov The Service's wetland Status and Trends plot locations are considered proprietary information. Their location shall not be disclosed by copying or transmitting plot locations, geographical coordinates, or other locator information. Plots boundaries or data shall not be displayed, published or otherwise distributed. Copyright or use restrictions may also apply to the imagery used to update the plot information.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

http://policy.fws.gov/905fw1.html National estimates of the wetland status and trends (i.e., losses and gains), developed through statistical sampling, are made at approximately 10-year intervals contingent on funding. These estimates are used to evaluate the effectiveness of Federal programs and policies, identify national or regional problems, and increase public awareness. All are referenced in scientific literature and are used by Federal and State agencies, the scientific community and conservation groups for planning, decision making and wetland policy formulation and assessment. This design has been reproduced in whole or in part for coastal areas by the following authors: Tiner 1987; Frayer and Peters 1989; Hall et al. 1994; Hefner et al. 1994; Moulton et al. 1997; Dahl 1999, 2005.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

http://policy.fws.gov/905fw1.html NWI map production includes many quality control steps prior to releasing the final product, these are outlined at the website provided. Wetlands status and trends procedures for the coastal data are documented and available in the following technical manual: USFWS, 2004. Technical Procedure for Wetlands Status and Trends. U.S. Dept of the Interior, Fish and Wildlife Service, Branch of Habitat Assessment, Arlington, VA. 62 pp.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The wetland status and trends studies were based on a scientific probability sample of the surface area of the coastal areas for the 48 conterminous States and territories using a stratified, simple random sampling design. The statistical design including inference of data beyond spatial measurements are described in Dahl, 2000.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

NWI maps do not show all wetlands, but attempt to show most photointerpretable wetlands given considerations of map/photo scale and wetland delineation practices. A target mapping unit (tmu) is an estimate of the size class of the smallest group of wetlands that NWI attempts to map consistently (i.e, approximately one acre for coastal wetlands); it is not the smallest wetland mapped. http://wetlands.fws.gov/other/metadata/nwi_meta.txt The Fish and Wildlife Service's objective of mapping wetlands and deepwater habitats is to produce reconnaissance level information on the location, type, and size of these resources. The maps are prepared from by the analysis of high altitude imagery. Wetlands are identified based on vegetation, visible hydrology and geography. There is a margin error inherent in the use of imagery, thus detailed on-the-ground inspection of any particular site, may result in revision of the wetland boundaries or classification, established through image analysis.The accuracy of image interpretation depends on the quality of the imagery, the experience of the image analysts, the amount and quality of the collateral data, and the amount of ground truth verification work conducted. Metadata should be consulted to determine the date of the source imagery used and any mapping problems.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

The NWI maps do not show all wetlands since the maps are derived from aerial photointerpretation with varying limitations due to scale, photo quality, inventory techniques, and other factors. Consequently, the maps tend to show wetlands that are readily photointerpreted given consideration of photo and map scale. http://wetlands.fws.gov/other/metadata/nwi_meta.txt

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The The purpose of this survey was not to map all wetlands and deepwater habitats of the United States, but rather to use aerial photointerpretation techniques to produce thematic maps that show, in most cases, the larger ones and types that can be identified by such techniques.

Indicator: Coastal Sediment Quality Index (333)

Contaminated sediments pose an immediate threat to benthic organisms and an eventual threat to estuarine ecosystems as a whole. Contaminants in sediments may be resuspended into the water by anthropogenic activities, storms or other natural events, where they can expose organisms in the water column, and can accumulate and move up the food chain, eventually posing health risks to humans (EPA, 2004a).

This indicator, derived in part from the sediment quality index presented in EPA's National Coastal Condition Report (EPA, 2004b), is based on two measures: sediment contaminant concentrations and sediment toxicity. The data are from probabilistic surveys conducted of these measures in all estuarine waters of the conterminous 48 states and Puerto Rico.

Sediment concentration measurements of nearly 100 contaminants, including 25 PAHs, 22 PCBs, 25 pesticides, and 15 metals, were taken at each site. Homogenized samples were analyzed using standard wet chemistry and mass spectroscopy. Sediment condition was determined by comparing the observed concentrations to "effects range low" (ERL) and "effects range median" (ERM) values developed by the National Oceanic and Atmospheric Administration (Long et al., 1995). ERL and ERM values identify threshold concentrations that, if exceeded, are expected to produce ecological or biological effects based on the literature evaluated. Sediment contamination in this indicator is rated moderate if five or more ERLs are exceeded and high if one or more ERMs are exceeded.

Sediment toxicity depends not only on the concentrations of toxic materials, but also on their biological availability, which is controlled by acid volatile sulfides, pH, particle size and type, organic content, resuspension potential, and the specific form of contaminant (e.g., mercury vs. methyl mercury). Biological availability is determined in practice by bioassays that expose test organisms to sediments and evaluate their effects on the organisms' survival. For this indicator, sediment toxicity was based on 10-day static tests conducted using the benthic amphipod *Ampelisca abdita.* For this indicator, sediments were determined to be toxic if the bioassays resulted in greater than 20 percent mortality, or non-toxic if the bioassays resulted in 20 percent mortality or less (EPA, 2004b).

What the Data Show

Nationally, high sediment contamination levels were observed in 7 percent of coastal sediments for which contamination data were available, and moderate contamination was observed in an additional 8 percent (Figure 333-1). There was considerable variability in sediment contamination from one EPA region to the next, with Region 4 showing the largest proportion of estuarine area with low concentrations of sediment contaminants (99 percent), and Region 2 showing the largest proportion with high contamination (28 percent).

Nationwide, only 6 percent of coastal sediments had high toxicity scores, although again there was considerable variability from one EPA region to the next (Figure 333-2). In Regions 4 and 9, nearly 100 percent of estuarine area exhibited low sediment toxicity, while in some other regions, as much as 20 percent of estuarine area fell into the "high toxicity" category.

Although the percentage of sediments nationwide with high contamination is similar to the proportion exhibiting high toxicity, the two measures are not necessarily correlated. This indicator does not measure correlation, although in this case, the original data source actually shows little overlap between the two measures (EPA, 2004b). This indicator also does not reflect "missing" data, which accounted for a significant portion of estuarine area in a few regions. However, the probabilistic design of the survey ensures that the data that *were* collected are representative of each region as a whole.

Indicator Limitations

- Survey data are available only for the conterminous 48 states and Puerto Rico; 75 percent of the nation's estuaries are located in Alaska, which and are not included in the survey. Data also were not available for Hawaii, the U.S. Virgin Islands, and the Pacific territories.
- Samples are collected during an index period from July to September, and the indicator is only representative of this time period, but it is not likely that contaminant levels vary from season to season.
- The ERL and ERM are general guidelines for evaluating sediment contamination, and the sediment toxicity test uses one organism as a screening tool. This design ensures that a consistent metric is applied across the nation, but the results do not necessarily reflect the extent to which sediments may be toxic to the biota that actually inhabit any particular sampling location.
- Sediments that have toxic levels of contaminants do not always exhibit toxicity in the *Ampelisca* bioassay, and vice versa (some toxic chemicals may not be bioavailable, some may not be lethal, and not all potentially toxic chemicals are analyzed—see O'Connor et al., 1998 and O'Connor and Paul, 2000).
- The indicator does not include any microbial or plant toxicity tests.
- This indicator cannot be compared quantitatively with the indicator of pesticides in agricultural area streams (040), in which thresholds are based criteria that are intended to be protective of aquatic life with a margin of safety, instead of thresholds shown to cause biological effects.

Data Sources

The data source for this indicator is the National Coastal Condition Report II, U.S. Environmental Protection Agency, 2004. http://www.epa.gov/owow/oceans/nccr/2005/downloads.html.

References

EPA. 2004a. "Contaminated Sediment in Water." Fact Sheet: http://www.epa.gov/waterscience/cs/aboutcs.

EPA. 2004b. National Coastal Condition Report II, EPA-620/R-03/002. U.S. Environmental Protection Agency, Washington, DC. http://www.epa.gov/owow/oceans/nccr/2005/downloads.html.

Long, E.R., MacDonald, D.D., Smith, L., and Calder, F.D. 1995. Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. *Environmental Management* 19: 81-97.

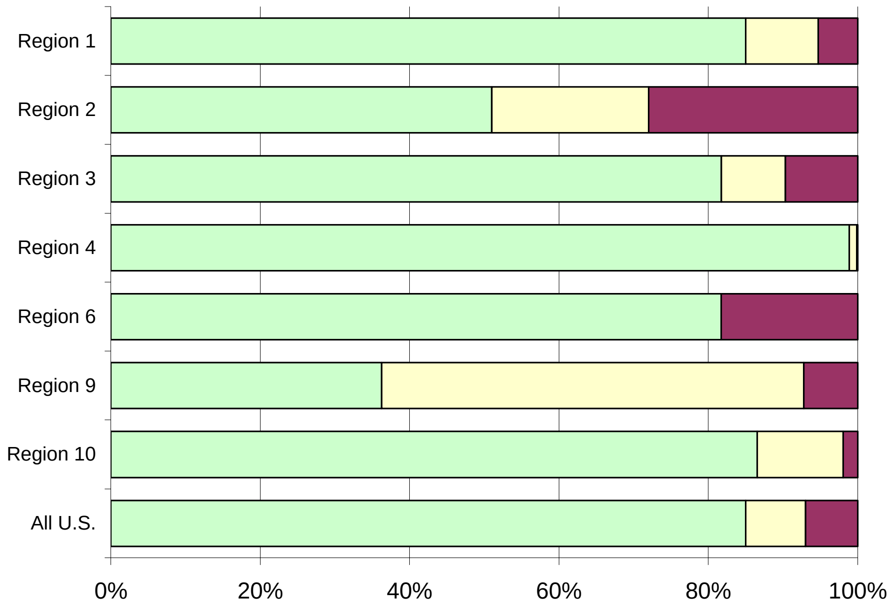
O'Connor, T.P., K.D. Daskalakis, J.L. Hyland, J.F. Paul, and J.K. Summers. 1998. Comparisons of sediment toxicity with predictions based on chemical guidelines. *Environmental Toxicology and Chemistry* 17(3): 468-471.

O'Connor, T.P., and J.F. Paul. 2000. Misfit between sediment toxicity and chemistry. *Marine Pollution Bulletin* 40(1): 59-64.

Graphics

Figure 333-1. Sedimen‍t Contamination

(Percentage of Estuarine Area)



Low: < 5 contaminants exceed ERL*

Moderate: 5 or more contaminants exceed ERL* (none exceed ERM*)

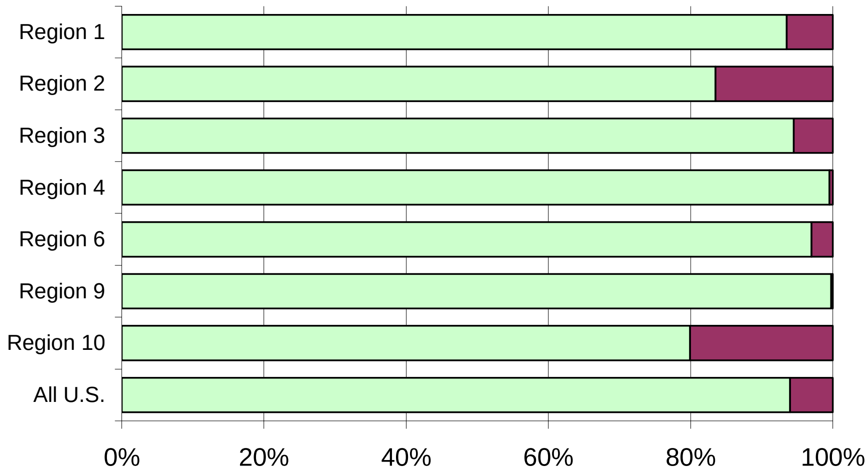
High: 1 or more contaminants exceed ERM*

Source: EPA, Office of Research and Development and Office of Water. National Coastal Condition Report II. 2004.

* ERL = effects range low; ERM = effects range median

Figure 333-2. Sediment Toxicity

(Percentage of Estuarine Area)



Low: Mortality of test species = 20% or lower

High: Mortality of test species > 20%

Source: EPA, Office of Research and Development and Office of Water. National Coastal Condition Report II. 2004.

R.O.E. Indicator QA/QC

Data Set Name: COASTAL SEDIMENT QUALITY INDEX
Indicator Number: 333 (89139)
Data Set Source: EPA/EMAP/NCA
Data Collection Date: 1999-2000
Data Collection Frequency: annually
Data Set Description: An issue of major environmental concern in estuaries is the contamination of sediments with toxic chemicals. The focus of the sediment quality index is on sediment condition, not just toxicity. The index is composed of sediment contaminant data, total organic carbon content, and toxicity to estuarine organisms.
Primary ROE Question: What are the trends in extent and condition of coastal waters?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Methods described for this survey represent a combination of standard, scientifically accepted sampling and analytical methodologies. They are described in ; US EPA 2001. National Coastal Assessment: Field Operations Manual. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA 620/R-01/003. pp72. U.S. EPA. 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual-Estuaries, Volume 1: Biological and Physical Analyses. U.S. Environmental Protection Agency, Office of Research and Development , Narragansett, RI. EPA/620/R-95/008. http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html EPA/620/R-95/008. http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

There is an entire portion of the EMAP website dedicated to principles and implementation of the NCA monitoring design and analysis. http://www.epa.gov/nheerl/arm/index.htm Diaz-Ramos, S., Stevens, D.L., Jr and Olsen, A.R. (1996) EMAP Statistical Methods Manual. Rep. EPA/620/R-96/002, U.S. Environmental Protection Agency, Office of Research and Development, NHEERL-WED, Corvallis, Oregon. Olsen, A.R., Stevens, D.L., Jr. and White, D. (1998) Application of global grids in environmental sampling. Computing Science and Statistics, 30, 279-84. Stevens, D.L., Jr. (1997) Variable density grid-based sampling designs for continuous spatial populations. Environmetrics, 8, 167-95. Stevens, D.L., Jr. and Olsen, A.R. (1999) Spatially restricted surveys over time for aquatic resources. Journal of Agricultural, Biological, and Environmental Statistics, 4, 415-28. Stevens, D.L., Jr. and Urquhart, N.S. (1999) Response designs and support regions in sampling continuous domains. Environmetrics, 11, 13-41. Stevens, D. L., Jr. and Olsen, A. R. Variance Estimation for Spatially Balanced Samples of Environmental Resources. Environmetrics 14:593-610. Stevens, D. L., Jr. and A. R. Olsen (2004). "Spatially-balanced sampling of natural resources." Journal of American Statistical Association 99(465): 262-278.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Some researchers would prefer that the sediment triad (chemistry, toxicity, and communities) be used to assess condition. This index only includes the chemical composition and toxicity of the sediments, with benthic communities being included as an independent variable for assessing ecological condition. Only attributes in sediments that can result in unacceptable changes in the biotic communities are included. Note that the original source has a “missing” category, but for this indicator, the “missing” category has been removed. These “missing” data points have been apportioned among the remaining categories according to the distribution of the existing data. This methodology is appropriate because of the survey’s probabilistic design.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Sampling for the indicator presents available information on a national scale for the conterminous 48 states and Puerto Rico. There are 50 sites sampled each year for each of the states or territory. Data collection began in 1999 and is ongoing in 2004.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

This indicator does not target specific plant or animal populations that may be sensitive to sediment condition. However, the indicator intentionally focuses on estuaries as a subset of coastal resources because estuaries are sensitive ecosystems in general.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Threshold values for sediment quality indicator components are based on existing criteria, guidelines, or the interpretation of scientific literature. For this index the ERM (Effects Range Median) and ERL (Effects Range Low) of Long et al., 1995 were utilized. These values were used consistently across all geographic areas of the study. Long, E.R., D.D. MacDonald, Smith, S.L., and Calder, F.D.: 1995, Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management 19(1): 81-97.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

U.S. EPA. 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual-Estuaries, Volume 1: Biological and Physical Analyses. U.S. Environmental Protection Agency, Office of Research and Development, Narragansett, RI. EPA/620/R-95/008. U.S. EPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Project Plan. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/002. U.S. EPA. 2001. National Coastal Assessment Field Operations Manual. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/003.
http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

http://www.epa.gov/emap/nca/html/data/index.html Stephen Hale, U.S. EPA, Atlantic Ecology Division, (401) 782-3048

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes, Using the documentation provided, the design can be reproduced by a competent statistician. All of the field sampling and analytical methods are also well documented.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

U.S. EPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Project Plan. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/002 Hale, S., J. Rosen, D. Scott, J. Paul, and M. Hughes. 1999. EMAP Information Management Plan: 1998-2001. U.S. Environmental Protection Agency, Office of Research and Development, Narragansett, RI.
http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html
http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

There is an entire portion of the EMAP website dedicated to principles and implementation of the NCA monitoring design and analysis. http://www.epa.gov/nheerl/arm/index.htm Diaz-Ramos, S., Stevens, D.L., Jr and Olsen, A.R. (1996). See T1Q2. Note that the original source has a "missing" category, but for this indicator, the "missing" category has been removed. These "missing" data points have been apportioned among the remaining categories according to the distribution of the existing data. This methodology is appropriate because of the survey's probabilistic design.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes, measurements of uncertainty are provided with each indicator.
http://www.epa.gov/nheerl/arm/index.htm

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Inconsistency in application of the design, sample collection, or sample analysis. These are controlled through standardization of methodologies, publication of operational manuals, and training of personnel involved. It is monitored through quality assurance requirements and audits.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Data gaps result from missing or lost samples. In this event, the analysis is performed without those sites. Any error associated with the index may only increase slightly, but would be controlled by the number of sites and the survey design. Samples are collected during an index period from July to September, and the indicator is only representative of this time period, but it is not likely that contaminant levels vary from season to season.The ERL and ERM are general guidelines for evaluating sediment contamination, and the sediment toxicity test uses one organism as a screening tool. This design ensures that a consistent metric is applied across the nation, but the results do not necessarily reflect the extent to which sediments may be toxic to the biota that actually inhabit any particular sampling location.Sediments that have toxic levels of contaminants do not always exhibit toxicity in the Ampelisca bioassay, and vice versa (some toxic chemicals may not be bioavailable, some may not be lethal, and not all potentially toxic chemicals are analyzed – see O’Connor et al. 1998 and O’Connor and Paul 2000). The indicator also does not include any microbial or plant toxicity tests.This indicator cannot be compared quantitatively with the indicator of pesticides in agricultural area streams (040), in which thresholds are based criteria that are intended to be protective of aquatic life with a margin of safety, instead of thresholds shown to cause biological effects

Indicator: Coastal Water Quality Index (332)

Water quality is a critical aspect of coastal aquatic ecosystems, and four interlinked components are especially critical: nutrients (nitrogen and phosphorus), chlorophyll, dissolved oxygen, and water clarity. Nitrogen is understood to be the most important limiting nutrient driving large increases of microscopic phytoplankton in estuaries called “algal blooms,” but phosphorus can become limiting in coastal systems if available nitrogen is abundant (EPA, 2003). Nitrogen and phosphorus can come from point sources, such as wastewater treatment plants and industrial effluents, and non-point sources, such as runoff from farms, over-fertilized lawns, leaking septic systems, and atmospheric deposition. Chlorophyll is a measure of the actual abundance of microscopic algae that constitute algal blooms. In addition to nutrients, chlorophyll levels also are affected by declines in filtering organisms like clams, mussels, or oysters. High concentrations of chlorophyll *a* indicate overproduction of algae, which can cause noxious odors, decreased clarity, and low dissolved oxygen. Reduced water clarity (usually measured as the amount and type of light penetrating water to a depth of one meter) can impair normal algae and other submerged vegetation growth. Reduced water clarity can be caused by algal blooms and by storm-related events that cause erosion or mixing from the sediments. Low dissolved oxygen levels caused by algal blooms or the decay of organic matter from the watershed are stressful to estuarine organisms and often lead to algal scums, fish kills, and noxious odors (EPA, 2004).

This indicator, developed as part of EPA’s Coastal Condition Report, is based on an index constructed from probabilistic survey data on dissolved oxygen (DO), nitrogen, phosphorus, chlorophyll *a*, and water clarity (EPA, 2004). The survey was designed to be representative of all estuarine waters of the conterminous 48 states and Puerto Rico. The Great lakes indicator is based on available non-probabilistic data. Reference conditions were established for each region for nutrients, water clarity, and chlorophyll a. A national reference condition of 2 mG/L was used for dissolved oxygen, because this measure does not tend to vary by region (Diaz and Rosenberg, 1995; EPA, 2000). Assignments of classifications to individual sits varies by region and is described in detail, along with the regional reference conditions, in EPA (2004, pp 19-20).

The five “sub-indicators” are combined into a single index of water quality. For each site, the indicator is rated high if none of the five components of the index are rated low, and nor more than one is rated moderate. It is rated low if more than two components are rated low. All other sites are rated moderate. If two components of the indicator were missing, and the available indicators did not suggest a moderate or low rating, the site was rated missing. Data from the individual sites then were expanded from the probability sample to provide unbiased estimates of the sub-indicator for each region and for the entire nation.

Regions were rated high if less than 10% of coastal waters were rated low, and less than 50% of coastal waters were in combined low and moderate condition; moderate if 10% to 20% of coastal waters were in low condition, or more than 50% of coastal waters were in combined moderate to low condition; and low if more than 20% of coastal waters were in low condition.

What the Data Show

Data from the National Coastal Assessment indicate that the overall condition of the nation’s estuaries as measured by the water quality index is moderate (Figure 332-1). EPA Region 1 was rated high, Region 3 was rated low, and all other Regions and the Great Lakes were rated moderate.

Based on surface area, 11% of the nation’s estuaries exhibit low water quality condition scores, 40% exhibit high scores, and 49% is exhibit moderate water quality scores. Only EPA Region 3 had low ratings for more than 15% of the estuarine area. More than 1/3 of the estuarine area in most EPA Regions was rated high, with Region 1 having 71% of the area rated high.

Based on the individual components of the water quality index, most of the nation's coastal area fell below the corresponding regional reference conditions, ranging from 51% for chlorophyll a to 82% for nitrogen concentrations (Figure 332-2). Areas exceeding reference conditions were generally below 10%, except for water clarity, which exceeded regional reference conditions in 25% of estuaries. These percentages do not include the Great Lakes or the hypoxic zone in offshore Gulf Coast waters (see indicator Areal Extent of Hypoxia in the Gulf of Mexico).

Indicator Limitations

- The coastal areas of Alaska and Hawaii have been sampled, but not yet assessed. Data are also not available for the U.S. Virgin Islands, and the Pacific territories.
- Trend data are not yet available for this indicator.
- The National Coastal Assessment surveys measure dissolved oxygen conditions only in estuarine waters and do not include observations of dissolved oxygen concentrations in offshore coastal shelf waters; such as the hypoxia zone in Gulf of Mexico shelf waters.
- The water quality index used in this report is intended to characterize the typical distribution of water quality conditions in coastal waters. It does not consistently identify the "worst-case" condition for sites experiencing occasional or infrequent hypoxia, nutrient enrichment, or decreased water clarity.

Data Sources

The data source for this indicator is the National Coastal Condition Report II, U.S. Environmental Protection Agency, 2004.
http://www.epa.gov/owow/oceans/nccr/2005/downloads.html

References:

Diaz, R.J. and R. Rosenberg. 1995. Marine benthic hypoxia: A review of its ecological effects and the behavioral responses of benthic macrofauna. *Oceanography and Marine Biology Annual Review 33:245-303.*

U.S. Environmental Protection Agency. 2000. Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hatteras. EPA 822-R-00-12. Office of Water/Office of Science and Technology and Office of Research and Development/National Health and Environmental Effects Research Laboratory. November 2000.

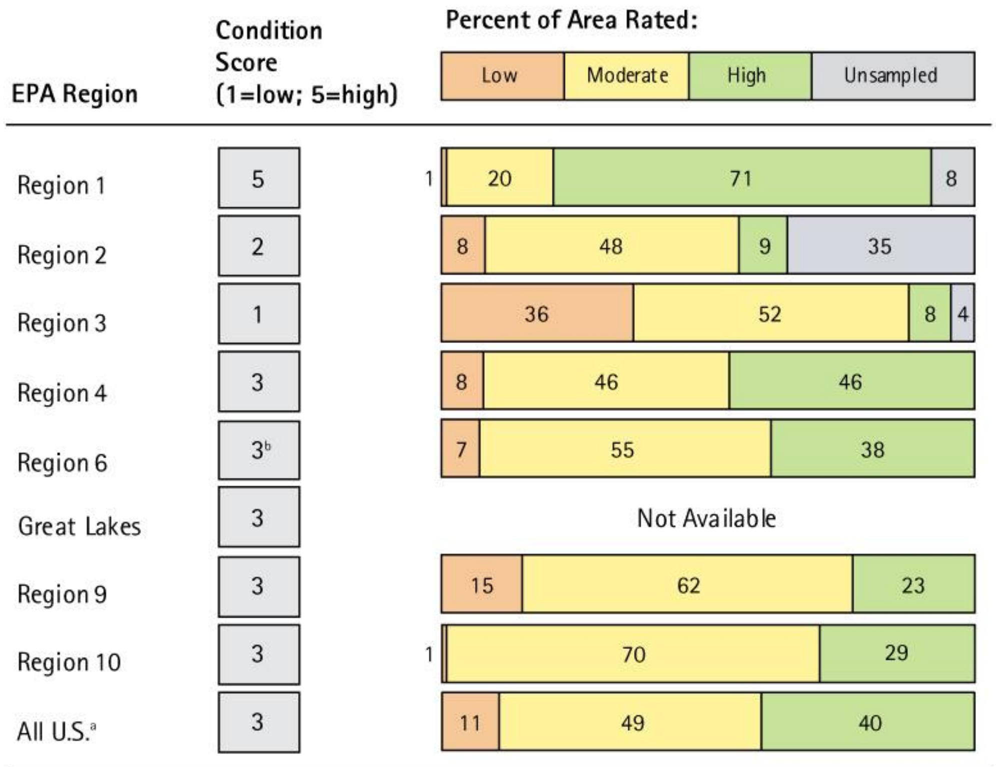
U.S. Environmental Protection Agency. 2003. Mid-Atlantic Integrated Assessment, MAIA – Estuaries 1997-98, Summary Report, EPA 620-R-02-003. Narragansett, RI: U.S. Environmental Protection Agency, Office of Research and Development, Atlantic Ecology Division, May 2003.

EPA. 2004. National Coastal Condition Report II, EPA-620/R-03/002. U.S. Environmental Protection Agency, Washington, DC.

Schindler, D.W. 1977. Evolution of phosphorus limitation in lakes. Science 179:260-262.

Graphics

Figure 332-1: Overall Summary of Condition Based on the Water Quality Index

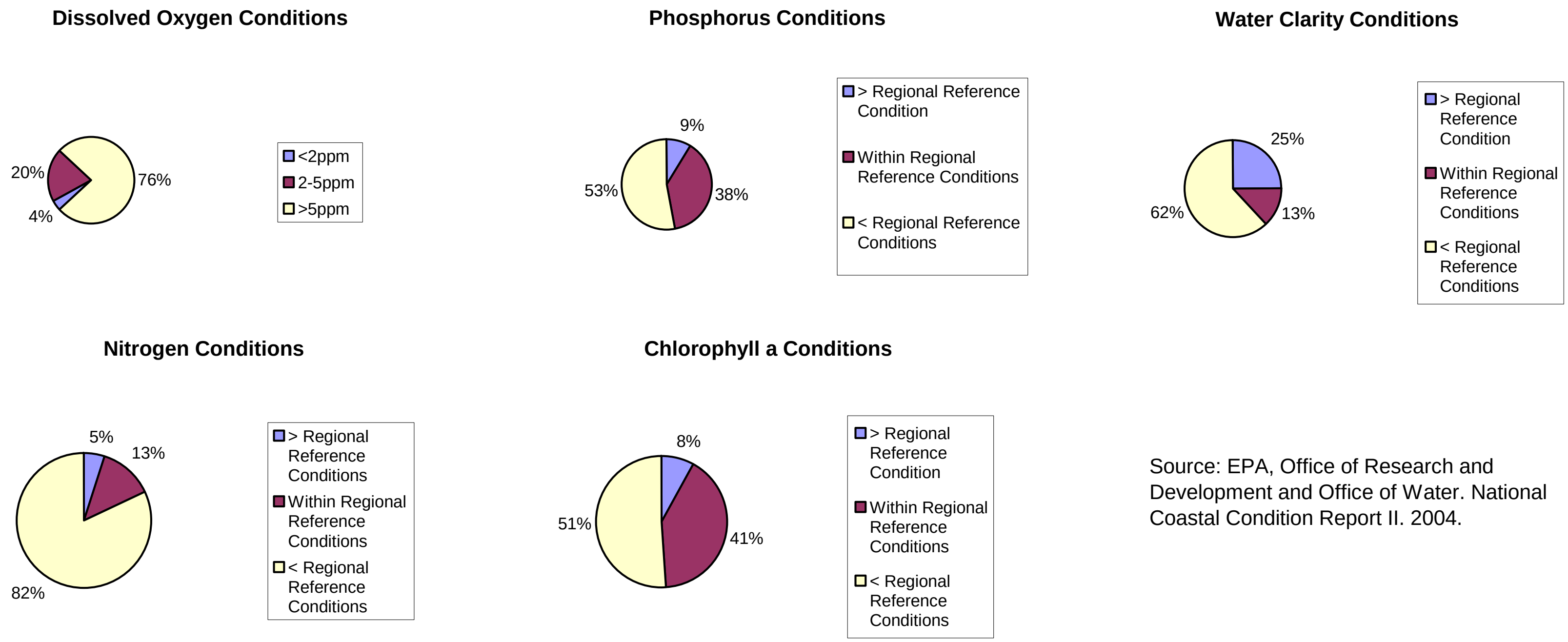


Source: National Coastal Condition Report II, US EPA, 2004.

Notes: [a] The national score is based on an aerially weighted mean of the regional scores.

[b] This rating does not include the impact of the hypoxic zone in offshore Gulf Coast waters.

Figure 332-2. Coastal Water Quality, 1997-2000:
Percentage of Estuarine Area (48 Conterminous U.S. States and Puerto Rico)



Source: EPA, Office of Research and Development and Office of Water. National Coastal Condition Report II. 2004.

R.O.E. Indicator QA/QC

Data Set Name: COASTAL WATER QUALITY INDEX
Indicator Number: 332 (89145)
Data Set Source: EPA/EMAP/NCA
Data Collection Date: 1999-2000
Data Collection Frequency: annually
Data Set Description: The water quality index is intended to characterize acutely degraded water quality conditions. The index is made up of five indicators: nitrogen, phosphorus, chlorophyll a, water clarity, and dissolved oxygen.
Primary ROE Question: What are the trends in extent and condition of coastal waters

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Methods described for this survey represent a combination of standard, scientifically accepted sampling and analytical methodologies. They are described in ; US EPA 2001. National Coastal Assessment: Field Operations Manual. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA 620/R-01/003. pp72. U.S. EPA. 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual-Estuaries, Volume 1: Biological and Physical Analyses. U.S. Environmental Protection Agency, Office of Research and Development , Narragansett, RI. EPA/620/R-95/008. http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

There is an entire portion of the EMAP website dedicated to principles and implementation of the NCA monitoring design and analysis. http://www.epa.gov/nheerl/arm/index.htm Diaz-Ramos, S., Stevens, D.L., Jr and Olsen, A.R. (1996) EMAP Statistical Methods Manual. Rep. EPA/620/R-96/002, U.S. Environmental Protection Agency, Office of Research and Development, NHEERL-WED, Corvallis, Oregon. Olsen, A.R., Stevens, D.L., Jr. and White, D. (1998) Application of global grids in environmental sampling. Computing Science and Statistics, 30, 279-84. Stevens, D.L., Jr. (1997) Variable density grid-based sampling designs for continuous spatial populations. Environmetrics, 8, 167-95. Stevens, D.L., Jr. and Olsen, A.R. (1999) Spatially restricted surveys over time for aquatic resources. Journal of Agricultural, Biological, and Environmental Statistics, 4, 415-28. Stevens, D.L., Jr. and Urquhart, N.S. (1999) Response designs and support regions in sampling continuous domains. Environmetrics, 11, 13-41. Stevens, D. L., Jr. and Olsen, A. R. Variance Estimation for Spatially Balanced Samples of Environmental Resources. Environmetrics 14:593-610. Stevens, D. L., Jr. and A. R. Olsen (2004). "Spatially-balanced sampling of natural resources." Journal of American Statistical Association 99(465): 262-278.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

These measurements were combined into a water quality index because they represent what are considered to be the major components of water quality in estuaries. This was based on a concensus of scientific opinion on the topic.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Sampling for the indicator presents available information on a national scale for the conterminous 48 states and Puerto Rico. There are 50 sites sampled each year for each of the states or territory. Data collection began in 1999 and is ongoing in 2004.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Sensitive populations or ecosystems are represented to a limited extent. The monitoring design at the scale presented is to characterize condition on a regional scale, not specific areas.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Threshold values for water quality indicator components are based on existing criteria, guidelines, or the interpretation of scientific literature. Some of these values were regionally specific, and therefore could not be applied across all geographic areas. Though, each geographic component had identical measurements.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

U.S. EPA. 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual-Estuaries, Volume 1: Biological and Physical Analyses. U.S. Environmental Protection Agency, Office of Research and Development, Narragansett, RI. EPA/620/R-95/008. U.S. EPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Project Plan. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/002. U.S. EPA. 2001. National Coastal Assessment Field Operations Manual. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/003.
http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

http://www.epa.gov/emap/nca/html/data/index.html Stephen Hale, U.S. EPA, Atlantic Ecology Division, (401) 782-3048

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes, Using the documentation provided for the design can be reproduced by a competent statistician. All of the field sampling and analytical methods are also well documented.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

U.S. EPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Project Plan. . U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/002 Hale, S., J. Rosen, D. Scott, J. Paul, and M. Hughes. 1999. EMAP Information Management Plan: 1998-2001. U.S. Environmental Protection Agency, Office of Research and Development , Narragansett, RI. http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Not Applicable

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes, measurements of uncertainty are provided with each indicator. http://www.epa.gov/nheerl/arm/index.htm

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Inconsistency in application of the design, sample collection, or sample analysis. These are controlled through standardization of methodologies, publication of operational manuals, and training of personnel involved. It is monitored through quality assurance requirements and audits.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

In the original data set there was an inconsistency in measurements taken for water clarity. Secchi disk depths for all areas and light energy values for some. In order to calculate our water clarity indice, light energy values were required for all sites. A model was developed to predict the light energy penetration using the secchi disk depths so that the indice could be calculated. This paper had been submitted for internal EPA review.

Indicator: Hypoxia in the Northern Gulf of Mexico and in Long Island Sound (238R)

Nutrient pollution is one of the most pervasive and troubling pollution problems facing U.S. coastal waters (U.S. Commission on Ocean Policy, 2004). More than half of the nation's estuaries experience low levels of dissolved oxygen (hypoxia) and other symptoms of eutrophication (Bricker et al. 1999). The Gulf of Mexico and Long Island Sound are prime examples of coastal and estuarine areas experiencing eutrophic conditions. While hypoxia can occur naturally and has existed throughout geologic time, its occurrence in shallow coastal and estuarine areas appears to be increasing and is most likely accelerated by human activities (Vitousek et al. 1997; Jickells 1998). As a result, coastal ecosystems suffer a number of environmental problems that can, at times, be attributed to the introduction of excess nutrients from upstream watersheds (NRC, 2000). Tracking dissolved oxygen conditions provides an indicator of whether nutrients are a concern, whether actions to control nutrients are having the desired effect, and of the natural variability in the condition of the waterbodies.

Concentrations of dissolved oxygen above 5 mg/L are supportive of marine life. As oxygen levels fall, the effects on aquatic life become more severe. At about 3 mg/L, bottom living fishes start to leave the area, and the growth of sensitive species such as crab larvae is reduced. At 2.5 mg/L, the larvae of even less sensitive species of crustaceans start to die, and the growth of crab species is more severely limited. At levels less than 2 mg/L, some juvenile fish and crustaceans that cannot leave the area start to die. At levels less than 1 mg/L, fish totally avoid the area or begin to die in large numbers (Howell and Simpson, 1994, U.S. Environmental Protection Agency, 2000).

This indicator tracks trends in hypoxia in the Gulf of Mexico and in Long Island Sound.

The Gulf of Mexico hypoxic zone on the Texas-Louisiana Shelf is the largest zone of coastal hypoxia in the Western Hemisphere (CAST, 1999). It exhibits seasonally low oxygen levels as a result of complicated interactions involving excessive nutrients carried to the Gulf by the Mississippi and Atchafalaya Rivers; physical changes in the basin, such as channelization, construction of dams and levees, and loss of natural wetlands and vegetation along the banks and wetland conversion throughout the basin; and the stratification in the waters of the northern Gulf caused by the interaction of fresh river water and the saltwater of the Gulf (CENR, 2000). Increased nitrogen and phosphorus inputs from human activities throughout the basin cause the production of an overabundance of algae, which die and fall to the sea floor, where they consume oxygen. Fresh water from the rivers entering the Gulf of Mexico forms a fresh water layer above the saltier Gulf of Mexico waters and prevents re-oxygenation of oxygen depleted water along the bottom. The Gulf of Mexico indicator is based on data collected at least annually, although recently there have been as many as four surveys per year. The number of locations varies from 60-90 depending on the length of the cruise, the size of the hypoxic zone, logistical constraints, and the density of station locations. The surveys usually occur in mid-July to late-July.

In Long Island Sound, seasonally low levels of oxygen usually occur in bottom waters from mid-July though September, and are more severe in the western portions of the Sound, where the nitrogen load is higher and stratification is stronger, reducing mixing and reaeration processes (Welsh et al. 1991). While nitrogen fuels the growth of microscopic plants that leads to low levels of oxygen in the Sound, temperature, wind patterns, rainfall, and salinity, also contribute. The low levels of oxygen impair the feeding, growth, and reproduction of aquatic life in the Sound. The Long Island Sound indicator is based on bi-weekly surveys conducted at 36 sites from mid-June through September. The indicator includes both extent and duration of the hypoxic period.

What the Data Show

The size of the hypoxic zone in the Gulf of Mexico has varied considerably since 1985 (Figure 238R -1). Between 1993 and 1999 the zone of midsummer bottom-water hypoxia area (<2 mg/L) in the Northern Gulf of Mexico was estimated to be larger than 4,000 square miles. In 1999, it increased to 8,000 square miles, but in 2000, the zone was reduced to only 1,700 square miles. In the latest year of sampling, 2004, the hypoxic zone measured over 5,800 square miles (Figure 238R-2). The five year running average for the years 1996 – 2000 was 5,454 square miles.

The area and duration of moderate hypoxic (less than 3 mg/l) in Long Island Sound also has varied considerably since 1987, and in most years, the lowest dissolved oxygen levels are found in the western end of the Sound (Figure 238R-3). Since 1987, the largest area of DO less than 3 mg/l was 393 square miles and occurred in 1994. The smallest area, 30 mi^2, occurred in 1997. The shortest duration of moderate hypoxia was 34 days in 1996 and the longest duration, 82 days, in 1989. While there are year-to-year variations in water quality conditions, there has been an overall trend toward less severe hypoxia since 1987, as indicated by the area and duration of DO < 3 mg/l. In 2004, the latest year for which data are available, the maximum area and duration of DO 3 mg/l in Long Island Sound was 202 square miles and 60 days, respectively (Figure 238R-4). The 18 year averages are 210 mi^2 and 57 days.

Indicator Limitations

Gulf of Mexico

- Anoxic periods (no oxygen at all) occurring at times other than the mid-summer surveys are not captured in the indicator.
- The extent of hypoxia is generated during a single midsummer sampling cruise, so duration cannot be estimated.
- Surveys usually end offshore the Louisiana-Texas State line; in years when hypoxia extends onto the upper Texas coast, the areal extent of hypoxia is underestimated.

Long Island Sound

- Anoxic period that may occur between the two week surveys are not captured in the indicator. two weeks during the critical summer period.
- Samples are taken in the daytime, approximately one meter off the bottom. Lower oxygen conditions at night or near the sediment-water interface are not captured by the indicator.

Data Sources

Committee on Environment and Natural Resources (CENR). 2000. Integrated Assessment of Hypoxia in the Northern Gulf of Mexico. National Science and Technology Council Committee on Environment and Natural Resources, Washington, DC. http://www.nos.noaa.gov/Products/pubs_hypox.html Council for Agricultural Science and Technology (CAST). 1999. Gulf of Mexico Hypoxia: Land and Sea Interactions. Task Force Report No. 134.

National Coastal Condition Report (NCCR). 2001. EPA-620/R-01/005. Office of Research and Development/Office of Water, Washington, DC.

Rabalais, N.N., Louisiana Universities Marine Consortium, 8124 Hwy. 56, Chauvin, LA 70344.

Rabalais, N.N. and R.E. Turner (eds.). 2001. Coastal Hypoxia: Consequences for Living Resources and Ecosystems. Coastal and Estuarine Studies 58, American Geophysical Union, Washington, D.C., 454 p.

Rabalais, N.N., R.E. Turner and D. Scavia. 2002. Beyond science into policy: Gulf of Mexico hypoxia and the Mississippi River. BioScience 52: 129-142.

Scavia, D., N.N. Rabalais, R.E. Turner, D. Justić, and W.J. Wiseman, Jr. 2003. Predicting the response of Gulf of Mexico hypoxia to variations in Mississippi River nitrogen load. Limnology & Oceanography 48: 951-956.

Turner, R.E., N.N. Rabalais, E.M. Swenson, M. Kasprzak and T. Romaire. 2005 (online www.sciencedirect.com Aug 2004). Summer hypoxia in the northern Gulf of Mexico and its prediction from 1978 to 1995. Marine Environmental Research 59: 65-77.

Connecticut Department of Environmental Protection.
http://dep.state.ct.us/wtr/lis/monitoring/monsum.htm
http://dep.state.ct.us/wtr/lis/monitoring/lis_page.htm

References

Howell, P. and Simpson, D. Abundance of Marine Resources in Relation to Dissolved Oxygen in Long Island Sound. Estuaries. 17:394-402. 1994.

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U.S. Environmental Protection Agency. Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hatteras. EPA 822-R-00-12. Office of Water/Office of Science and Technology and Office of Research and Development/National Health and Environmental Effects Research Laboratory. November 2000.

Welsh, B.L. and F. C. Eller. Mechanisms Controlling Summertime Oxygen Depletion in Western Long Island Sound. Estuaries. 14:265-278. 1991.

Bricker, S.B., et al. 1999. *National eutrophication assessment: Effects of nutrient enrichment in the nation's estuaries*. Silver Spring, MD: NOAA National Ocean Service. 71 pp.

Vitousek, Peter M. et al. 1997. Human alteration of the global nitrogen cycle: Sources and consequences, ecological applications. *Ecological Applications* 7(3):737-50.

Jichells, T.D. 1998. Nutrient biogeochemistry of the coastal zone. *Science* 281:217-21.

National Research Council (NRC). 2000. Clean Coastal Waters: understanding and reducing the effects of nutrient pollution. National Academy Press, Washington, DC, 405 pp.

Graphics

Figure 238R-1: Estimated Size of Bottom-Water Hypoxia in Mid-Summer

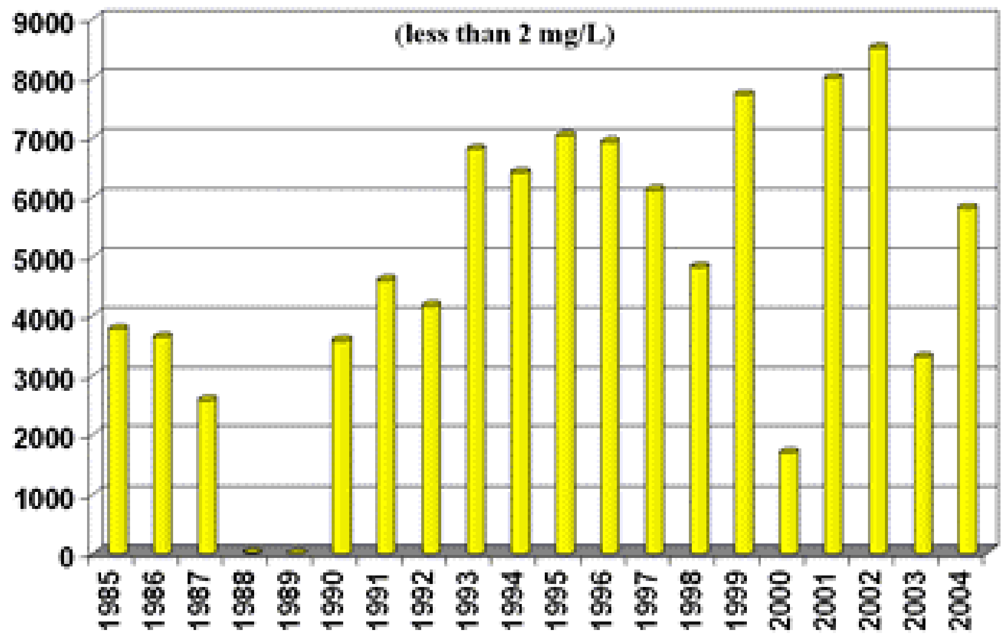
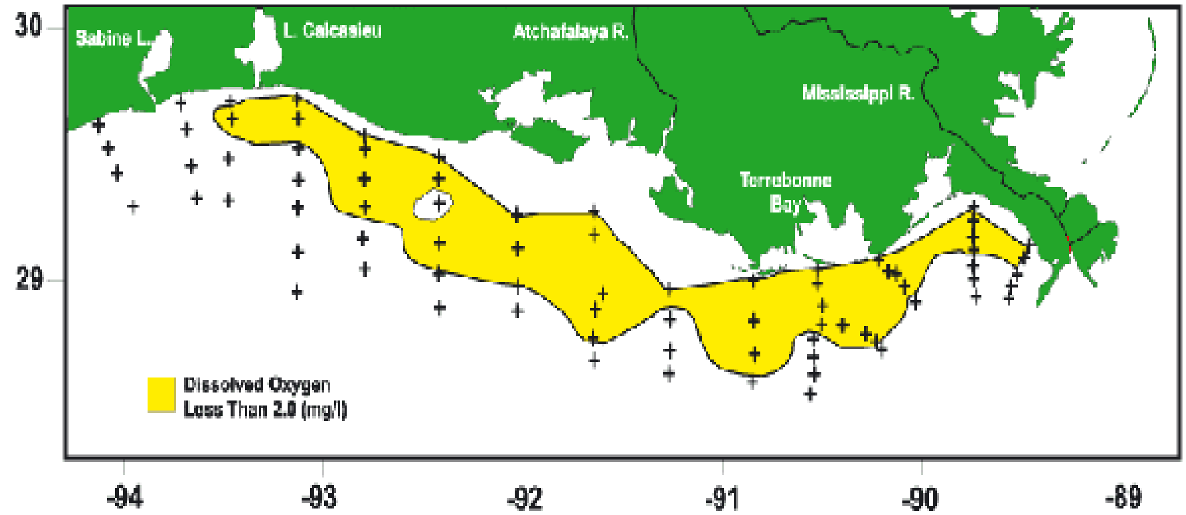


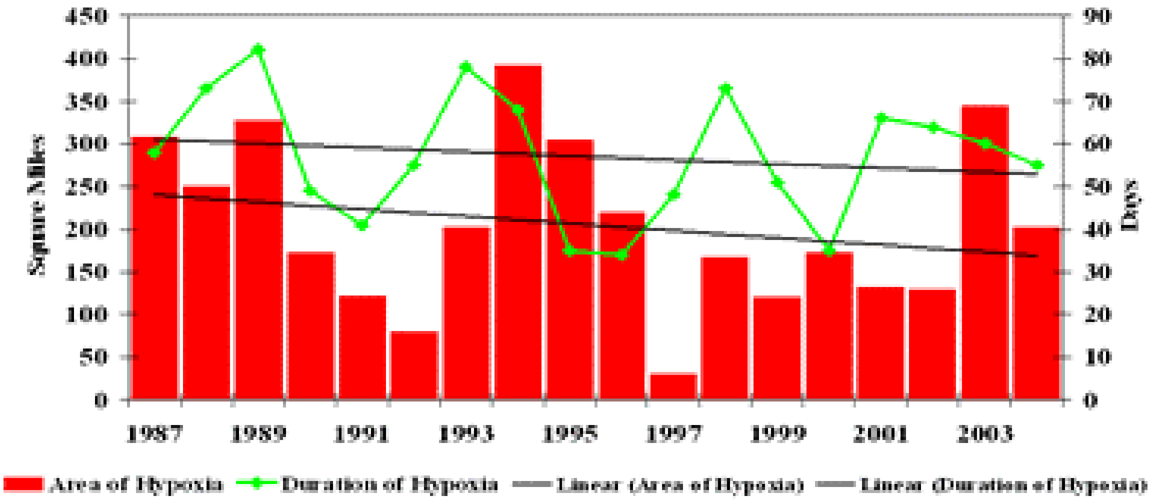
Figure 238R-2: July 21-25, 2004 - Area of Bottom Hypoxia



Data Source: N. Rabalais, LUMCON

Figure 238R-3: Maximum Area and Duration of Hypoxia in Long Island Sound

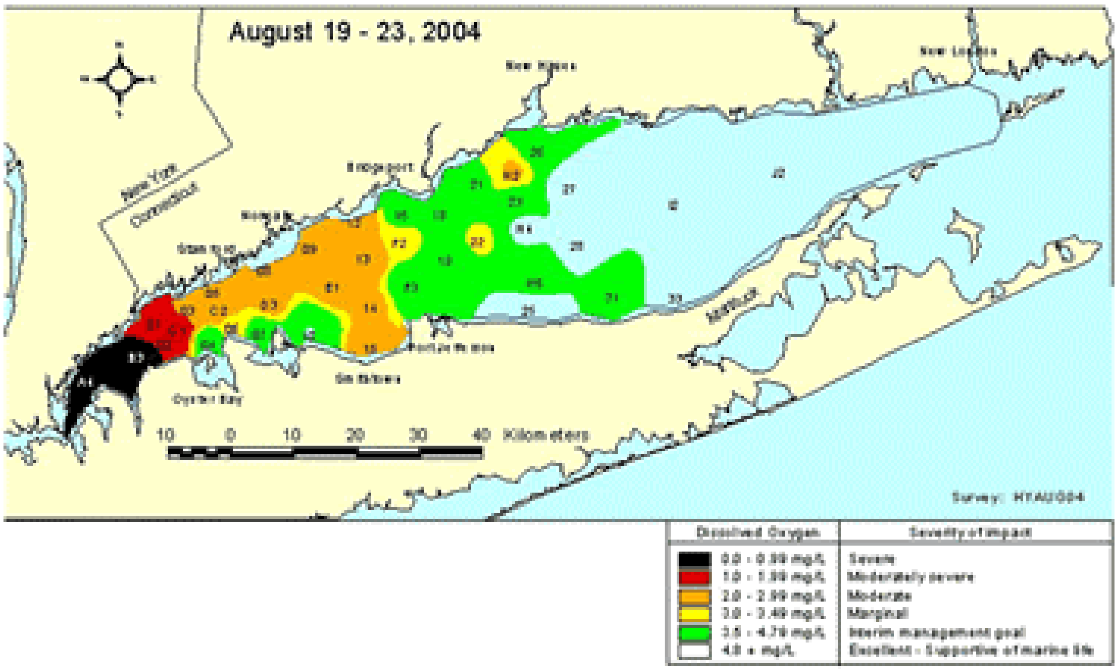
(less than 3.0 mg/l)



CT DEP LIS Water Quality Monitoring Program

Figure 238R-4:

Dissolved Oxygen in Long Island Sound Bottom Waters



R.O.E. Indicator QA/QC

Data Set Name: EXTENT OF HYPOXIA IN GULF OF MEXICO AND LONG ISLAND SOUND
Indicator Number: 238R (89157)
Data Set Source: Hypoxia Studies of Rabalais et al.
Data Collection Date: mid to late July.
Data Collection Frequency: Yearly, 1985 to present (not 1988)
Data Set Description: The Areal Extent of Hypoxia in the Gulf of Mexico and Long Island Sound
Primary ROE Question: What are the trends in extent and condition of coastal waters

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes, we follow standard procedures as outlined in our proposals to NOAA, peer-reviewed publications, and reports sent to NOAA. Rabalais, N.N., Louisiana Universities Marine Consortium, 8124 Hwy. 56, Chauvin, LA 70344. Rabalais, N.N. and R.E. Turner (eds.). 2001. Coastal Hypoxia: Consequences for Living Resources and Ecosystems. Coastal and Estuarine Studies 58, American Geophysical Union, Washington, D.C., 454 p. Rabalais, N.N., R.E. Turner and D. Scavia. 2002. Beyond science into policy: Gulf of Mexico hypoxia and the Mississippi River. BioScience 52: 129-142. Scavia, D., N.N. Rabalais, R.E. Turner, D. Justi, and W.J. Wiseman, Jr. 2003. Predicting the response of Gulf of Mexico hypoxia to variations in Mississippi River nitrogen load. Limnology & Oceanography 48: 951-956. Turner, R.E., N.N. Rabalais, E.M. Swenson, M. Kasprzak and T. Romaire. 2005 (online www.sciencedirect.com Aug 2004). Summer hypoxia in the northern Gulf of Mexico and its prediction from 1978 to 1995. Marine Environmental Research 59: 65-77.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes, we conduct the survey in a consistent manner from year to year so that the data are comparable. The data collection procedures are documented in several peer-reviewed publications. Rabalais, N.N., Louisiana Universities Marine Consortium, 8124 Hwy. 56, Chauvin, LA 70344. Rabalais, N.N. and R.E. Turner (eds.). 2001. Coastal Hypoxia: Consequences for Living Resources and Ecosystems. Coastal and Estuarine Studies 58, American Geophysical Union, Washington, D.C., 454 p. Rabalais, N.N., R.E. Turner and D. Scavia. 2002. Beyond science into policy: Gulf of Mexico hypoxia and the Mississippi River. BioScience 52: 129-142. Scavia, D., N.N. Rabalais, R.E. Turner, D. Justi , and W.J. Wiseman, Jr. 2003. Predicting the response of Gulf of Mexico hypoxia to variations in Mississippi River nitrogen load. Limnology & Oceanography 48: 951-956. Turner, R.E., N.N. Rabalais, E.M. Swenson, M. Kasprzak and T. Romaire. 2005 (online www.sciencedirect.com Aug 2004). Summer hypoxia in the northern Gulf of Mexico and its prediction from 1978 to 1995. Marine Environmental Research 59: 65-77.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

THE DATA PRESENTED IN THE HISTOGRAM ARE DATA POINTS OF ESTIMATED SIZE DEVELOPED FROM THE BOTTOM-WATER DISSOLVED OXYGEN DATA OVER A 5-DAY PERIOD IN MID-SUMMER.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The sampling design and timing of sampling is appropriate for determining the expected maximal extent of summertime bottom-water hypoxia. The number of locations varies from 60-90 depending on the length of the cruise, the size of the hypoxic zone, logistical constraints, and the density of data points (station locations). The beginning and ending dates are found on each graph, and stored with the data at NOAA NODC. They usually occur in mid-July to late-July, but not always.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The sample design represents the area most likely to have hypoxic bottom-waters in mid-summer. The mapping exercise maximized the ability to obtain values below 2 mg/l and above 2 mg/l on each transect so that closed contours can be drawn from the data points.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

The nominal definition of hypoxia for the study area is 2 mg/l, based on observational data from trawl surveys that indicate demersal catch is minimal or non-existent when the oxygen is below 2 mg/l. The definition of hypoxia is consistent across the spatial and temporal extent of the data set. The data can also be expressed in percent saturation of dissolved oxygen, which takes into account temperature, salinity, and density. The map contours, however, are drawn only on values in mg/l.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The metadata are stored at http://www.cast-net.org/metadata/

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The data are submitted to NOAA NODC after appropriate QA/QC and completion of metadata. Backup copies are maintained by the Hypoxia Studies group at LUMCON, Nancy Rabalais or Adam Sapp at nrabalais@lumcon.edu or asapp@lumcon.edu, 985-851-2800 for switchboard.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes http://www.cast-net.org/metadata/

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

No, the routine for QA/QC differs by variable of measurement. There is no software. The protocols are included in the metadata. The areal estimate is just that an estimate. QA/QC is performed by the Hypoxia Studies group at LUMCON, Nancy Rabalais or Adam Sapp at nrabalais@lumcon.edu or asapp@lumcon.edu, 985-851-2800 for switchboard.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. Scavia, D., N. N. Rabalais, R. E. Turner, D. Justi , and W. J. Wiseman, Jr. 2003. Predicting the response of Gulf of Mexico hypoxia to variations in Mississippi River nitrogen load. Limnology & Oceanography 48: 951-956. Turner, R. E., N. N. Rabalais, E. M. Swenson, M. Kasprzak and T. Romaire. 2005 (online www.sciencedirect.com Aug 2004). Summer hypoxia in the northern Gulf of Mexico and its prediction from 1978 to 1995. Marine Environmental Research 59: 65-77. And 2 as yet to be published models.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No. The indicator is an estimated size.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No. Sources of error are not being able to complete the survey, not being able to reach the shallowest depths of hypoxia because of the draft of the vessel, inexactness of the hand contouring versus digitized contours. The sampling and monitoring design is sound for generating an estimate of the size of hypoxia during a 5-6 day period in mid summer.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Anoxic periods (no oxygen at all) occurring at times other than the mid-summer surveys are not captured in the indicator. The extent of hypoxia is generated during a single midsummer sampling cruise, so duration cannot be estimated. Surveys usually end offshore the Louisiana-Texas State line; in years when hypoxia extends onto the upper Texas coast, the areal extent of hypoxia is underestimated. There are no gaps in the data that serve to generate the bottom-water hypoxia contours. To properly interpret the size data from one year to the next, the user needs to know basic biological processes, the physical oceanography of the northern Gulf of Mexico, the seasonal dynamics of the biological/physical interactions that lead to the formation and maintenance of hypoxia, the condition of river discharge and nutrient flux for the period (up to 6 months) prior to the mapping cruise, the weather conditions prior to the cruise and during the cruise, the occurrence, timing, and severity of any tropical storm activity prior to the cruise, the wind speed, wind direction, and wave state, the current conditions (ADCP data gathered en route).

R.O.E. Indicator QA/QC

Data Set Name: EXTENT OF HYPOXIA IN GULF OF MEXICO AND LONG ISLAND SOUND - PART 2 OF 2
Indicator Number: 238R (114848)
Data Set Source: LIS Study Monitoring Program conducted by the Connecticut Department of Environmental Protection
Data Collection Date: regular: 1987-present
Data Collection Frequency: monthly October-May, biweekly June-September
Data Set Description: The Areal Extent of Hypoxia in the Gulf of Mexico and Long Island Sound - Long Island SOund QA, See part 1 for Indicator Text and graphics.
Primary ROE Question: What are the trends in extent and condition of coastal waters

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes, standard procedures are used and are documented in the program's Environmental Research Institute Standard Operating Procedures For Long Island Sound Study(2001) and revised Quality Assurance Project Plan (April 2002. Copies are available upon request. The method used to measure dissolved oxygen is Winkler titration. Precision is within 0.5 mg/l.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The sampling design is described in the report Long Island Sound Ambient Monitoring Program: Hypoxia Monitoring Survey 1991-1998 Data Review (CTDEP, 2000). The sampling design has also been used for the EPA National Coastal Assessment monitoring program, through a cooperative agreement between EPA and CTDEP.
http://dep.state.ct.us/wtr/lis/monitoring/lis_page.htm

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

There is no conceptual model. The data presented in the histogram are estimates of the area and duration of hypoxia determined from the spatial and temporal sampling effort.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The indicator directly responds to the question, what is the status and trends in the severity of hypoxia in LIS? Severity is considered by both the maximum hypoxic area and duration of time it persists. While a more frequent and dense sampling design would improve the precision of the estimates, the benefits would not be worth the added cost. The indicator is directly in response to an issue of national concern. The US Commission on Ocean Policy identified impairment of coastal waters due to nutrient enrichment as a national problem. The Commission also recommended that EPA set measurable pollution reduction targets for coastal waters and take steps to reduce nutrient pollution from point and nonpoint sources to nutrient-impaired waterbodies. This indicator directly measures the status and trends in the quality of a nutrient-impaired waterbody, Long Island Sound. Furthermore, EPA and the states of NY and CT have set nitrogen reduction targets for LIS to address the impairment.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The sampling design is meant to characterize conditions throughout LIS and not target subareas. However, sampling frequency is increased from monthly to biweekly during the summer to capture water quality conditions during this critical period when hypoxia occurs.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

The is no universal definition of hypoxia. There are effects gradients over a range of concentrations that will vary with the resources being affected. The LIS indicator uses concentrations below 3.0 mg/l of dissolved oxygen as a working definition of hypoxia. This is clearly a concentration of concern based on EPA's marine DO criteria and reflects impairments to water quality standards.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Standard procedures are used and are documented in the Environmental Research Institute Standard Operating Procedures For Long Island Sound Study(2001) and revised Quality Assurance Project Plan (CTDEP, April 2002). Copies are available upon request. EPA has reviewed and approved the QAPP for the program.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The complete data set is available: Matthew Lyman CTDEP 860-424-3158
matthew.lyman@po.state.ct.us

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. Complete descriptions descriptions are documented in the project QAPP and related reports.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The QAPP has been developed by CTDEP and approved by EPA. The QAPP documents all QA/QC procedures.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes, the data are presented only for the time and area collected. Simple contour plots are prepared to graphically show the areal distribution of dissolved oxygen in bottom waters during the summer. The maximum area and maximum duration (in days) less than 3 mg/l each year are presented from 1987-1994.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No. The indicators are estimated size and duration measures.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No. Sources of error are not being able to complete a survey, not being able to reach shallow areas due to the draft of the boat, and the inexactness of countour plotting.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

There is no limitation that could lead to a fundamental error. Anoxic period that may occur between the two week surveys are not captured in the indicator. two weeks during the critical summer period. Samples are taken in the daytime, approximately one meter off the bottom. Lower oxygen conditions at night or near the sediment-water interface are not captured by the indicator. Additional temporal and spatial sampling would provide greater resolution of conditions, but would be unlikely to fundamentally change the conclusions on the indicator.

Indicator: Harmful Algal Bloom Outbreaks Occurring in the Near Shore Waters of the Western Florida Coastline (327R)

Harmful Algal Blooms (HABs) are "blooms" of large numbers of microscopic algae (phytoplankton) that occur in aquatic environments, especially in nearshore coastal waters and estuaries, that may harm humans and/or the environment. HABs can be caused by a number of species of phytoplankton. One type of HAB common in the Gulf of Mexico is "red tide," which is caused by the phytoplankton organism *Karenia brevis* (a dinoflagellate). *K. brevis* can cause massive fish kills, marine mammal mortality, and in humans, neurotoxic shellfish poisoning (NSP) and respiratory irritation (NRC 2000). In the Gulf of Mexico, red tide occurs almost every year, generally in the late summer or early fall (Haverkamp, 2004). The blooms are most common off the central and southwest coasts of Florida, but they may occur anywhere in the Gulf. Most red tide blooms last three to six months and may affect hundreds of square miles (Haverkamp, 2004). However, occasionally, blooms continue sporadically for up to eighteen months and may affect thousands of square miles (Haverkamp, 2004). The Gulf of Mexico has experienced intense blooms of *K. brevis* in 22 of the last 23 years (HABSOS, 2004).

At least 40 species of toxic, or potentially toxic, marine microalgae, including 11 ichthyotoxic species, have been identified from Gulf of Mexico waters (Landsberg, 2000). All of these have potential impacts on natural resources and public health. Blooms of the toxic dinoflagellate, *K. brevis* have been responsible for most documented HAB events along the Gulf coast. For at least the last 50 years, *K. brevis* 'red tides' have been mostly concentrated along the west coast of Florida and, to a lesser extent, along the Texas coast (HABSOS, 2004). In 1996, red tides occurred in the coastal waters of all five Gulf States for the first time in recorded history, resulting in Gulf wide fish mortalities and numerous beach and shellfish bed closures (Prospectus, 2002). In addition, red tide persisted for over a year along the coast of Florida, killing over 150 endangered manatees (Prospectus, 2002).

K. brevis bloom events occur most frequently from August through February but have been documented in every month of the year. Offshore surveys have shown that Florida red tides generally begin 10 to 40 miles from the coast in the Gulf of Mexico on the mid-continental shelf. Winds and currents may push the patches of red tide onshore or along the shore to other areas. If conditions are right a bloom may remain in an area for several weeks or may move up and down along the coast for months at a time.

K. brevis may be found year-round throughout the Gulf of Mexico at background concentrations of approximately 1,000 cells per liter (Geesy and Tester, 1993). When *K.brevis* concentrations reach approximately 5,000 cells per liter, monitoring efforts intensify and the harvesting of shellfish is prohibited if these concentrations are detected in a shellfish harvesting area (ISSC, 1999). Monitoring for *K. brevis* requires resource managers to collect water samples for microscopic examination with supplemental data provided by animal mortalities, satellite imagery, and shellfish bed closures as blooms intensify (NOAA).

This indicator presents data on the frequency and duration of *K. brevis* blooms off the Gulf coast of Florida from 1996-2001. Data are from the Florida Fish and Wildlife Conservation Commission's red tide monitoring program and historical database of *K. brevis* cell concentrations and associated data. The monitoring program and dataset are used for prediction and management of HAB events, for addressing hypotheses concerning the ecophysiology of blooms, and for providing information to the public on current bloom status and locations.

What the Data Show

Red tide bloom events in 1997 and 2001 persisted along the Florida coastline for over 120 consecutive days (Figure 237R). In 1996, four separate red tide bloom events occurred along the western Florida coastline, and for the first time in recorded history, blooms of red tide were documented in all five of the Gulf States.

Indicator Limitations

- HAB data are biased toward surface and inshore sampling.

Data Sources

Florida Fish and Wildlife Conservation Commission, FWRC:
http://ocean.floridamarine.org/mrgis/viewer.htm

References

Geesy. M and P.A. Tester. 1993. Gymnodinium breve: Ubiquitous in the Gulf of Mexico waters? In: Smayda, T.J. and Shimizu, Y. (eds)., Toxic Phytoplankton Blooms in the Sea, Elsevier, N.Y., 251-255.

HABSOS, An Integrated Case Study for the Gulf of Mexico. Final Report July 2004

Haverkamp, Darlene, Steidinger, K.A., and Heil, C.A. 2004. HAB Monitoring and Datbases: The Florida *Karenia Brevis* Example. Harmful Algae Management and Mitigation, 102-109.

ISSC Model Ordinance 1999.

Jan H. Landsberg, Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute. The Effects of Harmful Algal Blooms on the Health of Florida's Fish. Abstract submitted to the Florida Chapter, American Fisheries Society. (see: http://www.sdafs.org/flafs/doc/abs-2000.html)

National Research Council (NRC). 2000. Clean Coastal Waters: understanding and reducing the effects of nutrient pollution. National Academy Press, Washington, DC, 405 pp.

Prospectus, The Gulf of Mexico Pilot Project for a Harmful Algal Blooms Observing System (HABSOS) May 29, 2002.

Graphics

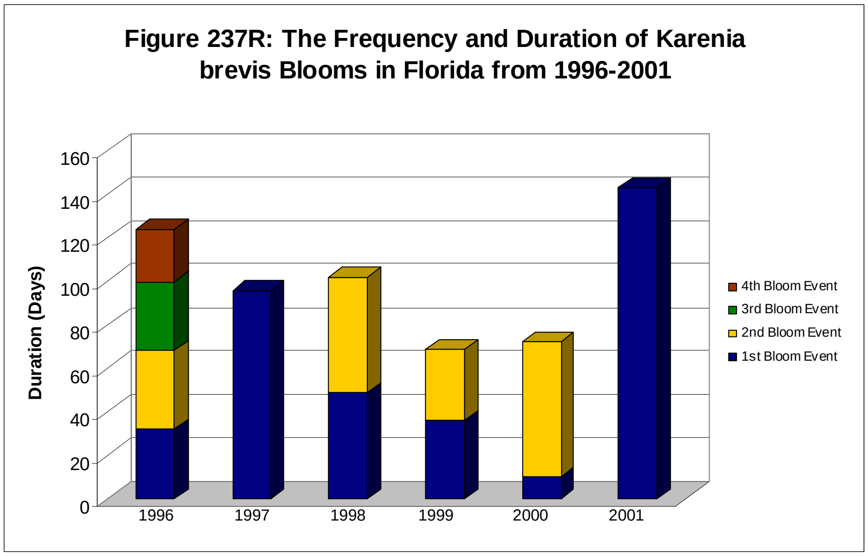


Figure 237R: The Frequency and Duration of Karenia brevis Blooms in Florida from 1996-2001
Duration (Days)
0
20
40
60
80
100
120
140
160
1996
1997
1998
1999
2000
2001
4th Bloom Event
3rd Bloom Event
2nd Bloom Event
1st Bloom Event

R.O.E. Indicator QA/QC

Data Set Name: HARMFUL ALGAL BLOOM OUTBREAKS OCCURRING IN THE NEAR SHORE WATERS OF THE WESTERN FLORIDA COASTLINE
Indicator Number: 237R (89158)
Data Set Source: FMRI, DISL, ADPH, USM-GCRL, LUMCON, UTMSI, TPWD
Data Collection Date: 1996-2000 (and as needed)
Data Collection Frequency: As outbreak conditions occur
Data Set Description: Harmful Algal Bloom Outbreaks Occurring in the Near Shore Waters of the Western Florida Coastline
Primary ROE Question: What are the trends in extent and condition of coastal waters?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. Florida has had an on-going database project at the Florida Fish and Wildlife Research Institute for Harmful Algal Bloom (HAB) monitoring and event response. This database includes data collected by citizens, commercial fishermen, private and public institutions throughout the state since 1953. This historical data was recently rescued and almost 50 years of data digitized. HAB monitoring cruises in the Gulf of Mexico have been conducted with some regularity since 1954, particularly since 1997 with the advent of the Ecology and Oceanography of Harmful Algal Blooms (ECOHAB): Florida program. In May 2000, the Red Tide Offshore Monitoring Program (a citizen volunteer network) was begun, enhancing the spatial and temporal sampling efforts of federal and state funded HAB monitoring.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. Additional details are provided in: HABSOS Case Study Report; Fisher, William S., Thomas C. Malone and James D. Giattina. 2003. Pilot Project to Detect and Forecast HABs in the N. Gulf of Mexico. Environ. Monit. Assess. 81 (1-3): 373-381. (ERL, GB 1141). Development of the Volunteer Offshore Red Tide Monitoring Program for the Gulf Coast of Florida. Steidinger, Karen A., Jay Paul Abbott and Earnest W. Truby. Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute. Available online at:
http://research.myfwc.com/engine/download_redirection_process.asp?file=volunteer_posterforweb_1949.pdf&objid=24851&dltype=article

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The data presented in the bar chart illustrates the K. brevis bloom events for the western shelf of Florida from 1996-2001. According to NOAA, monitoring HAB events requires resource managers to use data collected from animal mortalities, cell counts, satellite imagery, and shellfish bed closures. Satellite imagery alone does not detect the early stages of HAB bloom events and cannot differentiate between the different HAB species (or any other phytoplankton species) unless direct cell counts are available for validation. The State of Florida closes shellfish beds based on direct cell count data and will open the shellfish beds based on mouse assays. The underlying dataset for this indicator is based upon the State of Florida's HAB database that is developed from direct counts of water samples provided by a year round monitoring program. As a component of the Florida HAB dataset, a Volunteer Offshore Monitoring Program was established to provide regular sampling in offshore areas where red tides have traditionally come onshore. The Volunteer Offshore Monitoring Program was designed for charter captains to sample twice per month at distances of 1,5,10, 20 and 30 miles offshore at established targeted sampling sites. Available online at: http://research.myfwc.com/engine/download_redirection_process.asp?file=volunteer_posterforweb_1949.pdf&objid=24851&dltype=article

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The HAB indicator serves as a measure of the number of events and duration of K. brevis blooms in the western Florida shelf. Although K. brevis may be found year round in the Gulf of Mexico at background concentrations (<1,000 cells/L), the harvesting of bivalve (filter-feeding) shellfish is prohibited in an approved or conditionally approved shellfish harvesting area when concentrations in the area reach 5,000 cells/L. Based upon this, the States will monitor and sample in response to a bloom event to protect public health and the environment from HAB effects. The indicator is also based upon an issue of national concern. The Harmful Algal Bloom and Hypoxia Research and Control Act was enacted in 1998 (PL 105-383) in response to concerns that HABs and related environmental events are increasingly a threat to human and coastal ecosystem health.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

K. brevis bloom events can cause massive fish kills, marine mammal mortality, and in humans, neurotoxic shellfish poisoning (NSP) and respiratory irritation. However, the purpose of this conceptual model is to serve as an ecological indicator and not a linkage to coastal eutrophication or anthropogenic stressors. The sampling design in primarily based upon locations where red tides have traditionally come onshore in the western shelf area of Florida.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

During the 1980's, the State of Florida formalized a federally approved biotoxin control plan that regulates shellfish harvesting during K. brevis blooms, to reduce the public health risks associated with red tides. Under this plan, guidelines were established for monitoring cell concentrations and closing shellfish beds when K. brevis was detected at concentrations above background levels in bay and lagoon passes or inlets. Harvesting bivalve (filter-feeding) shellfish is prohibited in an approved or conditionally approved shellfish harvesting area when concentrations in the area reach 5 x 103 K. brevis cell L-1. When the bloom terminates and the K. brevis population drops below that level, shellfish usually purge the toxins from their systems in two to six weeks. The shellfish meats are tested for toxicity during that period and the beds are reopened when mouse bioassay results demonstrate that shellfish meats are <20 Mouse Units (MU) per 100 grams of shellfish meat. Harvesting bans do not apply to crabs, shrimp, lobsters, or fish, which are safe to eat even during red tide blooms because brevetoxins do not accumulate in the parts of those organisms that are consumed by humans. (Haverkamp 2004)

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Haverkamp, D., K. A. Steidinger and C. A. Heil. 2004. HAB Monitoring and Databases: The Florida Karenia brevis example. In: Hall, S., S. Etherridge, D. Andereson, J. Sleindinst, M. Zhu and Y Zou (eds.), Harmful Algae Management and Mitigation, Asia-Pacific Economic Cooperation (Singapore): APEC Publication #204-MR-04.2, pp. 102-109.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

To protect public health and the environment from harmful bloom effects, the Florida Fish & Wildlife Conservation Commission's Fish and Wildlife Research Institute has developed a red tide monitoring program in cooperation with another state agency, which consists of both microalgal and shellfish monitoring components. As part of this monitoring program, FWRI created and maintains a historical (1953-present) database of K. brevis cell concentrations and associated data (e.g., collection time, date, location, associated water-quality parameters). It is updated daily by FWRI staff as new data are available. Currently (2004), the database includes more that 63,000 records. Public and scientific access to the database is provided by 1) a CD-ROM that includes a subset of the database, GIS tools to view the data, Java-based query tools to ask summary questions of the data, and remote sensing images for the identification and potential prediction of red tide blooms; and 2) web access to the data, which will eventually incorporate additional meteorological and physical oceanography (i.e., current) data. Available online at: http://ocean.floridamarine.org/mrgis/viewer.htm

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The State of Florida continuously monitors for K. brevis and other potentially toxic, harmful, or nuisance microalgal bloom species in state waters and working with the

Florida Department of Agriculture and Consumer Services Division of Aquaculture, successfully manages shellfish resources to protect the public from NSP. Development of an effective red tide monitoring program for Florida has involved four major components: 1) establishment of a network of individuals associated with marine-related industries affected by red tide, who provide water samples collected from diverse regions; 2) training staff to routinely identify and enumerate toxic phytoplankton within these samples to the species level; 3) development of a database suitable to the specific program needs; and 4) identification of methods and means to provide this data to the public on a timely basis.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Haverkamp, D., K. A. Steidinger and C. A. Heil. 2004. HAB Monitoring and Databases: The Florida Karenia brevis example. In: Hall, S., S. Etherridge, D. Andereson, J. Sleindinst, M. Zhu and Y Zou (eds.), Harmful Algae Management and Mitigation, Asia-Pacific Economic Cooperation (Singapore): APEC Publication #204-MR-04.2, pp. 102-109.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

The data has not been extrapolated beyond that actual point of measurement. The bars on the chart represent actual K. brevis blooms events during 1996-2001 for the west coast of Florida.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No. The indicator is a summary of the number and duration of K. brevis events in the western shelf region of Florida.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not being able to complete a survey, not being able to reach shallow areas due to the draft of the boat and missed bloom events could cause the number and/or duration of blooms to be smaller than was actually the case in any particular year, but this is not believed to significantly affect the overall trend pattern represented by the indicator.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

There is no limitation that could lead to a fundamental error. A data gap may occur when a K. brevis bloom is present and no measurement was taken to verify.

Indicator: Lake and Stream Acidity (041)

Acid deposition can have serious effects on aquatic ecosystems. For example, aquatic organisms in acidified waters can develop calcium deficiencies that weaken bones and exoskeletons and cause eggs to be weak or brittle; acidified waters can impair the ability of fish gills to take in oxygen from water; and increasing amounts of acid in surface water can change the mobility of certain trace metals (e.g., aluminum, cadmium, manganese, iron, arsenic, mercury), which in turn can place fish and other species sensitive to these metals at risk (Acid Deposition: State of Science and Technology, Volume II, Aquatic Processes and Effects). The Indicator "Acid Deposition" explains the factors that contribute to acid deposition and describes how acid deposition patterns have changed over the last 15 years.

The capacity of a water body to "resist" acidification depends on the ability of the water and watershed soils to neutralize the acid deposition it receives. The best measure of this ability is acid neutralizing capacity (ANC), which characterizes the amount of dissolved compounds that will counteract acidity. ANC depends largely on the surrounding watershed's physical characteristics, such as geology, soils, and size. Surface water with an ANC greater than 200 micro equivalents per liter (µeq/L) is usually considered non-acidic; surface water with an ANC less than 50 µeq/L is considered highly sensitive to acidification (is often seasonally acidic); and surface water with an ANC less than 0 µeq/L is considered chronically acidic, meaning the watershed no longer has the capacity to neutralize further acid deposition (EPA 2003).

This indicator is derived from ANC measurements on probability survey samples representing 5, 617 lakes and 72,000 stream miles in the five geographic regions shown in Figure 041-1 as part of the TIME (Temporally Integrated Monitoring of Ecosystems) and on 120 additional acid-sensitive lakes and 78 acid-sensitive streams in the LTM (Long-Term Monitoring) project, for which data were available between 1990 and 2000 (EPA 2003, pg 5). The lakes sampled include only those in areas potentially sensitive to acidification with areas greater than 4 hectares. Smaller lakes generally are not used in this type of assessment because they are more likely to be acidic due to natural causes, although acid deposition can cause them to become further acidified.

What the Data Show

Between 1990 and 2000, ANC in lakes in the Adirondacks and the Upper Midwest (northeastern Minnesota, northern Wisconsin, and northern Michigan) and in streams in the Northern Appalachians (southern New York, west-central Pennsylvania, and eastern West Virginia) has increased to a degree where approximately 30% of the water bodies labeled "chronically acidic in 1990 were no longer classified as such in 2000 (Figure 041-1). This increase suggests that surface waters in these areas are beginning to recover from acidification. However, acidic surface waters are still found in these regions.

The ANC in lakes in New England and streams in the Ridge/Blue Ridge region (east-central Pennsylvania, western Maryland, and western Virginia) have not risen from their 1990 levels. Therefore, all of the water bodies classified as "chronically acidic" in these regions in 1990 still kept that label in 2000.

The trend of increasing ANC in the Adirondacks, the Upper Midwest, and the Northern Appalachian region during the 1990s corresponds with a decrease in acid deposition in each of these regions (see Indicator "Acid Deposition") and reduced air emissions of the main precursors to acid deposition (sulfur dioxide (see Indicator "SO2 Emissions") and nitrogen oxides (see Indicator "NOx Emissions")) during the same time period.

Indicator Limitations

- ANC sampling is limited to five regions, concentrated in the Northeast. There is no coverage in the Southeast, West, or much of the Midwest. These regions were chosen for sampling because previous research has shown that they are among the most sensitive to acid deposition due to the soils and other watershed characteristics. In addition, as Indicator "Acid Deposition" shows, many of these regions receive the highest rates of acid deposition in the U.S. For these two reasons the waters sampled are likely to be at the greatest risk of becoming acidified.
- Interpreting trends for this indicator is complicated because multiple factors contribute to changes in ANC levels. For example, in areas where watershed soil characteristics are changing (e.g., decreases in concentrations of base cations in the soil), even dramatic reductions in acid deposition will not necessarily result in large rebounds in ANC levels.

Data Sources

Stoddard, J. L., J. S. Kahl, F. A. Deviney, D. R. DeWalle, C. T. Driscoll, A. T. Herlihy, J. H. Kellogg, P. S. Murdoch, J. R. Webb, and K. E. Webster. *Response of surface water chemistry to the Clean Air Act Amendments of 1990.* 2003. EPA/620/R-03/001, U.S. Environmental Protection Agency, Washington, DC.

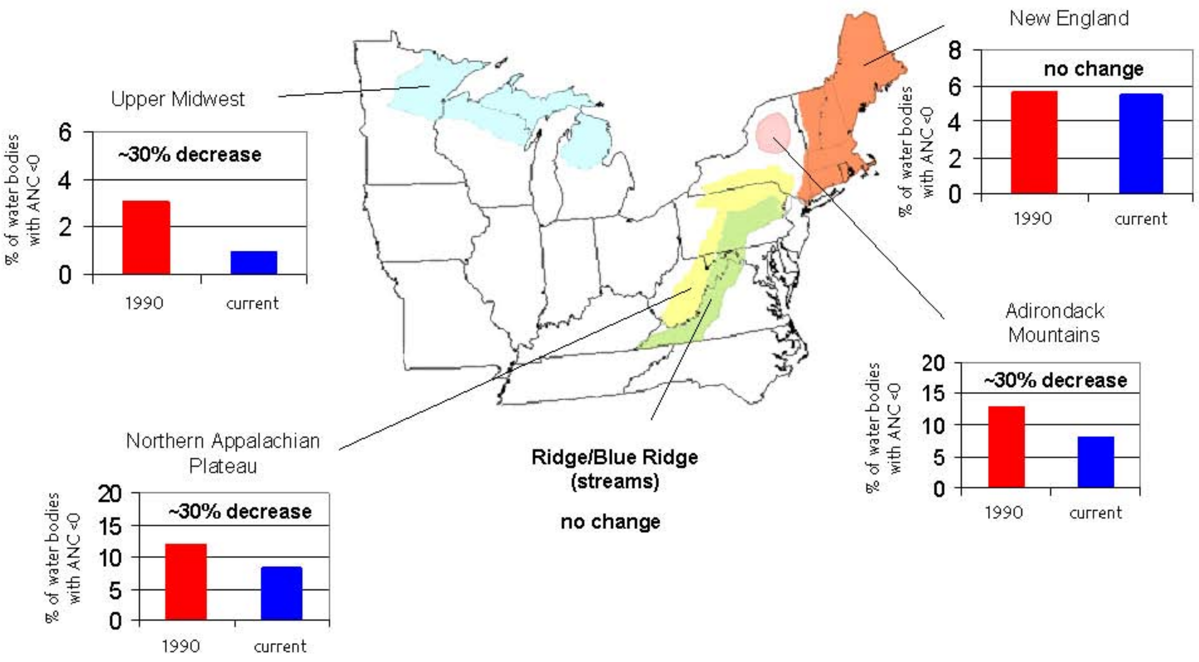
References

National Acid Precipitation Assessment Program. 1991.Acid Deposition: State of Science and Technology, Volume II, Aquatic Processes and Effects, Washington, DC: National Acid Precipitation Assessment Program,

U.S. Environmental Protection Agency. 2003 Response of Surface Water Chemistry to the Clean Air Act Amendments of 1990, EPA 620-R-03-001. Research Triangle Park, NC: U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, January

Graphics

Figure 041-1: Change in Chronic Acidity in Lakes and Streams as Measured by Acid Neutralizing Capacity (ANC)



R.O.E. Indicator QA/QC

Data Set Name: LAKE & STREAM ACIDITY
Indicator Number: 041 (89069)
Data Set Source:
Data Collection Date: 1990-2000
Data Collection Frequency: See referenced report.
Data Set Description: Lake & Stream Acidity
Primary ROE Question: What are the trends in extent and condition of fresh surface waters in the United States?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes, Acid Neutralizing Capacity has been used in every major assessment of surface water acidification for the past 20 years. It is a direct measurement of water's ability to neutralize acid, and is therefore a direct indicator of a lake or stream's ability to neutralize acid rain. The best reference for the method is Section 5 of: U.S.

Environmental Protection Agency. 1987. Handbook of Methods for Acid Deposition Studies: Laboratory Analysis for Surface Water Chemistry. EPA 600/4-87/026, U.S. Environmental Protection Agency, Washington, D.C. Further references can be found in the Quality Assurance plans for the TIME and LTM projects: Morrison, M. 1991. Quality Assurance Plan for the Long-Term Monitoring Project. Pages 1.1-B.1 in U.S. Environmental Protection Agency, Data User's Guide to the United States Environmental Protection Agency's Long-Term Monitoring Project: Quality Assurance Plan and Data Dictionary. U.S. Environmental Protection Agency, Corvallis, OR. Newell, A. D., C. F. Powers, and S. J. Christie. 1987. Analysis of Data from Long-term Monitoring of Lakes. U.S. Environmental Protection Agency, Corvallis, OR. Peck, D. V. 1992. Environmental Monitoring and Assessment Program: Integrated Quality Assurance Project Plan for the Surface Waters Resource Group. EPA/600/X-91/080, U.S. Environmental Protection Agency.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes, The sampling/monitoring design is based on sound scientific principles. This sampling/monitoring plan has been used in a number of peer reviewed publications. Some examples of these peer-reviewed publications are: Kahl, J. S., J. L. Stoddard, R. Haueber, S. G. Paulsen, R. Birnbaum, F. A. Deviney, J. R. Webb, D. R. DeWalle, W. Sharpe, C. T. Driscoll, A. T. Herlihy, J. H. Kellogg, P. S. Murdoch, K. Roy, K. E. Webster, and N. S. Urquhart. 2004. Have U.S. surface waters responded to the Clean Air Act Amendments. Environmental Science and Technology 38:485A-490A. Skjelkvåle, B. L., J. L. Stoddard, and T. Andersen. 2001. Trends in surface water acidification in Europe and North America (1989-1998). Water Air and Soil Pollution 130:787-792. Stoddard, J. L., D. S. Jeffries, A. Lükewille, T. A. Clair, P. J. Dillon, C. T. Driscoll, M. Forsius, M. Johannessen, J. S. Kahl, J. H. Kellogg, A. Kemp, J. Mannio, D. Monteith, P. S. Murdoch, S. Patrick, A. Rebsdorf, B. L. Skjelkvåle, M. Stainton, T. Traaen, H. van Dam, K. E. Webster, J. Wieting, and A. Wilander. 1999. Regional trends in aquatic recovery from acidification in North America and Europe. Nature 401:575-578. Stoddard, J. L., J. S. Kahl, F. A. Deviney, D. R. DeWalle, C. T. Driscoll, A. T. Herlihy, J. H. Kellogg, P. S. Murdoch, J. R. Webb, and K. E. Webster. 2003. Response of surface water chemistry to the Clean Air Act Amendments of 1990. EPA/620/R-03/001, U.S. Environmental Protection Agency, Corvallis, Oregon.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Not applicable

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The TIME (Temporally Integrated Monitoring of Ecosystems) and LTM (Long-Term Monitoring) projects are focused on surface waters sensitive to acidification. Some references documenting this: Stoddard, J. L., C. T. Driscoll, S. Kahl, and J. Kellogg. 1998. Can site-specific trends be extrapolated to a region? An acidification example for the Northeast. Ecological Applications 8:288-299. Stoddard, J. L., A. D. Newell, N. S. Urquhart, and D. Kugler. 1996. The TIME project design: II. Detection of regional acidification trends. Water Resources Research 32:2529-2538. Young, T. C., and J. L. Stoddard. 1996. The TIME project design: I. Classification of Northeast lakes using a combination of geographic, hydrogeochemical, and multivariate techniques. Water Resources Research 32:2517-2528.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Yes. As chemically defined, an ANC value of zero is the threshold between acidic and non-acidic water. It is the ideal cut-point for use in assessments of acidification. This threshold is consitently used across the spatial and temporal extent of the data set.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Stoddard, J. L., J. S. Kahl, F. A. Deviney, D. R. DeWalle, C. T. Driscoll, A. T. Herlihy, J. H. Kellogg, P. S. Murdoch, J. R. Webb, and K. E. Webster. 2003. Response of surface water chemistry to the Clean Air Act Amendments of 1990. EPA/620/R-03/001, U.S. Environmental Protection Agency, Corvallis, Oregon. Additional references can be found in the response to question T1Q1

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes, The data are collected through a series of cooperative agreements with cooperating Universities and Agencies. There exists an informal confidentiality agreement which states that data less than two years old will only be used for official reports, and will not be made publicly available. For the purposes of the ROE, all verified and validated data are accessible.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

QA procedures can be found in the following documents: Morrison, M. 1991. Quality Assurance Plan for the Long-Term Monitoring Project. Pages 1.1-B.1 in U.S. Environmental Protection Agency, Data User's Guide to the United States Environmental Protection Agency's Long-Term Monitoring Project: Quality Assurance Plan and Data Dictionary. U.S. Environmental Protection Agency, Corvallis, OR. Newell, A. D., C. F. Powers, and S. J. Christie. 1987. Analysis of Data from Long-term Monitoring of Lakes. U.S. Environmental Protection Agency, Corvallis, OR. Peck, D. V. 1992. Environmental Monitoring and Assessment Program: Integrated Quality Assurance Project Plan for the Surface Waters Resource Group. EPA/600/X-91/080, U.S. Environmental Protection Agency.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes, The TIME project uses a statistical survey method to select sites for sampling, and its results can be extrapolated to target populations of streams and lakes. See examples in: Stoddard, J. L., J. S. Kahl, F. A. Deviney, D. R. DeWalle, C. T. Driscoll, A. T. Herlihy, J. H. Kellogg, P. S. Murdoch, J. R. Webb, and K. E. Webster. 2003. Response of surface water chemistry to the Clean Air Act Amendments of 1990. EPA/620/R-03/001, U.S. Environmental Protection Agency, Corvallis, Oregon.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes, See data on variability in: Stoddard, J. L., A. D. Newell, N. S. Urquhart, and D. Kugler. 1996. The TIME project design: II. Detection of regional acidification trends. Water Resources Research 32:2529-2538.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No, a description of the uncertainty and variability and it's impacts on our ability to detect trends can be found in Stoddard, J. L., A. D. Newell, N. S. Urquhart, and D. Kugler. 1996. The TIME project design: II. Detection of regional acidification trends. Water Resources Research 32:2529-2538.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

No, although the target population does not include all geographic areas that have lakes and streams that are sensitive to acid deposition.

Indicator: Nitrate and Pesticides in Groundwater in Agricultural Watersheds (033)

Nitrogen is a critical plant nutrient, and most nitrogen is used and reused by plants within an ecosystem (Vitousek, et al., 2002). Thus, in undisturbed ecosystems, minimal “leakage” occurs into either surface runoff or ground water, and concentrations are very low. However, when nitrogen fertilizers are applied in amounts greater than can be incorporated into crops or lost to the atmosphere through volatilization or denitrification, nitrate concentrations in groundwater can increase. Elevated nitrogen levels also might come from disposal of animal waste, onsite septic systems, sewage treatment plants, or in the form of atmospheric deposition. Nitrate contamination in shallow ground water (less than 100 feet below land surface) raises potential concerns for human health in infants, particularly in rural agricultural areas where shallow ground water is used for domestic water supply. Concentrations above the federal drinking water standard of 10 mg/L may pose a risk of methemoglobinemia or “blue baby syndrome,” a condition that interferes with oxygen transport in the blood of infants (EPA, 2004).

More than one billion pounds of pesticides are used in the U.S. each year to control weeds, insects, and other organisms that threaten or undermine human activities (Aspelin, 2003). About 80% of the total is used for agricultural purposes. Although pesticide use has resulted in increased crop production and other benefits, pesticide contamination of groundwater poses risks to human health if contaminated groundwater is used as a drinking water source – especially if untreated.

This indicator is based on groundwater samples collected between 1992 and 1998 as part of the U.S. Geological Survey’s National Water Quality Assessment (NAWQA) Program. During this period, NAWQA analyzed stream and groundwater samples from 36 major river basins across the conterminous United States. Groundwater samples were collected from existing wells where possible, and for consistency, all samples were targeted at the uppermost layer of the aquifer. Most wells were sampled once; a few were sampled multiple times as part of a detailed nutrient study, and the results averaged. This indicator reports concentrations of nitrate and pesticides in groundwater samples collected in predominantly agricultural watersheds. A related indicator reports concentrations of nitrate and pesticides in streams that drain agricultural watersheds (Indicator “Nitrate and Pesticides in Streams in Agricultural Watersheds”).

The nitrate component of this indicator covers 1,190 wells in agricultural watersheds, with concentrations reported in mg/L. Results are compared with the federal drinking water standard of 10 mg/L, which is EPA’s Maximum Contaminant Level (MCL).(U.S. EPA, 2005). MCLs are enforceable standards representing the highest level of a contaminant that is allowed in drinking water. MCLs take into account cost and best available treatment technology, but are set as close as possible to the level of the contaminant below which there is no known or expected risk to health, allowing for a margin of safety.

Pesticide data come from a subset of 1,068 wells that NAWQA screened for a list of 73 pesticides and 7 selected pesticide degradation products. This suite of chemicals accounts for approximately 75% of the total amount of agricultural pesticides applied annually in the United States by weight (USGS, 1999). Three types of U.S. EPA human health-related standards and guidelines were used to evaluate pesticide data: Maximum Contaminant Level (MCL) (as described above), Risk-Specific Dose (RSD), and Lifetime Health Advisory (HA-L) (U.S. EPA 2000, 2001). In all three cases, the standard and guideline levels are concentrations pertaining to lifetime exposure through drinking water. The RSD is a guideline for potential carcinogens associated with a specified cancer risk of 1 in 100,000, based on drinking-water exposure over a 70-year lifetime. The HA-L is an advisory guideline for drinking-water exposure over a 70-year lifetime, considering non-carcinogenic adverse health effects. More detail on these types of benchmarks, their derivation, and their underlying assumptions is provided in Nowell and Resek (1994). For this indicator, if a chemical had multiple benchmarks, the MCL took precedence; if no MCL was available, the lower of the RSD (at 1 in 100,000 cancer risk) and HA-L values was selected. An exceedance was identified if a yearly, time-weighted mean concentration exceeded the relevant standard or guideline (Heinz Center, 2002).

What the Data Show

NAWQA data compiled for The Heinz Center (2002) indicate that on average during the 1992-1998 period:

- Nitrate concentrations were above 2 mg/L in 55% of wells sampled in areas where agriculture is the primary land use (Figure 033-1).
- About 20% of the wells had nitrate concentrations that exceeded the federal drinking water standard (10 mg/L). Concentrations above this range may pose a health risk to infants, as noted above (EPA, 2004).
- Less than 1% of the wells in agricultural watersheds had one or more pesticides in concentrations that exceeded human health standards or guidelines (Heinz Center, 2002). However, as shown in Figure 033-2, about 60% of wells in agricultural areas had a least one detectable pesticide, and 10.6% had an average of five or more compounds at detectable levels.
- A relatively small number of these chemicals, specifically the herbicides atrazine (and its breakdown product desethylatrazine), metolachlor, cyanazine, and alachlor, accounted for most detections in ground water. The high detection frequency for these pesticides is related to their use. All are among the top five herbicides used in agriculture across the nation (Kolpin, et al., 1998).

Indicator Limitations

- These data only represent conditions in the 36 major river basins and aquifers sampled by the NAWQA program between 1992 and 1998. While they were subjectively chosen to be representative of watersheds across the United States, they are the result of a targeted sample design. The data also are highly aggregated and should only be interpreted as an indication of national patterns.
- Drinking water standards or guidelines do not exist for 44% (35 of 80) of the pesticides and pesticide degradation products analyzed. Current standards and guidelines also do not account for mixtures of pesticide chemicals and seasonal pulses of high concentrations. Possible pesticide effects on reproductive, nervous, and immune systems, as well as on chemically sensitive individuals, are not yet well understood.
- This indicator does not provide information on the extent to which pesticide concentrations exceed or fall below standards, nor the extent to which they exceed or fall below other reference points (e.g., Maximum Contaminant Level Goals (MCLGs) for drinking water).

Data Sources

The data sources for this indicator were the U.S. Geological Survey's National Water Quality Assessment (NAWQA) Program, as compiled for The Heinz Center (2002), http://www.heinzctr.org/ecosystems/farm/pest_strms.shtml**.** Additional information about the NAWQA data used in the Heinz Center report can be found at: http://water.usgs.gov/nawqa/heinz_ctr/**.**

References

Aspelin, A.L. 2003. Pesticide Usage in the United States: Trends During the 20th Century. Raleigh, NC: Center for Integrated Pest Management, North Carolina State University. February 2003. http://www.pestmanagement.info/pesticide_history/index.pdf.

Kolpin, D. W., Barbash, J. E., and R.J. Gilliom, R. J. 1998. Occurrence of Pesticides in Shallow Groundwater of the United States: Initial Results from the National Water-Quality Assessment Program. Environ. Sci. Technol., 32(5), 558-566.

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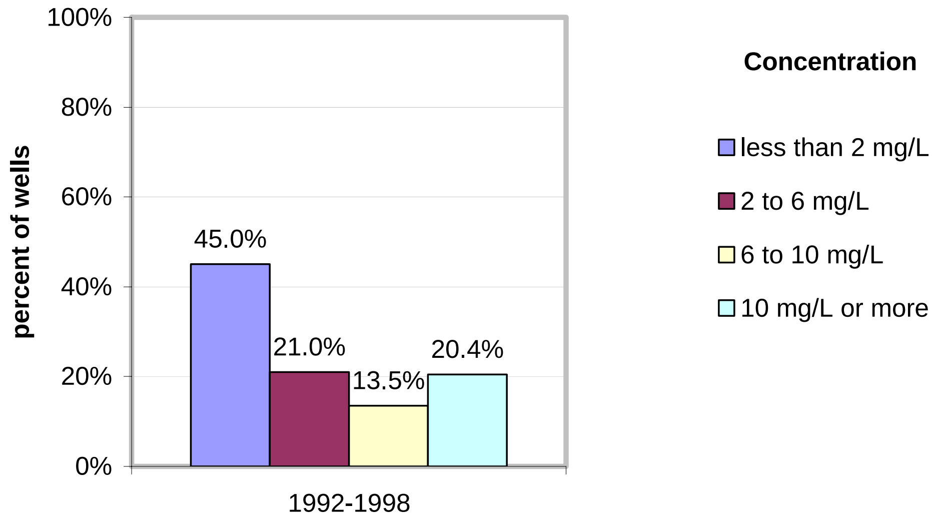
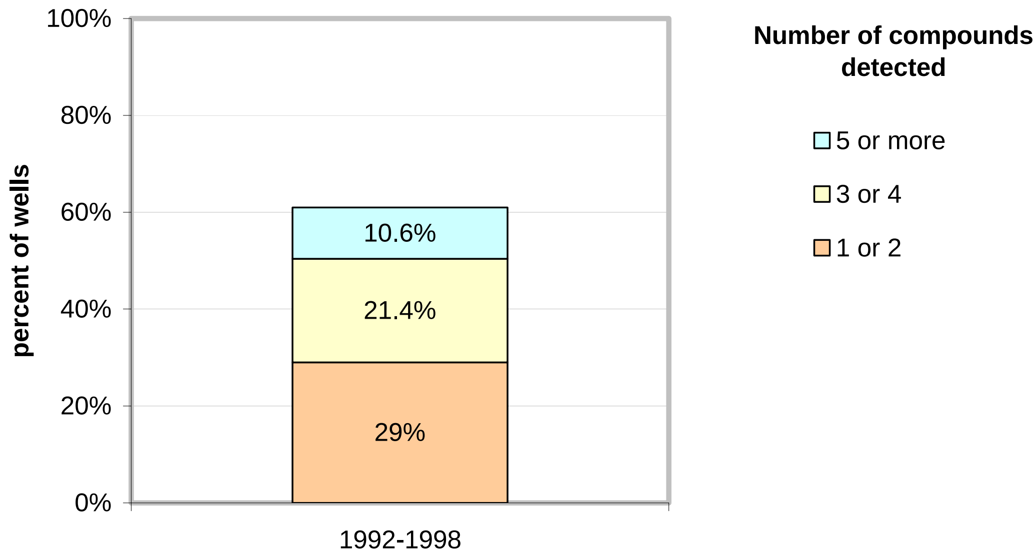
Graphics

Figure 033-1. Nitrate in groundwater in agricultural watersheds, 1992-1998



EPA's drinking water standard is 10 mg/L (Maximum Contaminant Level, or MCL).

Figure 033-2. Pesticides in groundwater in agricultural watersheds, 1992-1998



R.O.E. Indicator QA/QC

Data Set Name: NITRATE AND PESTICIDES IN GROUNDWATER IN AGRICULTURAL WATERSHEDS
Indicator Number: 033 (89148)
Data Set Source: U.S. Geologic Survey
Data Collection Date: Irregular: 1993-1998
Data Collection Frequency: 1-2yr.
Data Set Description: Nitrate and Pesticides in Groundwater in Agricultural Watersheds
Primary ROE Question: What are the trends in extent and condition of groundwater in the United States?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

This indicator is based on data collected by USGS NAWQA program. NAWQA s overall sample design represents a comprehensive effort to assess the nation s water quality through study units across the lower 48 states, which were chosen to be broadly representative of various land uses and hydrogeologic settings. Gilliom et al. (1995) provides an official description of sample design (full citation in T3Q3). Although aquifer selection was not random, well location was. Data for this indicator were deliberately collected at or near the top of the water table only (i.e., shallow wells). However, this limitation is appropriate because it ensures that the sample is representative of the groundwater most likely to be consumed by humans, as the purpose of this indicator is to evaluate potential risks to human health. The data for this indicator were collected between 1992 and 1998, a period that covers two full NAWQA sampling cycles and a total of 36 NAWQA study units. Within these 36 study units were several watersheds in which agriculture was considered a significant land use, according to a standard set of criteria described in Gilliom and Thelin (1997) (full citation in T3Q3). Samples from 1,190 wells in these agricultural watersheds were analyzed for both nitrate and pesticides. Although samples were generally only collected once per well, this is considered a scientifically valid way to assess groundwater conditions because changes in groundwater chemistry occur on a relatively slow timescale.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

This indicator is based on data collected by USGS's NAWQA program. NAWQA s overall sample design represents a comprehensive effort to assess the nation's water quality through study units across the lower 48 states, which were chosen to be broadly representative of various land uses and hydrogeologic settings. Gilliom et al. (1995) provides an official description of sample design (full citation in T3Q3). Although aquifer selection was not random, well location was. Data for this indicator were deliberately collected at or near the top of the water table only (i.e., shallow wells). However, this limitation is appropriate because it ensures that the sample is representative of the groundwater most likely to be consumed by humans, as the purpose of this indicator is to evaluate potential risks to human health. The data for this indicator were collected between 1992 and 1998, a period that covers two full NAWQA sampling cycles and a total of 36 NAWQA study units. Within these 36 study units were several watersheds in which agriculture was considered a significant land use, according to a standard set of criteria described in Gilliom and Thelin (1997) (full citation in T3Q3). Samples from 1,190 wells in these agricultural watersheds were analyzed for both nitrate and pesticides. Although samples were generally only collected once per well, this is considered a scientifically valid way to assess groundwater conditions because changes in groundwater chemistry occur on a relatively slow timescale.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

This indicator did not require a great deal of data manipulation. For its report to the Heinz Center, NAWQA simply aggregated the data, reporting average chemical concentrations for groups of wells and summarizing results by land use type. Results are expressed in terms of whether health criteria are exceeded. The health standards and guidelines used in compiling this indicator are documented in T2Q3; all are values that have been scientifically established by EPA.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Overall, the spatial, temporal, and chemical coverage of this indicator are all appropriate for answering the question "What are the trends in extent and condition of groundwater?" in agricultural areas where nitrate and pesticides may be a particular problem. This indicator uses a limited number of aquifers as a basis for generating an overall national indicator. However, the NAWQA program was specifically designed with this in mind, as the program intentionally targeted a sample that was representative of the variety of land-use types and hydrogeologic conditions (e.g., geology, recharge vs. discharge zones, etc.) across the lower 48 states. NAWQA is currently working on a design to better relate individual well water samples to regional patterns of contamination, but these data are not currently available. Thus, the choice of study aquifers was not random; aquifers were specifically targeted to give a national cross-section. However, well locations within each aquifer were random. NAWQA did not consider data from springs, drains, wells that were too close to other wells, or other locations that might taint or bias the overall result (http://water.usgs.gov/nawqa/nutrients/datasets/nutconc2000/). Beginning in 1991, NAWQA set out to examine 51 study areas, which are shown in the map on NAWQA s website (http://water.usgs.gov/nawqa/). The subsequent 9-year period was divided into three-year cycles, with approximately one-third of the study units sampled intensely during each cycle. This indicator reports data from agricultural watersheds within the 36 study units that were visited during the first two cycles, between 1992 and 1998. The indicator includes data from 1,190 wells that were screened for nitrate and 1,068 that were screened for pesticides. In all cases, samples were taken from the uppermost portions of the aquifer. Thus, results are not indicative of the condition of U.S. aquifers as a whole, but they are indicative of the condition of the groundwater that is most likely to be consumed as drinking water (i.e., pumped from shallow wells). Because this indicator is designed to assess risks from long-term exposure to contaminants in drinking water, NAWQA compared measured concentrations with the most up-to-date and relevant drinking water standards and guidelines available, all of which are based on risks from prolonged exposure. Most wells were only sampled once. However, in a few cases, multiple samples were analyzed, with contaminant concentrations averaged together into a single figure for this report (Bill Wilber, USGS, personal communication, 2005). Because conditions in groundwater are relatively stable (slow flow, slow dispersion), there should be little change in contaminant concentrations on a day-to-day or year-to-year timescale. Thus, even one or two samples should be sufficient for comparison with guidelines for prolonged exposure (Bill Wilber, USGS, personal communication, 2005). In terms of chemicals, this indicator covers a broad range of compounds that may be present as a result of agricultural applications. Nitrate, though it occurs naturally, may also be found in elevated levels due to the presence of runoff from fertilizer as well as human and animal waste. The 73 pesticides and 7 pesticide degradation products screened for this indicator account for approximately 75% of the total agricultural pesticide application in the U.S. by weight (NAWQA: http://ca.water.usgs.gov/pnsp/anstrat/). All are chemicals whose presence may be of concern to humans who use groundwater as their domestic water supply, particularly if it is untreated.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

This indicator is designed to report the condition of the uppermost portion of aquifers in agricultural regions, as the sample is intended to be representative of the groundwater most commonly used as a water supply for humans, but there was no attempt to target well water sampling at sensitive populations such as infants (nitrate) or people who are particularly susceptible to pesticide contamination.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

EPA has established drinking water standards or guidelines for many of the chemicals screened. The current drinking water standard for nitrate is 10 mg/L, which is EPA s Maximum Contaminant Level (MCL). Pesticide reference thresholds for this indicator are listed at http://oregon.usgs.gov/sumrpt/Benchmrk.1.html and http://oregon.usgs.gov/sumrpt/Benchmrk.2.html, along with the sources of these values. For some pesticide-related contaminants, reference values have not yet been established.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

All NAWQA groundwater sampling procedures are documented in official USGS reports (full citations appear below). Lapham et al. (1995) documents official procedures for establishing well sites. Because of the expense of drilling, NAWQA sought to sample from existing wells where possible (Bill Wilber, USGS, personal communication, 2005). Koterba et al. (1995) discusses sample collection and preservation, while Koterba (1998) describes procedures for obtaining ancillary data at each well site, including information about the location of the well screen relative to the water table. Laboratory methods are fully documented by USGS. NAWQA measured nitrate concentrations using procedures described in Fishman (1993). Pesticide concentrations were measured using two primary methods: gas chromatography/mass spectrometry (GC/MS) (Zaugg et al., 1995) and high-performance liquid chromatography (HPLC) (Werner et al., 1996). The list of pesticides and degradation products measured is the same as the list used in NAWQA s 1994 summary reports, which included 73 pesticides and 7 related degradation products (list available in two parts, located at http://or.water.usgs.gov/sumrpt/Constits.1.html and http://or.water.usgs.gov/sumrpt/Constits.2.html) (Lisa Nowell, USGS, personal communication, 2005). The website http://ca.water.usgs.gov/pnsp/anstrat/ provides a list of the specific laboratory methods used for each of these chemicals (see Table 2 on this website). Detection limits, which are compound-specific, are listed at the same website. Fishman, M.J. 1993. Methods of analysis by the U.S. Geological Survey National Water-Quality Laboratory--Determination of inorganic and organic constituents in water and fluvial sediments. U.S. Geological Survey Open-File Report 93-125. Koterba, M.T., F.D. Wilde, and W.W. Lapham, 1995, Ground water data-collection protocols and procedures for the National Water-Quality Assessment Program: Collection and documentation of water-quality samples and related data; U.S. Geological Survey Open-File Report 95-399. Koterba, M.T., 1998, Ground water data-collection protocols and procedures for the National Water-Quality Assessment Program: Collection, documentation, and compilation of required site, well, subsurface, and landscape data for wells. U.S. Geological Survey Water-Resources Investigations Report 98-4107. Lapham, W. W., F.D. Wilde, and M.T. Koterba, 1995, Ground water data collection protocols and procedures for the National Water-Quality Assessment Program: Selection, installation, and documentation of wells and collection of related data. U.S. Geological Survey Open-File Report 95-398. Werner, S.L., Burkhardt, M.R., and DeRusseau, S.N., 1996, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory: Determination of pesticides in water by Carbopak-B solid-phase extraction and high-performance liquid chromatography: U.S. Geological Survey Open-File Report 96-216, Denver, Colorado, 42 pp. Zaugg, S.D., Sandstrom, M.W., Smith, S.G., and Fehlberg, K.M., 1995, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory-Determination of pesticides in water by C-18 solid-phase extraction and capillary-column gas chromatography/mass spectrometry with selected-ion monitoring: U.S. Geological Survey Open-File Report 95-181, Denver, Colorado, 49 pp.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Water quality data collected by NAWQA may be accessed through the NAWQA database, http://infotrek.er.usgs.gov/servlet/page?_pageid=543&_dad=portal30&_schema=PORTAL30. These data may also be accessible through USGS s general water quality database, located at http://waterdata.usgs.gov/nwis/qw. EPA obtained the data for this indicator directly from the Heinz Center s 2002 report, the State of the Nation s Ecosystems. This report was based on a subset of data that the Heinz Center obtained from NAWQA, which contained a summary of data from the 1992-1998 NAWQA cycle, with sites and results classified by land-use type. For nitrate concentrations, the report NAWQA prepared for the Heinz Center may be accessed online at http://water.usgs.gov/nawqa/nutrients/datasets/nutconc2000/, although this report lists values for aggregations of wells, not individual wells. This indicator reports data for nitrate plus nitrite, which is often abbreviated as nitrate because concentrations of nitrite are typically small relative to concentrations of nitrate. For pesticide concentrations, the report NAWQA prepared for the Heinz Center does not appear to be available online. However, the Heinz Center does provide access to all data that appear directly in the graphics in its 2002 report, through the following links: http://www.heinzcenter.org/ecosystems/farm/datasets/nitrate_in_gdwtr.shtml. http://www.heinzctr.org/ecosystems/farm/datasets/pesticide_significance.shtml. http://www.heinzctr.org/ecosystems/farm/datasets/pesticide_occurrence.shtml.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Reproducibility is inherently limited because this indicator reports historical data. Nonetheless, NAWQA and the Heinz Center have provided several references to document the design of the survey upon which this indicator is based. Gilliom et al. (1995) discusses the overall design of the NAWQA program, while Gilliom and Thelin (1997) provide a good description of how study units were classified as to land use. Scott (1989) describes the organization of land use data into a computer database. NAWQA s report to the Heinz Center (http://water.usgs.gov/nawqa/nutrients/datasets/nutconc2000/sw_nuts_Heinz.xls) includes a list of groups of wells where nutrient (e.g., nitrate) samples were collected for agricultural watersheds, but does not identify specific well sites. However, all raw data for this indicator could conceivably be acquired from the NAWQA database and then queried following the criteria outlined in the sources above in order to replicate the dataset for the indicator. NAWQA has published a full list of the 73 pesticides and 7 related degradation products that were screened for this indicator, which can be found in two parts at http://or.water.usgs.gov/sumrpt/Constits.1.html and http://or.water.usgs.gov/sumrpt/Constits.2.html. This is the same set of chemicals that was discussed in NAWQA's 1994 report (Lisa Nowell, USGS, personal communication, 2005). Aquatic and human health standards and guidelines for this indicator are documented at http://oregon.usgs.gov/sumrpt/Benchmrk.1.html and http://oregon.usgs.gov/sumrpt/Benchmrk.2.html. Gilliom, R.J., W.M. Alley, and M.E. Gurtz. 1995. Design of the National Water-Quality Assessment Program: Occurrence and distribution of water-quality conditions. U.S. Geological Survey Circular 1112. Gilliom, R. J., and G.P. Thelin, 1997, Classification and mapping of agricultural land for National Water-Quality Assessment. U.S. Geological Survey Circular 1131. Scott, J.C. 1989. A computerized data-base system for land-use and land-cover data collected at ground-water sampling sites in the pilot National Water-Quality Assessment Program. U.S. Geological Survey Water-Resources Investigations Report 89-4172.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

NAWQA provides several references that describe QA/QC procedures for the collection and analysis of groundwater samples. Martin (1999) provides particularly good coverage of field and laboratory protocols such as field blanks and replicates. NAWQA also discusses how and why certain wells were excluded from this particular analysis (http://water.usgs.gov/nawqa/nutrients/datasets/nutconc2000/). Martin, J.D. 1999. Quality of pesticide data for environmental water samples collected for the National Water-Quality Assessment Program, 1992-96, and examples of the use of quality-control information in water-quality assessments. U.S. Geological Survey. Accessed January 10, 2003 at http://ca.water.usgs.gov/pnsp/rep/qcsummary.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

This indicator does not require temporal manipulation. Levels of contaminants in groundwater do not generally show much variability on a day-to-day or year-to-year timescale, so a single set of measurements should be sufficient to describe current conditions. In the few cases where multiple samples were collected from the same well, NAWQA simply averaged the results (Bill Wilber, USGS, personal communication, 2005). Spatially, the sample design was designed to provide a broad national picture, so no further extrapolation or generalization is necessary.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Uncertainty estimates are not available for the exact subset of data included in this indicator. However, NAWQA has published uncertainty figures for the overall data collection effort, which should be indicative of uncertainty for this indicator. Mueller (1998) specifically discusses nutrient (nitrate) data, while Martin (2002) evaluates uncertainty for pesticide data. Mueller, D.K., 1998, Quality of nutrient data from streams and ground water sampled during 1993-95--National Water-Quality Assessment Program, U.S. Geological Survey Open File Report 98-276. Martin, J.D., 2002, Variability of pesticide detections and concentrations in field replicate water samples collected for the National Water-Quality Assessment Program 1992-97, U.S. Geological Survey Water Resources Investigation Report 01-4178.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Because uncertainty varies depending on the chemical and analytical method in question, it is difficult to make a single definitive statement about the impact of uncertainty on this indicator. However, because results from over 1,000 wells are generalized over the entire nation, the summary figures reported by this indicator should be considered reasonably accurate. Because this indicator generally relies on samples that were only collected once per well, it does not account for day-to-day or year-to-year variability in groundwater concentrations of the chemicals in question. However, groundwater conditions are assumed to be relatively constant over time; movement of water and dispersion of contaminants are slow processes, particularly as compared with changes in aboveground streams (Indicator 040). Thus, groundwater conditions do not require the same frequency of sampling as conditions in surface water (which NAWQA measured 15-25 times over the course of a given year) to be reflective of long-term trends.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Limitations to this indicator include the following: 1. Data for this indicator only represent conditions in 36 NAWQA study areas, each of which typically encompasses a single major river basin or aquifer. While study units were subjectively chosen to be representative of watersheds across the U.S., they still reflect the results of a targeted sample, not a full survey of all watersheds. Data are also highly aggregated and should only be interpreted as an indication of national patterns. 2. This indicator does not report the extent to which pesticide concentrations may be above or below standards for human health; it just reports whether the standard has been exceeded. It also does not report the extent to which concentrations may exceed other reference values that were not used for this report (e.g., Maximum Contaminant Level Goals (MCLGs) for drinking water). 3. Many chemicals lack an established reference value for human health. Of the 80 pesticide-related chemicals screened, only 45 had drinking water standards or guidelines at the time the indicator was constructed. Current standards and guidelines also do not account for mixtures of pesticide chemicals and seasonal pulses of high concentrations. Possible pesticide effects on reproductive, nervous, and immune systems, as well as chemically sensitive individuals, are not yet well understood. 4. Contaminant levels do not necessarily reflect the concentrations that humans will be exposed to in their drinking water supply, as nitrate and pesticides may be partially or completely removed through water treatment. 5. Although limited historical data are available to characterize long-term trends in groundwater contamination, this indicator specifically examines just the most current conditions.

Indicator: Submerged Aquatic Vegetation in Chesapeake Bay (317R)

Submerged Aquatic Vegetation (SAV) is important to most aquatic ecosystems. For example, SAV produces oxygen, supplies food for many species (especially waterfowl), offers shelter and nursery habitat for fish and shellfish, reduces wave action and shoreline erosion, absorbs excess nutrients, such as nitrogen and phosphorus, and traps sediments. The loss of SAV from shallow waters of Chesapeake Bay, which was first noted in the early 1960s, is a widespread, well documented problem (Batiuk, et al., 2000). Although other factors, such as climatic events and herbicide toxicity, may have contributed to the decline of SAV in the Bay, the primary causes are eutrophication and associated reductions in light availability (Batiuk, et. al., 2000). Trends in the distribution and abundance of SAV over time are useful in understanding trends in water quality (Moore, et. al. 2004). Review of photographic evidence from a number of sites dating back to 1937 suggests that close to 200,000 acres of SAV may have historically grown along the shoreline of the Bay (Moore, et. al. 2004). However, by 1984, the SAV community had fallen to a low of about 38,000 acres (Virginia Institute of Marine Science).

This indicator presents the distribution of SAV in Chesapeake Bay and its tributaries from 1978-2003, as mapped from black and white aerial photographs. The surveys follow fixed flight routes over shallow water areas of the Bay to comprehensively survey all tidal shallow water areas of the Bay and its tidal tributaries. Non-tidal areas are omitted from the survey. SAV beds less than 1 square meter are not included due to the limits of the photography and interpretation. Annual monitoring began in1978, however no surveys were conducted from 1979-1983 or in 1988. In events where the entire area could not be surveyed due to flight restrictions or weather events, estimates were included.

What the Data Show

The extent of SAV in the Chesapeake Bay increased during the monitoring period, from 41,000 acres in 1978 to 65,000 acres in 2003 (Figure 317R-1). The maximum annual extent of SAV during this period was 90,000 acres, seen in 2002. However, by 2003, SAV acreage had dropped 30 percent. Even at its maximum extent, SAV coverage in the Bay represents less than half its historic coverage.

The significant changes in SAV distribution in 2003 appear to be the result of substantial reductions in widgeongrass populations in the lower and mid-bay regions. In addition to the large declines in widgeongrass, major declines in freshwater SAV species occurred in the upper portion the Potomac River and Susquehanna region. While populations of SAV appeared to be present in these segments very early in the growing season, the persistent turbidity resulting from rain occurring throughout the spring and summer may have contributed to a very early decline, well before Hurricane Isabel affected Chesapeake Bay (Orth et. al., 2004).

Indicator Limitations

- There were no surveys in the years 1979 through 1983 and 1988.

- The indicator includes partial estimated data for years with incomplete photographic documentation of the survey area. Spatial gaps in 1999 occurred due to hurricane disturbance and subsequent inability to reliably photograph SAV. Spatial gaps in 2001 occurred due to flight restrictions near Washington D.C. after the September 11th terrorist attacks. Other gaps occurred in 2003 due to adverse weather in the spring, summer, and fall (Hurricane Isabel). Estimates of acreage in the non-surveyed areas, based on prior years' surveys, were developed for 1999, 2001, and 2003.

Data Sources

Virginia Institute of Marine Science. The SAV distribution data files are located at http://www.vims.edu/bio/sav/savdata.html. The data used to construct the chart are located at http://www.chesapeakebay.net/pubs/statustrends/88-data-2002.xls. The SAV indicator is published at http://www.chesapeakebay.net/status.cfm?sid=88.

References

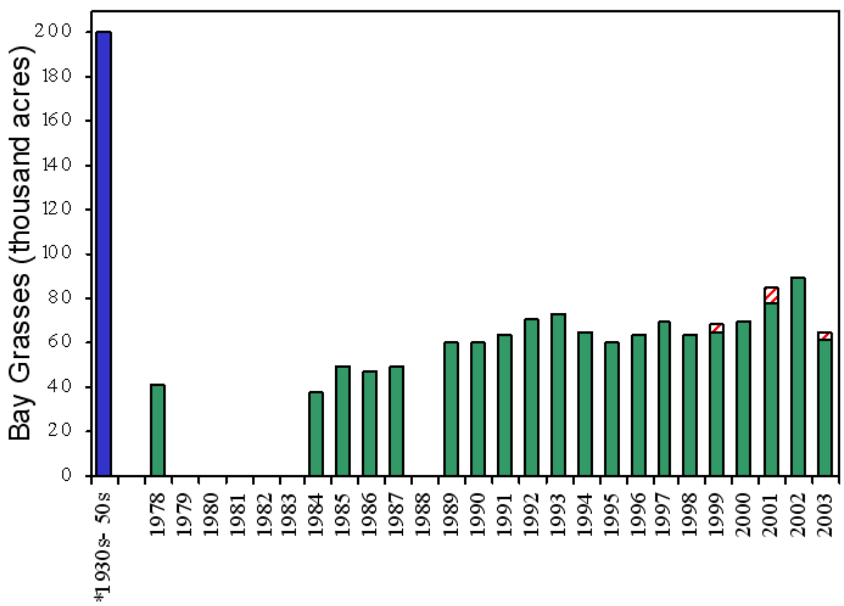
Batiuk, R., P. Bergstrom, M. Kemp, E. Koch, L. Murray, C. Stevenson, R. Bartleson, V. Carter, N. Rybicki, J. Landwehr, C. Gallegos, L. Karrh, M. Naylor, D. Wilcox, K. Moore, S. Ailstock, and M. Teichberg. 2000. Chesapeake Bay submerged aquatic vegetation water quality and habitat-based requirements and restoration targets: A second technical synthesis. CBP/TRS 245/00. EPA 903-R-00-014, U.S. EPA, Chesapeake Bay Program, Annapolis, MD. (http://www.chesapeakebay.net/pubs/sav/savreport.pdf)

Historical analysis of SAV in the Potomac River and Analysis of Bay-wide Historic SAV to establish a New Acreage Goal. K. A. Moore, D. J. Wilcox, B. Anderson, T. A. Parham, and M. D. Naylor. Report to EPA Chesapeake Bay Program. April 2004. (http://www.vims.edu/bio/sav/Final_SAV_Historical_Report_2004.pdf)

2003 Distribution of Submerged Aquatic Vegetation in Chesapeake Bay and Coastal Bays. R. J. Orth, D. J. Wilcox, L. S. Nagey, A. L. Owens, J. R. Whiting, A. Serio. Report to EPA Chesapeake Bay Program. December 2004. (http://www.vims.edu/bio/sav/sav03/index.html)

Graphics

Figure 317R-1: Extent of SAV in Chesapeake Bay (acres), 1978-2003 compared to historic extent



R.O.E. Indicator QA/QC

Data Set Name: SUBMERGED AQUATIC VEGETATION IN CHESAPEAKE BAY
Indicator Number: 317R (89155)
Data Set Source: Virginia Institute of Marine Science via EPA grant
Data Collection Date: 1978-2003, excluding 1979-1983 and 1988
Data Collection Frequency: 1 yr
Data Set Description: Acres of Submerged Aquatic Vegetation in Chesapeake Bay
Primary ROE Question: What are the trends in extent and condition of coastal waters

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. Methods developed for this survey are described in "2002 Distribution of submerged aquatic vegetation in the Chesapeake Bay and coastal bays. R. J. Orth, D. J. Wilcox, L. S. Nagey, A. L. Owens, J. R. Whiting, and A. Serio. VIMS Special Scientific Report Number 139. Final report to U.S. EPA, Chesapeake Bay Program, Annapolis, MD. Grant No.CB983649-01-0, 2003." available at http://www.vims.edu/bio/sav/sav02/ This indicator has undergone extensive technical and peer review by state, Federal and non-government organization partner members of the SAV workgroup and the Living Resources subcommittee. Data collection, data analysis and QA/QC is conducted by the principal investigators/scientists. The data are peer reviewed by scientists on the workgroup. Data selection and interpretation, the presentation of the indicator, along with all supporting information and conclusions, are arrived at via consensus by the scientists in collaboration with the resource manager members of the workgroup. The workgroup presents the indicator to the subcommittee where extensive peer review by Bay Program managers occurs. See Chesapeake Bay SAV special reports at http://www.vims.edu/bio/sav/savreports.html and bibliography at http://www.vims.edu/bio/sav/savchespub.html. The SAV distribution data files are located at http://www.vims.edu/bio/sav/savdata.html and also at http://www.chesapeakebay.net/pubs/statustrends/88-data-2002.xls. The SAV indicator is published at http://www.chesapeakebay.net/status.cfm?sid=88.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The SAV survey is a general monitoring program, conducted to optimize precision and accuracy in characterizing annually the status and trends of SAV in tidal portions of the Chesapeake Bay. The general plan is to follow fixed flight routes over shallow water areas of the Bay to comprehensively survey all tidal shallow water areas of the Bay and its tidal tributaries. Non-tidal areas are omitted from the survey. SAV beds less than 1 square meter are not included due to the limits of the photography and interpretation. Annual monitoring began in 1978 and is ongoing. Methods are described in the Quality Assurance Project Plan (QAPP) on file for the EPA grant (contact: EPA grant project officer, Mike Fritz (fritz.mike@epa.gov) and at the VIMS web site (http://www.vims.edu/bio/sav/). See Chesapeake Bay SAV special reports at http://www.vims.edu/bio/sav/savreports.html and bibliography at http://www.vims.edu/bio/sav/savchespub.html.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. This indicator has undergone extensive technical and peer review by state, Federal and non-government organization partner members of the SAV workgroup and the Living Resources subcommittee. Data collection, data analysis and QA/QC is conducted by the principal investigators/scientists. The data are peer reviewed by scientists on the workgroup. Data selection and interpretation, the presentation of the indicator, along with all supporting information and conclusions, are arrived at via consensus by the scientists in collaboration with the resource manager members of the workgroup. The workgroup presents the indicator to the subcommittee where extensive peer review by Bay Program managers occurs. See Chesapeake Bay SAV special reports at http://www.vims.edu/bio/sav/savreports.html and bibliography at http://www.vims.edu/bio/sav/savchespub.html. The SAV distribution data files are located at http://www.vims.edu/bio/sav/savdata.html and also at http://www.chesapeakebay.net/pubs/statustrends/88-data-2002.xls. The SAV indicator is published at http://www.chesapeakebay.net/status.cfm?sid=88.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The SAV survey is a general monitoring program, conducted to optimize precision and accuracy in characterizing annually the status and trends of SAV in tidal portions of the Chesapeake Bay. Methods developed for this survey are described in "2002 Distribution of submerged aquatic vegetation in the Chesapeake Bay and coastal bays. R. J. Orth, D. J. Wilcox, L. S. Nagey, A. L. Owens, J. R. Whiting, and A. Serio. VIMS Special Scientific Report Number 139. Final report to U.S. EPA, Chesapeake Bay Program, Annapolis, MD. Grant No.CB983649-01-0, 2003." available at http://www.vims.edu/bio/sav/sav02/

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The SAV measure is an indicator of Chesapeake Bay ecosystem health. Trends in the distribution and abundance of SAV over time are useful in understanding trends in water quality.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Yes. Please refer to Historical analysis of SAV in the Potomac River and Analysis of Bay-wide Historic SAV to establish a New Acreage Goal. K. A. Moore, D. J. Wilcox, B. Anderson, T. A. Parham, and M. D. Naylor. Report to EPA Chesapeake Bay Program. April 2004 at http://www.vims.edu/bio/sav/Final_SAV_Historical_Report_2004.pdf refer to page 12.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Please refer to http://www.vims.edu/bio/sav/sav02/report/reportindex_page.html Methods are also described in the Quality Assurance Project Plan (QAPP) on file for the EPA grant (contact: EPA grant project officer, Mike Fritz (fritz.mike@epa.gov) and at the VIMS web site (http://www.vims.edu/bio/sav/). See Chesapeake Bay SAV special reports at http://www.vims.edu/bio/sav/savreports.html and bibliography at http://www.vims.edu/bio/sav/savchespub.html.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. Please refer to http://www.vims.edu/bio/sav/sav02/report/reportindex_page.html Methods are also described in the Quality Assurance Project Plan (QAPP) on file for the EPA grant (contact: EPA grant project officer, Mike Fritz (fritz.mike@epa.gov) and at the VIMS web site(http://www.vims.edu/bio/sav/). See Chesapeake Bay SAV special reports at http://www.vims.edu/bio/sav/savreports.html and bibliography at http://www.vims.edu/bio/sav/savchespub.html. Metadata are included with the data set posted at the VIMS web site (http://www.vims.edu/bio/sav/metadata/recent.html)

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. Please refer to http://www.vims.edu/bio/sav/sav02/report/reportindex_page.html Methods are also described in the Quality Assurance Project Plan (QAPP) on file for the EPA grant (contact: EPA grant project officer, Mike Fritz (fritz.mike@epa.gov) and at the VIMS web site (http://www.vims.edu/bio/sav/). See Chesapeake Bay SAV special reports at http://www.vims.edu/bio/sav/savreports.html and bibliography at http://www.vims.edu/bio/sav/savchespub.html.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Quality assurance project plan for the EPA grant to the Virginia Institute of Marine Sciences describes data collection, analysis, and management methods. This is on file at the EPA Chesapeake Bay Program Office (contact: EPA grant project officer, Mike Fritz (fritz.mike@epa.gov). The VIMS web site at http://www.vims.edu/bio/sav/ provides this information as well. Metadata are included with the data set posted at the VIMS web site (http://www.vims.edu/bio/sav/metadata/recent.html)

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. Values used in the analysis are aggregated data, aggregated by Chesapeake Bay segment. Quality assurance project plan for the EPA grant to the Virginia Institute of Marine Sciences describes data collection, analysis, and management methods. This is on file at the EPA Chesapeake Bay Program Office (contact: EPA grant project officer, Mike Fritz (fritz.mike@epa.gov). The VIMS web site at http://www.vims.edu/bio/sav/ provides this information as well. Metadata are included with the data set posted at the VIMS web site (http://www.vims.edu/bio/sav/metadata/recent.html)

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. Quality assurance project plan for the EPA grant to the Virginia Institute of Marine Sciences describes data collection, analysis, and management methods. This is on file at the EPA Chesapeake Bay Program Office (contact: EPA grant project officer, Mike Fritz (fritz.mike@epa.gov). The VIMS web site at http://www.vims.edu/bio/sav/ provides this information as well. Metadata are included with the data set posted at the VIMS web site (http://www.vims.edu/bio/sav/metadata/recent.html)

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No. Some technical improvements (e.g., photointerpretation tools) were made over the 16 years of the annual SAV survey in Chesapeake Bay. Surveyors and analysts have carefullly evaluated the effect of methodological changes along the way and made corrections to adjust for any known effects. Quality assurance project plan for the EPA grant to the Virginia Institute of Marine Sciences describes data collection, analysis, and management methods. This is on file at the EPA Chesapeake Bay Program Office (contact: EPA grant project officer, Mike Fritz (fritz.mike@epa.gov). The VIMS web site at http://www.vims.edu/bio/sav/ provides this information as well. Metadata are included with the data set posted at the VIMS web site (http://www.vims.edu/bio/sav/metadata/recent.html)

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Due to funding constraints, there were no surveys in the years 1979-1983 and 1988. Spatial gaps in 1999 occurred due to hurricane disturbance and subsequent inability to reliably photograph SAV. Spatial gaps in 2001 occurred due to post-nine-eleven flight restrictions near Washington D.C. Spatial gaps in 2003 occurred due to adverse weather in the spring and summer and Hurricane Isabel in the fall. Estimates of acreage in the non-surveyed areas, based on prior year surveys, were developed for those years (1999, 2001, 2003).

Indicator: Wetland Extent, Change, and Sources of Change (020)

Freshwater wetlands support a variety of fish and wildlife species and contribute to the aesthetic and environmental quality of the U.S. Millions of Americans use freshwater wetlands annually for hunting, fishing, bird watching and other outdoor activities. Estuarine wetlands provide valuable nursery, feeding, breeding, staging, and resting areas for an array of fish, shellfish, mammals, and birds (Dahl, 2000). In addition, wetlands serve as groundwater recharge areas and filter contaminants from surface runoff (Mitsch and Gosselink, 1986). Destruction and/or alteration of wetlands, therefore, have wide-ranging biological and hydrological impacts.

When European settlers first arrived, wetland acreage in the area that would become the lower 48 states was more than 220 million acres, or about five percent of the total area of the conterminous U.S. Since then, extensive losses have occurred, and over half of our original wetlands have been drained and filled. By 1997, total wetland acreage was estimated to be 105.5 million acres (Dahl, 2000). Of that total, nearly 95 percent or 100.2 million acres were fresh water and about five percent or 5.3 million acres were intertidal marine and estuarine wetlands. Between 1986 and 1997, 98 percent of all wetland losses in the conterminous U.S. were freshwater wetlands (Dahl, 2000).

In addition to the sheer loss of wetland acreage, major ecological impacts have also resulted from the conversion of one wetland type to another such as clearing trees from a forested wetland or excavating a shallow marsh to create an open water pond. These types of conversions change habitat types and community structure in watersheds and impact the animal communities that depend on them (Dahl, 2000).

The National Wetlands Inventory Status and Trends survey (NWI) data provide estimates of the extent of all wetlands in the conterminous U.S. Data presented are derived from three separate analyses; one covering the 1950s to the 1970s; one covering the 1970s to 1980s, and one covering the 1980s to the 1990s. The NWI counts all wetlands every 10 years, regardless of land ownership, but only recognizes wetlands that are at least three acres in size. A permanent study design is used, based initially on stratification of the 48 conterminous states by state boundaries and 35 physiographic subdivisions. Within these subdivisions are located 4,375 randomly selected, four square mile (2,560 acres) sample plots. These plots are examined with the use of aerial imagery, ranging in scale and type; most are 1:40,000 scale, color infrared, from the National Aerial Photography Program. Field verification is conducted to address questions of image interpretation, land use coding, and attribution of wetland gains or losses; plot delineations are also completed. For example, for the 1980s to 1990s analysis, 21 percent of the sample plots were field-verified.

The data estimating the causes or sources of wetland losses are from the National Resource Inventory (NRI), which is a scientifically based, longitudinal panel survey of trends in the nation’s soil, water, and related resources. NRI data were collected using a variety of imagery, field office records, historical records and data, ancillary materials, and a limited number of on-site visits. The data have been compiled, verified, and analyzed to provide a comprehensive look at the state of the nation’s non-federal lands. The 1997 NRI provides results that are nationally consistent for all non-federal lands (accounting for 75 percent of the nation’s land area) for 1992 and 1997. The NRI captures data on over 300,000 primary sample units (nominally 160 acres each) containing over 800,000 sample points. The large sample size supports the analysis of data on a regional basis. In 2000, the NRI shifted to an annual survey in which data are collected at slightly less than 25 percent of the same sample sites. National data on sources of wetland change are presented from the 2002 NRI; however, due to the smaller sample size, the data cannot support regional analyses.

What the Data Show for Wetland Extent and Change

Rates of annual wetland losses have decreased from almost 500,000 acres a year three decades ago to less than 100,000 acres, averaged annually from 1986 to 1997 (Exhibit 020-1). The USFWS estimated the annual rate of loss at 58,500 acres per year between 1986 and 1997. This represents an 80 percent reduction compared to the previous decadal rate of loss

Freshwater wetland types include forested, shrub, and emergent wetlands, plus open water ponds. Forested and emergent wetlands make up over 75 percent of all freshwater wetlands (Dahl, 2000). Since the 1950s, freshwater emergent wetlands have declined by nearly 24 percent – a greater proportional loss than any other freshwater wetland type (Exhibit 020-2). Freshwater forested wetlands have sustained the greatest absolute losses – 10.4 million acres since the 1950s.

Coastal wetlands are the vegetated interface between aquatic and terrestrial components of estuarine ecosystems. Estuarine emergent wetlands account for nearly 75 percent of coastal wetlands. Since the 1950s, coastal and estuarine losses were about 1.4 million acres – a nearly 12 percent decline (Exhibit 020-3). However, long-term trends indicate that loss of estuarine vegetated and non-vegetated wetland area has slowed over time.

What the Data Show for Sources of Wetland Change

Development accounted for two-thirds of wetland acreage lost on non-federal lands in the conterminous United States between 1997 and 2002 (Exhibit 020-4). Agriculture contributed to approximately 20 percent of the gross losses during the same period but was also responsible for wetland acreage gains averaging 36,000 acres per year (USDA, 2004). Between 1992 and 1997, urban, suburban, and commercial development was also the primary cause of net wetland loss, accounting for 49 percent of losses nationally (Exhibit 020-4). During this period, agriculture accounted for 26 percent of the nation's net wetland losses on non-federal lands, and timber harvesting and silviculture were the source of 12 percent of the net loss. Prior to the NRI, the NWI estimated that agriculture accounted for 81 percent of all wetlands conversions between 1954 and 1974 (Frayer et al., 1983).

Regional level data on sources of wetland loss are available between 1992 and 1997 and illustrate that sources of loss vary by region (Exhibit 020-4). For example, in the midwest and northern plains, about 50 percent of losses were from agriculture whereas the east, southeast, and south central states had the highest percentages of wetland loss due to development. In the east, 67 percent of the wetland losses were attributed to development (USDA, 2000). Regional data for the NRI are not available between 1997 and 2002.

Indicator Limitations

- This indicator does not effectively address the question of wetland condition. While it is possible to inventory wetlands that have been lost, many wetlands have suffered degradation of condition and functions, which cannot be quantified nationally.
- Different methods were used in some of the early classification schemes to classify wetland types. The classification system that is currently used by NWI was not applied to some of the earlier maps (1970s). As methods and spatial resolution have improved over time, acreage data have been adjusted resulting in changes in the overall wetland base over time. Thus, the evaluation process is evolving, which contributes to reducing the accuracy of the trends observed.
- Ephemeral wetlands and effectively drained palustrine wetlands observed in farm production are not recognized as a wetland type by NWI and are therefore not included.
- Forested wetlands are difficult to photointerpret and are generally underestimated by NWI.

- The NWI does not survey wetlands under 3 acres in size. Therefore, no record exists of the extent of, and change in, this valuable resource.
- The NWI does not include Alaska and Hawaii.
- Statistics derived from the NRI database are estimates and not absolutes. They provide information at a coarse scale, summarized by state, and are useful for national reporting. Thus, there is some amount of uncertainty, which is explained in the appendix of the report.
- The NRI data do not include an adequate sample of coastal resources.
- The NRI does not collect data on federal lands (which represent about 25% of the nation's land area) or for the state of Alaska.
- Regional data for the NRI are not available between 1997 and 2002.

Data Sources

Dahl, T.E. and C.E. Johnson. *Status and Trends of Wetlands in the Conterminous United States, Mid-1970's to Mid-1980's*, Washington, D.C.: U.S. Department of the Interior, U.S. Fish and Wildlife Service, 1991.

Dahl, T.E. *Status and Trends of Wetlands in the Conterminous United States 1986 to 1997*, Washington, D.C.: U.S. Department of the Interior, U.S. Fish and Wildlife Service, 2000. http://wetlands.fws.gov/bha/SandT/SandTReport.html.

Frayer, W.E., T.J. Monahan, D.C. Bowden, and F.A. Graybill. *Status and Trends of Wetlands and Deepwater Habitats in the Conterminous United States, 1950's to 1970's*, Ft. Collins, CO: Colorado State University, 1983.

U.S. Department of Agriculture. *Summary Report: 2002 Annual National Resources Inventory.* Washington, D.C: Natural Resources Conservation Service and Ames, Iowa: Iowa State University Statistical Laboratory, 2004. http://www.nrcs.usda.gov/technical/land/nri02/.

U.S. Department of Agriculture. *Summary Report: 1997 National Resource Inventory (Revised December 2000).* Washington, D.C: Natural Resources Conservation Service and Ames, Iowa: Iowa State University Statistical Laboratory, 2000. http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/.

References

Dahl, T.E. and C.E. Johnson. *Status and Trends of Wetlands in the Coterminous United States, Mid-1970's to Mid-1980's*, Washington, D.C.: U.S. Department of the Interior, U.S. Fish and Widlife Service, 1991.

Dahl, T.E. *Status and Trends of Wetlands in the Conterminous United States 1986 to 1997*, Washington, D.C.: U.S. Department of the Interior, U.S. Fish and Wildlife Service, 2000. http://wetlands.fws.gov/bha/SandT/SandTReport.html.

Frayer, W.E., T.J. Monahan, D.C. Bowden, and F.A. Graybill. *Status and Trends of Wetlands and Deepwater Habitats in the Conterminous United States, 1950's to 1970's*, Ft. Collins, CO: Colorado State University, 1983.

Mitsch, W.J. and J.G. Gosselink. *Wetlands.* New York, NY. Van Nostrand Reinhold Company Inc. 1986.

Graphics

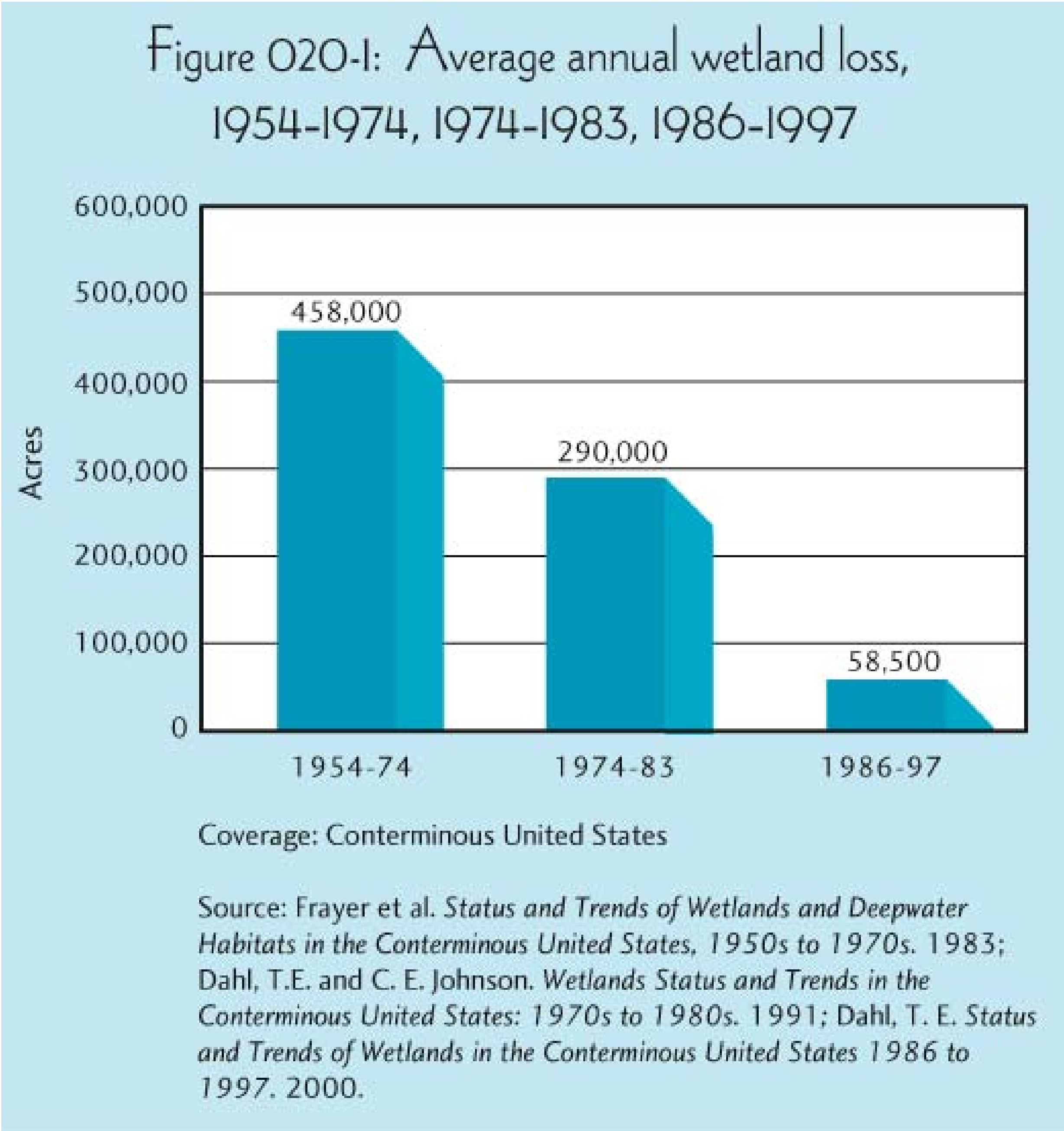
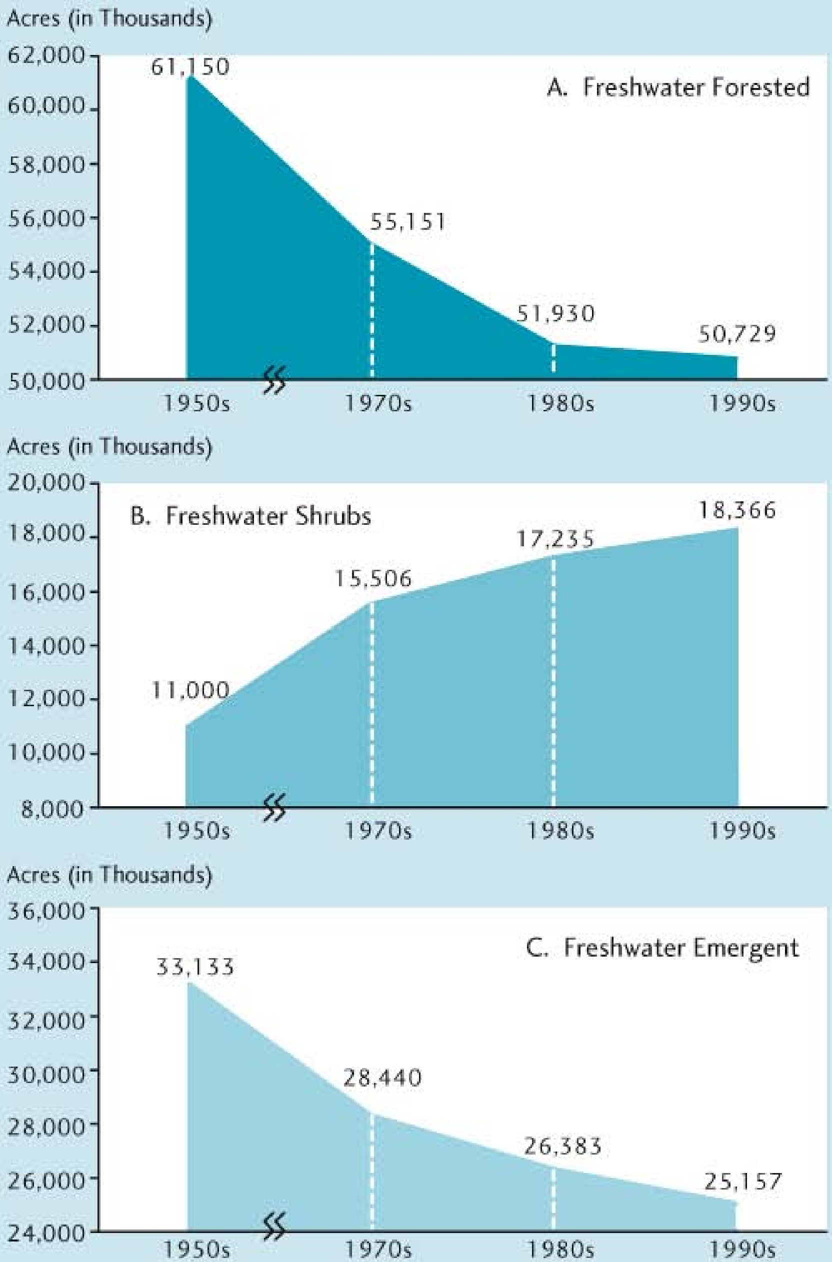


Figure 020-1: Average annual wetland loss, 1954-1974, 1974-1983, 1986-1997
600,000
500,000
400,000
300,000
200,000
100,000
0
Acres
458,000
290,000
58,500
1954-74
1974-83
1986-97
Coverage: Conterminous United States
Source: Frayer et al. Status and Trends of Wetlands and Deepwater Habitats in the Conterminous United States, 1950s to 1970s. 1983; Dahl, T.E. and C. E. Johnson. Wetlands Status and Trends in the Conterminous United States: 1970s to 1980s. 1991; Dahl, T. E. Status and Trends of Wetlands in the Conterminous United States 1986 to 1997. 2000.

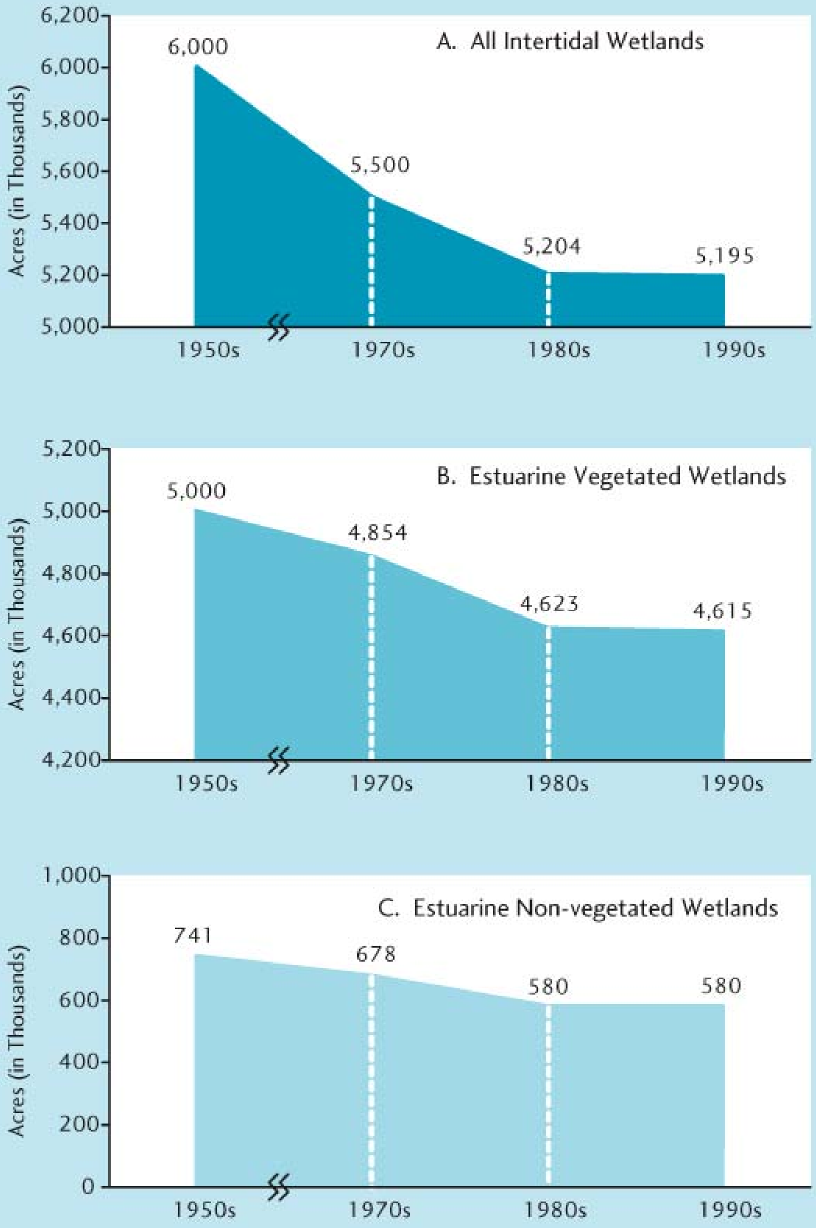
Figure 020-2: Long-term trends in selected freshwater wetlands, 1954-1997



Coverage: Conterminous United States

Source: Frayer et al. *Status and Trends of Wetlands and Deepwater Habitats in the Conterminous United States, 1950s to 1970s.* 1983; Dahl, T.E. and C. E. Johnson. *Wetlands Status and Trends in the Conterminous United States: 1970s to 1980s.* 1991; Dahl, T. E. *Status and Trends of Wetlands in the Conterminous United States 1986 to 1997.* 2000.

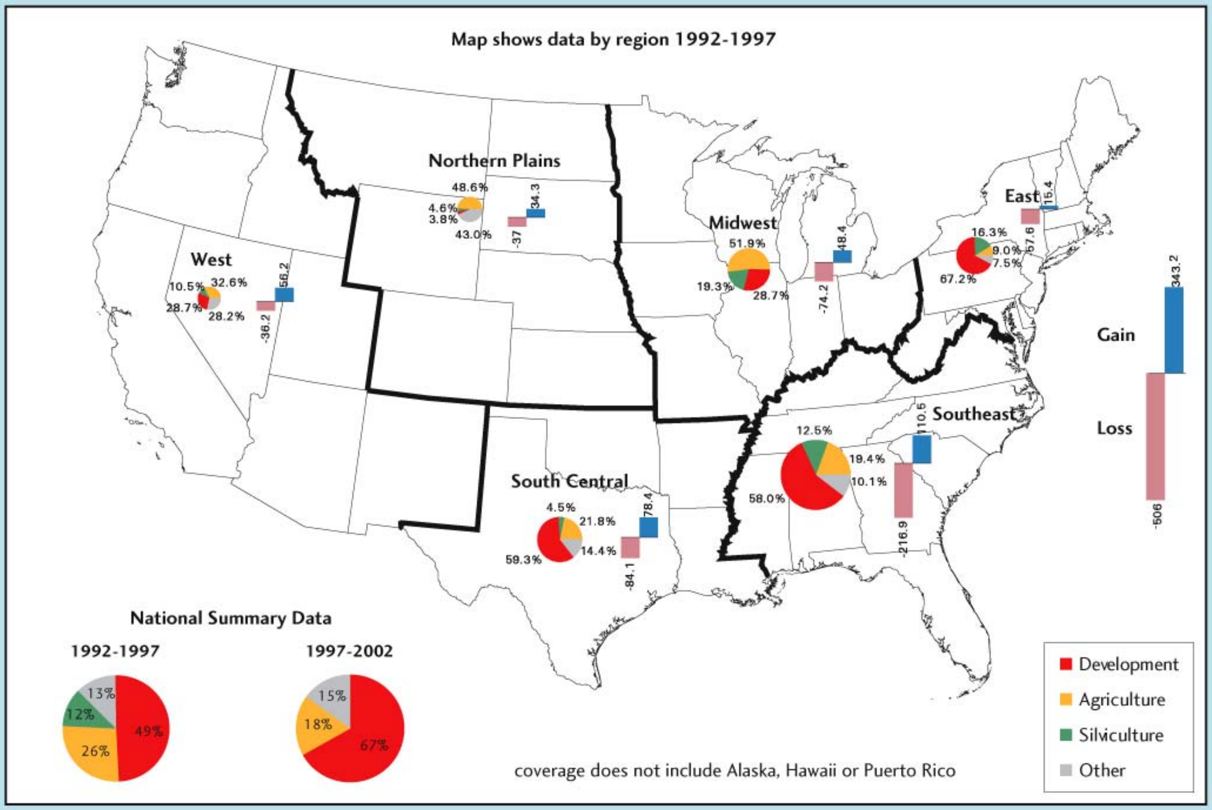
Figure 020-3: Long-term trends in selected estuarine wetlands, 1954-1997



Coverage: Conterminous United States

Source: Frayer et al. *Status and Trends of Wetlands and Deepwater Habitats in the Conterminous United States, 1950s to 1970s.* 1983; Dahl, T.E. and C. E. Johnson. *Wetlands Status and Trends in the Conterminous United States: 1970s to 1980s.* 1991; Dahl, T. E. *Status and Trends of Wetlands in the Conterminous United States 1986 to 1997.* 2000.

Figure 020-4: Reasons for conversion of wetlands on non-federal lands by region, 1992-1997, and nationally, 1992-2002



Source: *Summary Report: 1997 National Resources Inventory, December, 2000, revised. Summary Report: National Resources Inventory, 2002 Annual NRI, April, 2004.*

R.O.E. Indicator QA/QC

Data Set Name: WETLAND EXTENT, CHANGE, AND SOURCES OF CHANGE
Indicator Number: 020 (89138)
Data Set Source: U.S. Fish and Wildlife Service, National Wetlands Inventory
Data Collection Date: irregular: 1954-1974, 1974-1983, 1986-1997
Data Collection Frequency: every 10 years
Data Set Description: Two programs, the USFWS NWI status and trends studies and the NRCS NRI, estimate wetland extent. The USFWS surveys all wetlands in the conterminous U.S. The NRI surveys wetlands on non-federal lands, which make up approximately 75 percent of the nation's land base. The methods employed differ, but the statistical results from the most recent survey period were not significantly different. USFWS data are used for the "wetland extent and change" indicator due to their broader coverage. This indicator is derived from three separate analyses: one covering the 1950s to the 1970s; one covering the 1970s to the 1980s; and one covering the 1980s to the 1990s.
Primary ROE Question: What are the trends in the extent and condition of wetlands?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. An interagency group of statisticians developed the design for the U.S. Fish and Wildlife Service's (USFWS) national status and trends study. Dahl, T.E. Status and Trends of Wetlands in the Conterminous United States 1986 to 1997, Washington, D.C: U.S. Department of the Interior, U.S. Fish and Wildlife Service, 2000. http://wetlands.fws.gov/bha/SandT/SandTReport.html Dahl, T.E. and C.E. Johnson. Status and Trends of Wetlands in the Conterminous United States, Mid-1970's to Mid-1980's, Washington, D.C: U.S. Department of the Interior, U.S. Fish and Wildlife Service, 1991. http://wetlands.fws.gov/bha Frayer, W.E., T.J. Monahan, D.C. Bowden, and F.A. Graybill. Status and Trends of Wetlands and Deepwater Habitats in the Conterminous United States, 1950's to 1970's, Ft. Collins, CO: Colorado State University, 1983. OUT OF PRINT.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The basic sampling design and study objectives have remained constant for each wetland status and trends report. The study design consists of 4,375 randomly selected sample plots (4 square miles in area) that are examined and characterized using aerial imagery provided by the National Aerial Photography Program in combination with field verification to determine wetland change and are described extensively in Dahl, 2000.
http://wetlands.fws.gov/bha/SandT/SandTReport.html

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. Dahl, 2000. http://wetlands.fws.gov/bha/SandT/SandTReport.html The USFWS Status and Trends Reports undergo extensive interagency comment and review by Agency senior technical experts.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The sampling design and monitoring plan meet the criteria for indicator data to answer questions in the ROE. NWI sampling encompasses all wetlands of the conterminous 48 States and Puerto Rico, including coastal wetlands. The basic sampling design and study objectives have remained constant for each wetland status and trends report, and are repeated every 10 years. The study design consists of 4,375 randomly selected sample plots (4 square miles in area) that are examined and characterized using aerial imagery provided by the National Aerial Photography Program in combination with field verification to determine wetland change. Estimates of change in wetlands were made over a specific time period (1954 to 1974, 1974 to 1983, and 1986 to 1997). http://wetlands.fws.gov/bha/SandT/SandTReport.html

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The sampling design includes all ecosystem types, but does not capture wetlands smaller than 3 square acres.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

No. This indicator is a surrogate for condition, which assumes that loss of wetlands indicates a declining environment. The indicator is consistent across space and time.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

http://policy.fws.gov/905fw1.html provides guidance for conducting habitat mapping by the National Wetlands Inventory. See also: Dahl, T.E. Status and Trends of Wetlands in the Conterminous United States 1986 to 1997, Washington, D.C.: U.S. Department of the Interior, U.S. Fish and Wildlife Service, 2000.
http://www.wetlands.fws.gov/bha/SandT/SandTReport.html

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The data set and supporting information are available from
http://www.wetlands.fws.gov/bha/SandT/SandTReport.html

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. http://policy.fws.gov/905fw1.html provides guidance for conducting habitat mapping by the National Wetlands Inventory. http://www.wetlands.fws.gov/bha/SandT/SandTReport.html

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

http://policy.fws.gov/905fw1.html NWI map production includes many quality control steps prior to releasing the final product. These are outlined at the web site provided.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The wetland status and trends studies were based on a scientific probability sample of the surface area of the 48 conterminous States using a stratified, simple random sampling design. The statistical design including inference of data beyond spatial measurements are described in Dahl, 2000.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. Margins of error are described for each of the data sets in Dahl, 2000, Frayer et al., 1983, and Dahl and Johnson, 1991.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Only to the extent that as wetland losses decline nationally, the error margin increases due to the size of the data set.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

This indicator does not completely answer the question of wetland condition. While it is possible to inventory wetlands that have been lost, many wetlands have suffered degradation of condition and functions, which cannot be quantified nationally. Different methods were used in some of the early classification schemes to classify wetland types. The currently used classification system was not applied to some of the earlier (1970's) map. As methods and spatial resolution have improved over time, acreage data were adjusted, resulting in changes in the overall wetland base over time. Thus, the evaluation process is evolving which contributes to reducing the accuracy of the trends observed. Forested wetlands are difficult to photointerpret and are generally underestimated by the USFWS. Ephemeral wetlands and effectively drained palustrine wetlands observed in farm production are not recognized as a wetland type by the USFWS and, therefore, are not included. Also, USFWS does not survey wetlands under 3 square acres in size; therefore, no record exists of the extent and change in these wetlands. Pacific coast estuarine wetlands are not surveyed due to the discontinuity in their patch sizes. The temporal coverage of the coastal wetland loss indicator (length of record) is not consistent across the U.S.

R.O.E. Indicator QA/QC

Data Set Name: SOURCES OF WETLAND LOSS
Indicator Number: 021 (89137)
Data Set Source: U.S. Department of Agriculture, National Resources Inventory (NRI)
Data Collection Date: 1992-1997, annually since 2000
Data Collection Frequency: 1992 and 1997, annualized since 2000
Data Set Description: Sources of Wetland Change/Loss
Primary ROE Question: What are the trends in the extent and condition of wetlands?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. Details are available from U.S. Department of Agriculture. Summary Report: 1997 National Resources Inventory (Revised December 2000), Washington, D.C: Natural Resources Conservation Service and Ames, Iowa: Iowa State University, Statistical Laboratory, 2000. http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The NRI is a scientific, longitudinal panel survey of the nation's soil, water, and related resources, designed to assess conditions and trends every five years. For sources of wetland loss the NRI results are nationally consistent for all nonfederal lands for 1992 and 1997. Data collected for the 1997 NRI were based on a statistical design to sample 800,000 sample points, using photo-interpretation and other remote sensing methods and standards. Data gatherers used a variety of ancillary sources including USDA field office records, local Natural Resources Conservation Service (NRCS) field personnel, soil survey and wetland inventory maps and reports, and tables and technical guides developed by local field office staffs. Inventory procedures were developed to ensure that data reflect 1997 growing season conditions, that inventory results are nationally consistent, and that data recorded for 1992 are consistent with the 1997 determination. Intricate quality assurance procedures were developed to make sure that year-to-year differences reflect actual changes in resource conditions, rather than differences in the perspectives of two different data collection specialists or changes in technologies and protocols. The 2002 Annual NRI data are collected for slightly less than 25 percent of the same sample sites. As data from subsequent inventory years are added to the database, results will become available to support regional, state, and sub-state analyses. See http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/ and http://www.nrcs.usda.gov/technical/land/nri02/nri02wetlands.html (U.S. Department of Agriculture. Summary Report: 2002 Annual National Resources Inventory. Washington, D.C: Natural Resources Conservation Service and Ames, Iowa: Iowa State University Statistical Laboratory, 2004.)

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. Detailed information is available from http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/. See Appendix I: Statistical Reliability.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The NRI database accounts for and represents the total area of the United States, but very little information is given for points on federal lands. Data are collected at statistically selected sampling sites located in all counties and parishes of the 50 states and in Puerto Rico, the Virgin Islands, the District of Columbia, and selected portions of the Pacific Basin. Data for the 1997 NRI were collected for about 800,000 sample points. Data for the 2002 NRI were collected at slightly less than 25 percent of these same sites. See http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The sampling design does not try to capture sensitive ecosystems separately from other wetland types.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

The indicator does not try to reflect the state of the environment, but rather attributes wetland acreage change to sources, such as agriculture and development. The values are consistent across space and time. Including federal lands would produce different results. http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

U.S. Department of Agriculture, Summary Report: 1997 National Resources Inventory (Revised December 2000), Washington, D.C: Natural Resources Conservation Service and Ames, Iowa: Iowa State University, Statistical Laboratory, 2000. U.S. Department of Agriculture. Summary Report: 2002 Annual National Resources Inventory. Washington, D.C: Natural Resources Conservation Service and Ames, Iowa: Iowa State University Statistical Laboratory, 2004. See http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Selected national NRI summary data are displayed in 19 tables presented in the 1997 summary report, found at: http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/. Definitions of terms are the same as for the 1992 NRI (see Appendix 3 Glossary of Selected Terms). Additional data summaries can be found at: http://www.nrcs.usda.gov/technical/NRI/1997/obtain_data.html. This site includes active links to detailed compilations of data at the state level (available from individual state Internet sites). Data from the 2002 NRI are available only in summary form, at http://www.nrcs.usda.gov/technical/land/nri02/nri02wetlands.html.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. See p. 75 (Appendix I -- Statistical Reliability) of the 1997 Summary Report: http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/. Several requirements have been established regarding the database. The primary requirements are that the final database contains all of the information that has been gathered, that tabulations can be made easily, and that users of the database do not need to understand the complexities of the estimation procedures. Also, the database must produce estimates that agree with known data. U.S. Department of Agriculture. Summary Report: 2002 Annual National Resources Inventory. Washington, D.C: Natural Resources Conservation Service and Ames, Iowa: Iowa State University Statistical Laboratory, 2004.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Data quality assurance and quality control procedures are documented and accessible in the summary report: http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. See Appendix I -- Statistical Reliability in the 1997 summary report (http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/). The methods describing the 2002 Annual NRI can be found at: http://www.nrcs.usda.gov/technical/land/nri02/.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. The 1997 summary report (http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/) describes margin of error. The 2002 report also includes this information: see http://www.nrcs.usda.gov/technical/land/nri02/nri02wetlands.html (U.S. Department of Agriculture. Summary Report: 2002 Annual National Resources Inventory. Washington, D.C: Natural Resources Conservation Service and Ames, Iowa: Iowa State University Statistical Laboratory, 2004.)

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No. The large number of samples reduces the margin of error.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

NRI does not include data on federal lands or from the state of Alaska. The NRI data are based on statistical sampling, but they do not include an adequate sample of coastal resources. They provide information at a coarse scale, summarized by state, and are useful for national reporting. The large number of human data collectors is a source of potential error.

Indicator: Nitrate, Phosphorus, and Pesticides in Streams in Agricultural Watersheds (040)

Nitrogen is a critical plant nutrient, and most nitrogen is used and reused by plants within an ecosystem (Vitousek, et al., 2002). Thus, in undisturbed ecosystems, minimal "leakage" occurs into either surface runoff or groundwater, and concentrations are very low. However, when nitrogen is applied to the land in amounts greater than can be incorporated into crops or lost to the atmosphere through volatilization or denitrification, nitrogen concentrations in streams can increase. The major sources of excess nitrogen are fertilizer and animal waste; other sources include onsite septic systems, sewage treatment plants, and atmospheric deposition. In drinking water, concentrations of nitrate above the federal standard of 10 mg/L may pose a risk of methemoglobinemia, a condition that interferes with oxygen transport in the blood of infants (EPA, 2004). Excess nitrate has not been shown to harm aquatic life in the stream directly, but increased nitrogen/nutrients may result in overgrowth of algae which can decrease the dissolved oxygen content of the water, thereby harming or killing fish and other aquatic species (U.S. EPA, 2005a). In addition, excess nitrate can damage coastal ecosystems downstream, as discussed further in the indicator "Nitrogen and Phosphorus Discharge from Large Rivers."

Phosphorus is an essential nutrient for all life forms, but at high concentrations the most biologically active form of phosphorus can cause water quality problems by overstimulating the growth of algae. In addition to being visually unappealing and causing tastes and odors in water supplies, excess algal growth can contribute to the loss of oxygen needed by fish and other animals. Elevated levels of phosphorus in streams can result from fertilizer use, animal wastes and wastewater, and some detergents.

More than one billion pounds of pesticides are used in the United States each year to control weeds, insects, and other organisms that threaten or undermine human activities (Aspelin, 2003). About 80% of the total is used for agricultural purposes. Although pesticide use has resulted in increased crop production and other benefits, pesticide contamination of streams, rivers, lakes, reservoirs, coastal areas, and groundwater may cause unintended adverse effects on aquatic life, recreation, drinking water, irrigation, and other uses. Water also is one of the primary pathways by which pesticides are transported from their application areas to other parts of the environment (USGS, 2000).

This indicator is based on stream water samples collected between 1992 and 2001 from watersheds where agriculture represents the predominant land use, as part of the U.S. Geological Survey's National Water Quality Assessment (NAWQA) Program. Nitrate and phosphorus data are based on 12 to 25 samples collected annually at stream sites draining 115 watersheds in 49 major river basins across the conterminous United States. At each stream site, samples were collected at multiple times each year over a 1-to-3-year period. The indicator is based on a flow-weighted annual average of the samples. A related indicator reports the concentrations of nitrate and pesticides in groundwater in agricultural watersheds (Indicator "Nitrate and Pesticides in Groundwater in Agricultural Watersheds").

For nitrate, the indicator reports the percent of streams with average concentrations in one of four ranges: less than 2 parts per million (mg/L); 2-6 mg/L; 6-10 mg/L; and 10 mg/L or more. The highest level (10 mg/L) represents the Maximum Contaminant Level (MCL) for nitrate allowed in finished drinking water in the U.S. (U.S.EPA, 2005b), but because people are unlikely to drink untreated stream water, this concentration should be viewed as a reference level, and not necessarily as a health risk to consumers. There is no comparable aquatic health guideline for nitrate because nitrate does not represent a direct threat to organisms living in the stream.

Phosphorus concentrations are reported in four ranges: less than 0.1 mg/L, 0.1-0.3 mg/L, 0.3-0.5 mg/L, and 0.5 mg/L or more. There is currently no national water quality criterion to protect surface waters because the effects of phosphorus vary by region and are dependent on physical factors such as the size, hydrology, and depth of rivers and lakes. In general, levels above 0.1 mg/L have been associated with risks of nuisance growths of algae.

Pesticide data reflect conditions in 83 agricultural watersheds where NAWQA collected 10 to 49 stream water samples per year and analyzed for 76 different pesticides and 7 pesticide degradation products. Together, the analyzed compounds account for approximately 75% of the total amount of agricultural pesticides applied annually in the United States by weight (USGS, 1999). This indicator reports the number of sites where the annual time-weighted average concentration of one or more of these pesticides or their degradation products exceeds standards for aquatic or human health.

Three types of U.S. EPA human health-related standards and guidelines were used as reference levels for pesticide concentrations: Maximum Contaminant Levels (MCLs), Risk-Specific Dose (RSD), and Lifetime Health Advisory (HA-L) (U.S. EPA 2000, 2001). In all three cases, the standard and guideline levels are concentrations that pertain to lifetime exposure through drinking water (RSDs relate to potential carcinogens and HA-Ls relate to non-carcinogenic adverse health effects). More detail on these types of benchmarks, their derivation, and their underlying assumptions is provided in Nowell and Resek (1994). If a chemical had multiple benchmarks, the MCL was used if available; otherwise, the lower of the RSD (at 1 in 100,000 cancer risk) and HA-L values was selected. An exceedance was identified if a yearly, time-weighted mean concentration exceeded the relevant standard or guideline (Heinz Center, 2002).

The three types of freshwater aquatic-life guidelines used as reference levels for pesticides in this indicator are U.S. EPA chronic water-quality criteria for protection of aquatic organisms, Canadian water quality guidelines, and International Joint Commission (IJC) Great Lakes water-quality objectives (summarized at http://ca.water.usgs.gov/pnsp/source/). The U.S. EPA chronic water-quality criterion for protection of aquatic organisms is the estimated highest concentration of a constituent that aquatic organisms can be exposed to for a 4-day period, once every 3 years, without deleterious effects; the IJC and Canadian water-quality guidelines specify maximum concentrations that should not be exceeded at any time. If no U.S. EPA criterion existed for a given constituent, then Canadian water-quality guidelines were used, if available. The older IJC Great Lakes water-quality objectives were used only if neither U.S. EPA criteria nor Canadian guidelines were available. A concentration exceeding the aquatic-life guidelines in any single surface water sample was counted as an exceedance of the guideline.

What the Data Show

NAWQA data indicate that during the 1992-2001 period:

- Average flow-weighted nitrate concentrations were above 2 mg/L in about half of the stream sites where agriculture is the primary land use in the watershed (Figure 040-1). About 12% of stream sites had nitrate concentrations above the federal drinking water MCL of 10 mg/L.
- More than three-fourths of agricultural streams had average annual flow-weighted concentrations of phosphorus above 0.1 mg/L while nearly 15% had phosphorus concentrations above 0.5 mg/L (Figure 040-2).
- The annual average time-weighted concentration of at least one pesticide exceeded aquatic life guidelines in more than 75% of the streams sampled (Figure 040-3). Human health criteria for one or more pesticides were exceeded in 7.2% of streams.

At least one pesticide was present at detectable levels throughout the year in all monitored streams (Martin et al., 2003). NAWQA data indicate that, in agricultural streams, pesticides most often occur in mixtures (i.e., more than one compound is present in the sample). The human health and environmental impacts of pesticide contamination, particularly when the pesticides occur as mixtures, are not well understood.

Indicator Limitations

- These data represent conditions in streams draining agricultural watersheds in the 49 major river basins or study units sampled by the NAWQA program in the conterminous U.S. While they were subjectively chosen to be representative of agricultural watersheds across the United States, they are the result of a targeted sample design, and may not be an accurate reflection of the distribution of concentrations in all streams in agricultural watersheds in the U.S.
- Drinking water treatment can significantly reduce concentrations of nitrate and many pesticides. Thus, the levels of contaminants reported in this indicator are not necessarily representative of the exposures to people when these waters are used as public drinking water supplies.
- U.S. and Canadian aquatic life criteria and guidelines reflect exposures of 1-4 days; the use of annual flow- or time-weighted averages may mask 1-4 day concentrations that exceed guidelines in any particular stream. Aquatic life guidelines do not currently exist for 64% (51 of 80) of the pesticides and pesticide degradation products analyzed, while drinking water standards or guidelines do not exist for 44% (35 of 80). Current standards and guidelines do not account for mixtures of pesticide chemicals and seasonal pulses of high concentrations. Possible pesticide effects on reproductive, nervous, and immune systems, as well as on chemically sensitive individuals, are not yet well understood.
- This indicator does not provide information on the degree to which pesticide concentrations exceed or fall below guidelines.

Data Sources

Data for this indicator were collected and compiled by the U.S. Geological Survey's National Water Quality Assessment (NAWQA) Program. More information on this program can be found at http://water.usgs.gov/nawqa/.

References

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USGS. 1999. Pesticides Analyzed in NAWQA Samples: Use, Chemical Analyses, and Water-Quality Criteria. Updated August 20, 1999. http://ca.water.usgs.gov/pnsp/anstrat/

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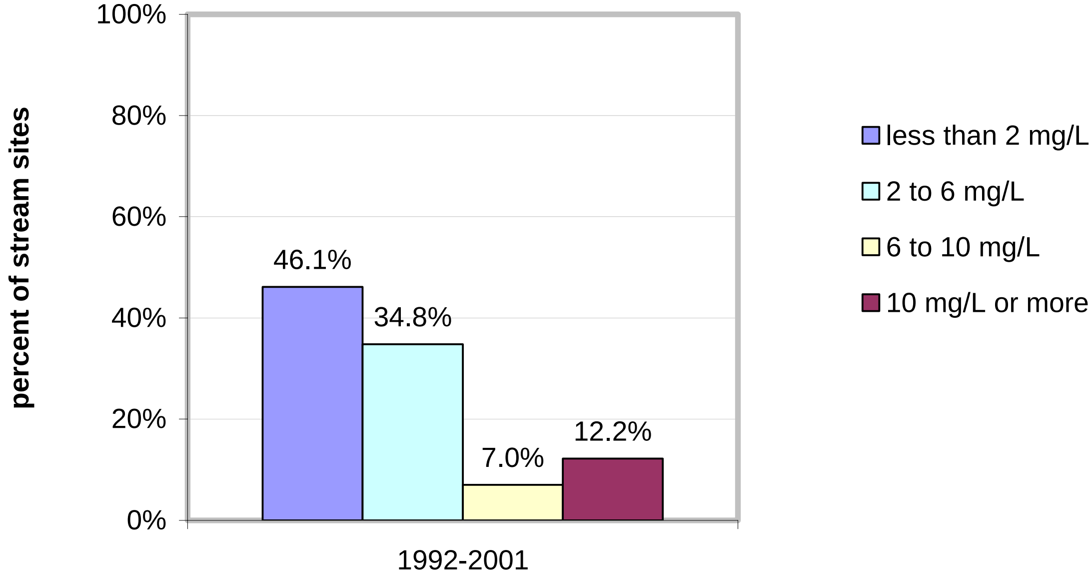
http://ca.water.usgs.gov/pnsp/rep/fs09200/

Vitousek, P., Mooney, H., Olander, L., and Allison, S. 2002. Nitrogen and nature. Ambio 31: 97-101.

Graphics

Figure 040-1. Nitrate in streams in 115 agricultural watersheds, 1992-2001



EPA's drinking water standard is 10 mg/L (Maximum Contaminant Level, or MCL).

Figure 040-2. Total phosphorus in streams in 115 agricultural watersheds, 1992-2001

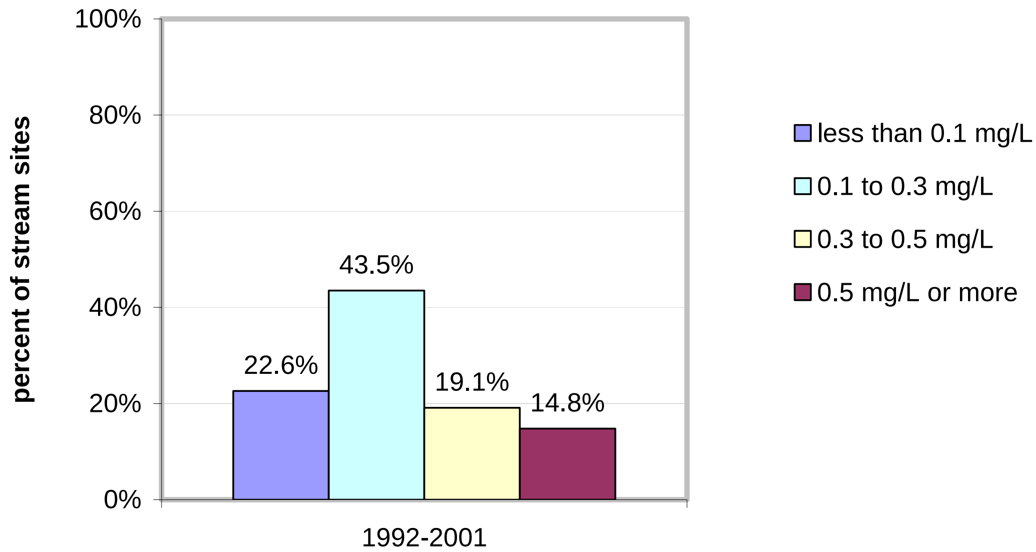
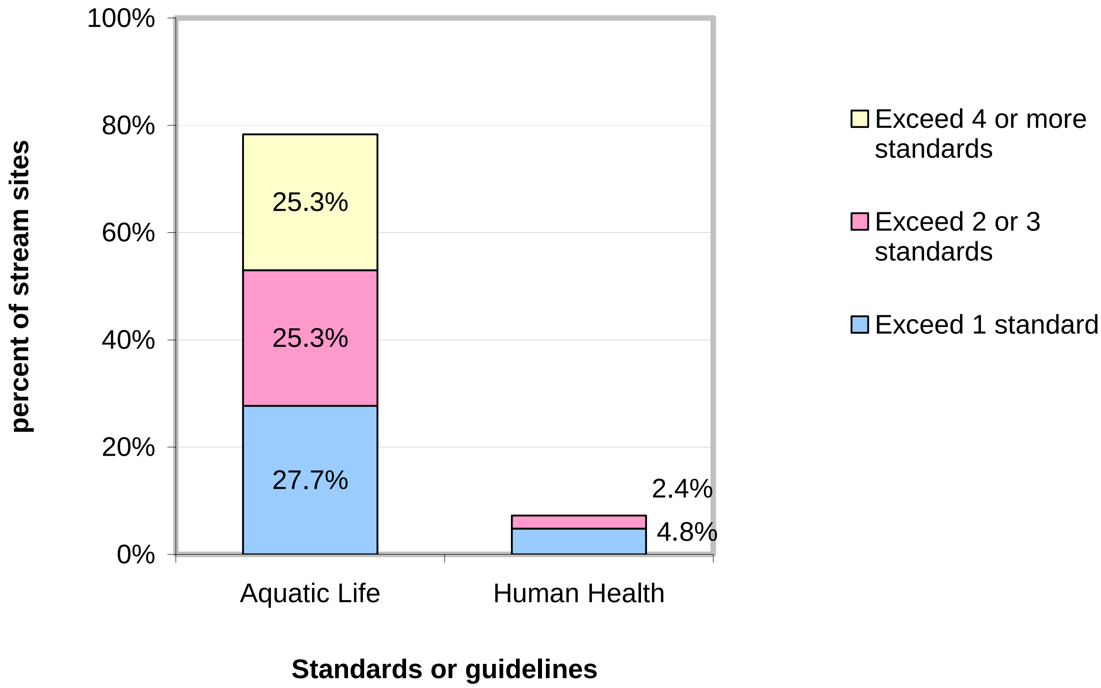


Figure 040-3. Pesticides in streams in agricultural watersheds, 1992-2001



R.O.E. Indicator QA/QC

Data Set Name: NITRATE, PHOSPHORUS, AND PESTICIDES IN STREAMS IN AGRICULTURAL WATERSHEDS
Indicator Number: 040 (89863)
Data Set Source: U.S. Geologic Survey
Data Collection Date: Irregular: 1993-1998
Data Collection Frequency: 1wk. - 1yr.
Data Set Description: Nitrate, Phosphorus, and Pesticides in Streams in Agricultural Watersheds
Primary ROE Question: What are the trends in extent and condition of fresh surface waters in the United States?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Field and laboratory methods are documented in official publications of the U.S. Geological Survey (USGS), which oversees the National Water Quality Assessment (NAWQA) Program that collected and analyzed the data for this indicator (full publication citations may be found in T3Q1). Field sampling follows established protocols that dictate how a sample is collected, depth-and-width integrated (to represent the full cross-section of the stream), and preserved (Shelton, 1994). These protocols include criteria for collection equipment, how the equipment is cleaned, and how samples are filtered to remove suspended particulate matter (**http://ca.water.usgs.gov/pnsp/pestsw/**). Laboratory analysis employs a variety of methods, which are described and cited in T3Q1. For each chemical, NAWQA uses the laboratory method that has been shown to be most sensitive and accurate. Each chemical/method has its own unique detection limit, but for the purposes of this survey, all relevant detection limits have been documented appropriately (**http://ca.water.usgs.gov/pnsp/anstrat/**).

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

This indicator is based on data collected by USGS's NAWQA program. NAWQA's overall sample design represents a comprehensive effort to assess the nation's water quality through study units across the lower 48 states, which were chosen to be broadly representative of various land uses. Gilliom et al. (1995) provides an official description of sample design (full citation in T3Q3). The data for this indicator were collected between 1992 and 2001, a period that covers three full NAWQA sampling cycles and a total of 49 NAWQA study units. Within these 49 study units were several watersheds in which agriculture was considered a significant land use, according to a standard set of criteria described in Gilliom and Thelin (1997) (full citation in T3Q3). Samples from 115 agricultural watersheds were analyzed for nitrate and phosphorus, while only 83 watersheds were screened for pesticides, due to the higher cost and complication of laboratory analysis for 83 different chemicals. Nonetheless, because of NAWQA's scientific sampling design, results are considered to be fairly representative of conditions in agricultural watersheds nationwide.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

To determine whether the concentrations of nitrate and phosphorus in a stream exceeded water quality standards, NAWQA calculated a flow weighted mean concentration. This type of calculation uses a regression model to transform non-daily measurements into a mean value that accounts for day-to-day variability in streamflow (volume) over the course of a given year. USGS commonly calculates a flow weighted mean when the concentration of a given constituent in this case, nitrate or phosphorus may be correlated with streamflow (i.e., total load is an issue). NAWQA has documented the nitrate and phosphorus regression model for this indicator at **http://water.usgs.gov/nawqa/nutrients/datasets/nutconc2000**. According to this description, NAWQA calibrated the regression model for this indicator using 1 to 2 years of daily streamflow data from USGS gages located at or near each of the water quality sampling sites. These gages are part of a network of thousands of USGS stream gages located across the U.S. A single gage may measure volumetric discharge directly using a current meter, or it may measure indirectly using calculations that can be performed on measurements of stream depth (a unique rating curve for each stream, relating volume to stream height). Collection of streamflow data follows long-standing USGS protocols. For a discussion and validation of these protocols, consult the following USGS online references: Depth (stage) gauging: **http://water.usgs.gov/pubs/twri/twri3-A6/** and **http://water.usgs.gov/pubs/twri/twri3a7/**. Conversion of depth to discharge: **http://water.usgs.gov/pubs/twri/twri3-a1/** and **http://water.usgs.gov/pubs/twri/twri3-a10/**. Direct measurement of discharge: **http://water.usgs.gov/pubs/twri/twri3a8/**. NAWQA calculated pesticide concentrations from each sampling site in the form of a time weighted mean. This step is necessary to generate a true average value, as samples were not necessarily collected at even intervals during the year, and taking a simple arithmetic mean would give disproportionate weight to samples taken during periods of high sampling frequency. Because NAWQA timed a significant portion of sampling events to occur during periods of heaviest pesticide application (in order to keep closer tabs on the higher end of potential exposures), a simple arithmetic mean would likely overstate mean annual concentrations. The time weighted mean approach is therefore more appropriate for this indicator. This approach is fully documented at **http://ca.water.usgs.gov/pnsp/rep/wrir984222/methods.html#data**. Standards and guidelines for human and ecological health are documented in T2Q3. All have been determined scientifically by the appropriate government agencies.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Overall, the spatial, temporal, and chemical coverage of this indicator are appropriate for reporting on the national issue of chemical contamination of streams in agricultural areas. This indicator uses a limited number of watersheds as a basis for generating an overall national indicator. However, the NAWQA program was specifically designed with this in mind, as the program intentionally sought to sample streams draining representative watersheds of each of the major land-use types, sometimes referred to as indicator sites. NAWQA study units are spread across the lower 48 states, as shown by the map on NAWQA's website (**http://water.usgs.gov/nawqa/**). Beginning in 1991, NAWQA set out to examine 51 study areas. The subsequent 9-year period was divided into three-year cycles, with approximately one-third of the study units intensely sampled during each cycle. This indicator reports data from 49 study units that were sampled intensely during these three cycles, between 1992 and 2001. Within each study unit, major streams were sampled 10-49 times per year over the period of intense monitoring, and less frequently in other years. For this indicator, the Heinz Center only used NAWQA data from the 1-3 years of most intense monitoring for each site. This indicator reports chemical concentrations in streams draining watersheds where agriculture was considered to represent a primary land use. However, NAWQA also sampled several forest and urban streams in order to provide some useful context for the agricultural data. Nutrient and pesticide data are not completely comparable, as nitrate and phosphorus were measured in 115 watersheds, and pesticides screened in only 83 (due to the greater cost and complication of laboratory analysis for a suite of 83 pesticide chemicals). However, both datasets were designed to be reflective of conditions nationwide, and both also reflect smoothing procedures that were used to transform a limited number of measurements (nitrate/phosphorus: 12-25 measurements; pesticides: 10-49) into long-term mean values. For nitrate and phosphorus, this step required a flow weighted regression approach that considers how concentrations vary with streamflow; for pesticides, it required a time weighted mean approach to reduce any bias toward periods of more frequent sampling (although averages may still only represent five months of frequent sampling, not full annual values). Averaging is appropriate and important for both nutrients and pesticides, as this indicator seeks to evaluate chemical concentrations in the context of long-term exposure thresholds for human and ecological health. In each case, NAWQA considered the most recent and relevant health criteria available. In terms of chemicals, this indicator covers a broad range of compounds that may be present as a result of agricultural applications. Nitrate, though it occurs naturally, may also be found in elevated levels due to the presence of runoff from fertilizer as well as human and animal waste. Runoff from fertilizer and animal wastes can also lead to elevated levels of phosphorus. The 76 pesticides and 7 pesticide degradation products screened for this indicator represent approximately 75% of the total agricultural pesticide application in the U.S. (NAWQA: **http://ca.water.usgs.gov/pnsp/anstrat/**). All are chemicals whose presence may be of concern to humans who use stream water as their domestic water supply, particularly if it is untreated.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

This broad national indicator is not specifically designed to target sensitive populations or ecosystems. It may be relevant to sensitive populations, however, to the extent that certain endangered species may be particularly sensitive to chemical contaminants.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator does not provide a historical or undisturbed baseline against which recent data may be compared. However, for many of the chemicals screened, EPA and other government agencies have established reference concentrations for human and/or ecological/aquatic health. The reference threshold for nitrate is 10 mg/L, which is EPA's Maximum Contaminant Level (MCL). Phosphorus thresholds vary by state or region, in part because the effects of phosphorus are dependent on physical factors such as the size, hydrology, and depth of rivers and lakes. In general, levels above 0.1 mg/L have been associated with risks of nuisance growths of algae. Reference thresholds for pesticides are listed at **http://ca.water.usgs.gov/pnsp/anstrat/** and sources of these values are listed at **http://ca.water.usgs.gov/pnsp/source/**. For some pesticide-related contaminants, reference values have not yet been established.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

All NAWQA sampling procedures are documented in official USGS reports (full citations appear below). Shelton (1994) describes field sampling protocols, including depth and width integrating techniques that ensure that stream samples represent the entire cross-section of the stream. Shelton (1994) also discusses methods of sample preservation. Laboratory methods are fully documented by USGS. NAWQA measured nitrate concentrations using procedures described in Fishman (1993); analytical procedures for total phosphorus are described in Patton and Truitt (1992). Pesticide concentrations were measured using two primary methods: gas chromatography/mass spectrometry (GC/MS) (Zaugg et al., 1995) and high-performance liquid chromatography (HPLC) (Werner et al., 1996). The website **http://ca.water.usgs.gov/pnsp/anstrat/** provides a list of the 76 pesticides and 7 related degradation products that NAWQA screened, along with the specific laboratory method used for each (see Table 2 on this website). This website also lists detection limits, which are compound-specific. Because nitrate and phosphorus concentrations typically vary with streamflow (volume), NAWQA calculated a flow-weighted mean concentration using a regression model. The model for this indicator is documented at **http://water.usgs.gov/nawqa/nutrients/datasets/nutconc2000**. NAWQA calibrated this model using 1 to 2 years of daily streamflow data from USGS gages located at each of the water quality sampling sites (or nearby, when the sampling site could not be located directly at a stream gage). Streamflow data may be obtained from USGS's database, **http://waterdata.usgs.gov/nwis/sw**, and methods of streamflow data collection are documented in the following USGS online references: Depth (stage) gauging: **http://water.usgs.gov/pubs/twri/twri3-A6/** and **http://water.usgs.gov/pubs/twri/twri3a7/**. Conversion of depth to discharge: **http://water.usgs.gov/pubs/twri/twri3-a1/** and **http://water.usgs.gov/pubs/twri/twri3-a10/**. Direct measurement of discharge: **http://water.usgs.gov/pubs/twri/twri3a8/**. For pesticides, NAWQA used a time weighted mean approach to ensure that the annual average values reported were not biased towards periods of more frequent sampling (since sampling was not always done at regular intervals). NAWQA has fully documented this approach at **http://ca.water.usgs.gov/pnsp/rep/wrir984222/methods.html#data**. This indicator reports an exceedance if any single measurement exceeds an aquatic health guideline, or if the time weighted mean exceeds the relevant human health guideline. Fishman, M.J. 1993. Methods of analysis by the U.S. Geological Survey National Water-Quality Laboratory--Determination of inorganic and organic constituents in water and fluvial sediments. U.S. Geological Survey Open-File Report 93-125. Patton, C.J., and Truitt, E.P. 1992. Methods of analysis by the U.S. Geological Survey National Water Quality

Laboratory--Determination of total phosphorus by a Kjeldahl digestion method and an automated colorimetric finish that includes dialysis: U.S. Geological Survey Open-File Report 92-146, 39 p. Method ID: I-4610-91. Shelton, L.R. 1994. Field guide for collecting and processing stream water samples for the National Water-Quality Assessment Program. U.S. Geological Survey Open-File Report 94-455. Werner, S.L., Burkhardt, M.R., and DeRusseau, S.N. 1996. Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory: Determination of pesticides in water by Carbopak-B solid-phase extraction and high-performance liquid chromatography: U.S. Geological Survey Open-File Report 96-216, Denver, Colorado, 42 pp. Zaugg, S.D., Sandstrom, M.W., Smith, S.G., and Fehlberg, K.M. 1995. Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory-Determination of pesticides in water by C-18 solid-phase extraction and capillary-column gas chromatography/mass spectrometry with selected-ion monitoring: U.S.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Water quality data collected by NAWQA may be accessed through the NAWQA database, **http://infotrek.er.usgs.gov/servlet/page?_pageid=543&_dad=portal30&_schema=PORTAL30**. These data may also be accessible through USGS's general water quality database, located at **http://waterdata.usgs.gov/nwis/qw**. Streamflow data are available from USGS at **http://waterdata.usgs.gov/nwis/sw**. This indicator depicts a subset of NAWQA data, which have been processed and classified by land-use type. EPA obtained the processed data for this indicator directly from NAWQA. While this data compilation has not been published, NAWQA can provide the data upon request. A similar dataset representing the first two NAWQA cycles (1992-1998) appeared in the Heinz Center's 2002 report, The State of the Nation's Ecosystems. For nitrate and phosphorus concentrations, this dataset may be accessed online at **http://water.usgs.gov/nawqa/nutrients/datasets/nutconc2000/**. This indicator reports data for nitrate plus nitrite, which is often abbreviated as nitrate because concentrations of nitrite are typically small relative to concentrations of nitrate. Phosphorus measurements represent total phosphorus. For pesticide concentrations, the report NAWQA prepared for the Heinz Center is not available online.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

NAWQA and the Heinz Center have provided several references to document the design of the survey upon which this indicator is based. Gilliom et al. (1995) discusses the overall design of the NAWQA program, while Gilliom and Thelin (1997) provides a good description of how watersheds were classified as to land use. NAWQA's report to the Heinz Center (**http://water.usgs.gov/nawqa/nutrients/datasets/nutconc2000/sw_nuts_Heinz.xls**) includes a list of the 105 locations where nutrient samples were collected for agricultural watersheds during the first two NAWQA cycles. A similar list is not immediately available for pesticide measurement sites, although all watersheds sampled for pesticides are also among those sampled for nutrients. Up-to-date lists may be obtained from NAWQA upon request. NAWQA has published a full list of the pesticides and related degradation products that were screened for this indicator: **http://ca.water.usgs.gov/pnsp/anstrat/**. Gilliom, R.J., W.M. Alley, and M.E. Gurtz. 1995. Design of the National Water-Quality Assessment Program: Occurrence and distribution of water-quality conditions. U.S. Geological Survey Circular 1112. Gilliom, R. J., and G.P. Thelin. 1997. Classification and mapping of agricultural land for National Water-Quality Assessment. U.S. Geological Survey Circular 1131.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Mueller et al. (1997) describes QA/QC procedures for the collection and analysis of stream water quality samples under the NAWQA program. Procedures documented include field blanks and replicates. Mueller, D. K., J.D. Martin, and T.J. Lopes. 1997. Quality-control design for surface water sampling in the National Water-Quality Assessment program. U.S. Geological Survey Open-File Report 97-223. (**http://water.usgs.gov/nawqa/protocols/OFR97-223/index.html**).

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

To transform a limited number of water quality samples (10 to 49 annually) into an indicator that characterizes mean concentrations, NAWQA had to employ some degree of spatial and temporal manipulation. Data manipulation procedures are generally well documented and appear to be used appropriately, although the exact specifications of the nutrient regression model are not described in NAWQA's online documentation. Spatially, this indicator requires that a given sample be representative of the entire cross-section of the stream in question, since the measurement should characterize the average condition of stream water in the watershed. NAWQA collected samples with this concern in mind, as described by Shelton (1994) (full citation below). Temporally, this indicator requires that a limited number of daily samples be transformed into a figure that accounts for day-to-day and seasonal variability. For nitrate and phosphorus, the model must account for streamflow, which can affect the overall concentrations. To this end, NAWQA employed a regression model that incorporated daily streamflow data from nearby USGS stream gages. This kind of modeling is a common and appropriate way to generate flow weighted mean values, as described in the documentation cited in T3Q3. For pesticides, NAWQA targeted periods of high use and high runoff for more frequent sampling, but made sure that samples were still collected from the other months of the year. To generate a realistic annual average, NAWQA used a time weighted mean approach, which ensures that periods of high sampling frequency are not over-represented in the final average. Shelton, L.R. 1994, Field guide for collecting and processing stream water samples for the National Water-Quality Assessment Program. U.S. Geological Survey Open-File Report 94-455.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Uncertainty estimates are not available for the exact subset of data included in this indicator. However, NAWQA has published uncertainty figures for the overall data collection effort, which should be indicative of uncertainty for this indicator. Mueller (1998) specifically discusses nutrient (nitrate and phosphorus) data, while Martin (2002) evaluates uncertainty for pesticide data. Mueller, D.K. 1998. Quality of nutrient data from streams and ground water sampled during 1993-95--National Water-Quality Assessment Program, U.S. Geological Survey Open File Report 98-276. Martin, J.D. 2002. Variability of pesticide detections and concentrations in field replicate water samples collected for the National Water-Quality Assessment Program 1992-97, U.S. Geological Survey Water Resources Investigation Report 01-4178.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Because uncertainty varies depending on the chemical and analytical method in question, it is difficult to make a single definitive statement about the impact of uncertainty on this indicator. However, because results are averaged over time and generalized over the entire nation, the summary figures reported by this indicator should be considered reasonably accurate. By incorporating flow- or time-weighted averages, the indicator design also accounts for much of the day-to-day and seasonal variability inherent in measurements of chemicals whose concentrations in stream water are linked in large part to streamflow or to the timing of pesticide application. The use of a time-weighted average for pesticides also accounts for variability in sampling frequency, which is inherent in NAWQA's targeted sampling program. This indicator does not account for year-to-year variability. NAWQA's overall sample design did include sampling streams outside of the 1 to 3 years of most intensive sampling, in order to account for year-to-year variability. However, the indicator was intended only to measure current conditions; as such, it does not include chemical concentrations measured outside of the intensive sampling window. In the future, once additional NAWQA cycles have been completed, this indicator should be able to present information on multi-year trends.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Limitations to this indicator include the following: 1. Although NAWQA measured several different nutrients in water, this indicator is limited to nitrate (actually nitrate plus nitrite) and phosphorus. It does not report concentrations of other forms of nitrogen (e.g., ammonia) that may also result from agricultural runoff. 2. This indicator is limited to streams. It does not report the condition of lakes and other surface bodies of water. 3. Data for this indicator only represent conditions in 49 NAWQA study areas, each of which typically encompasses a single major river basin. While study units were subjectively chosen to be representative of watersheds across the U.S., they still reflect the results of a targeted sample, not a full survey of all watersheds. Data are also highly aggregated and should only be interpreted as an indication of national patterns. 4. This indicator does not report the extent to which concentrations may be above or below standards for human or ecological health; it just reports whether the standard has been exceeded. It also does not report the extent to which concentrations may exceed other reference values that were not used for this report (e.g., Maximum Contaminant Level Goals (MCLGs) for drinking water). 5. Many chemicals lack an established reference value for human health, aquatic life, or both. There are no established aquatic life standards for nitrate, and no national human or aquatic standards for phosphorus. Of the 76 pesticides screened, only 43 have benchmarks for human health, and only 28 for aquatic life. Current standards and guidelines also do not account for mixtures of pesticide chemicals and seasonal pulses of high concentrations. Possible pesticide effects on reproductive, nervous, and immune systems, as well as chemically sensitive individuals, are not yet well understood. 6. Contaminant levels do not necessarily reflect the concentrations that humans will be exposed to in their drinking water supply, as nutrients and pesticides may be partially or completely removed through water treatment. 7. Although limited historical data are available to characterize long-term trends in surface water contaminants, this indicator specifically examines just the most current conditions.

Indicator: Nitrogen and Phosphorus Discharge from Large Rivers (146)

Nitrogen is a critical nutrient for plants and animals, and terrestrial ecosystems and headwater streams have a considerable ability to capture nitrogen or to reduce it to N_2 gas though the process of denitrification. Nitrogen cycling and retention is thus one of the most important functions of ecosystems (Vitousek, et al., 2002). When loads of nitrogen from fertilizer, septic tanks, and atmospheric deposition exceed the capacity of terrestrial systems (including croplands), the excess may enter surface waters, where it may have “cascading” harmful effects as it moves downstream to coastal ecosystems (Galloway and Cowling, 2002). Other sources of excess nitrogen include direct discharges from storm water or treated wastewater. This indicator specifically focuses on nitrate, which is one of the most bioavailable forms of nitrogen in bodies of water.

Phosphorus is a critical nutrient for all forms of life, but like nitrogen, phosphorus that enters the environment from man-made sources may exceed the needs and capacity of the terrestrial ecosystem. As a result, excess phosphorus may enter surface waters. Unlike nitrogen – which affects water quality primarily downstream, in coastal waters – the effects of excess phosphorus can be seen directly in lakes and streams. Because phosphorus is often the limiting nutrient in these bodies of water, an excess may contribute to unsightly algal blooms, which cause taste and odor problems and deplete oxygen needed by fish and other aquatic species. The most common sources of phosphorus in rivers are fertilizer and wastewater, including storm water and treated wastewater discharged directly into the river. In most watersheds, the atmosphere is not an important source or sink for phosphorus.

This indicator tracks trends in the discharges of nitrate and phosphorus from the four largest rivers in the United States: the Mississippi, Columbia, St. Lawrence, and Susquehanna. While not inclusive of the entire nation, these four rivers account for approximately 55 percent of all freshwater flow entering the ocean from the lower 48 states. This indicator relies on stream flow and water-quality data collected by the U.S. Geological Survey (USGS), which has monitored nitrate export from the Mississippi River since the mid-1950s and from the Susquehanna, St. Lawrence, and Columbia Rivers since the 1970s. Data were collected near the mouth of each river except the St. Lawrence, which was sampled near the point where it leaves the United States.

At the sites for which data are included in this indicator, USGS recorded daily stream levels and volumetric discharge using permanent stream gauges. Water quality samples were collected at least quarterly over the period of interest, in some cases up to 15 times per year. USGS calculated annual nitrogen load from these data using regression models relating nitrogen concentration to discharge, day-of-year (to capture seasonal effects), and time (to capture any trend over the period). These models were used to make daily estimates of concentrations, which were multiplied by the daily average discharge to yield the daily load (The Heinz Center, 2003). Because data on forms of nitrogen other than nitrate and nitrite are not as prevalent in the historical record, this indicator only uses measurements of nitrate plus nitrite. As nitrite concentrations are typically insignificant relative to nitrate, this mixture is simply referred to as nitrate.

What the Data Show

The Mississippi River, which drains more than 40 percent of the area of the lower 48 states, carries roughly 15 times more nitrate than any other U.S. river. Nitrate discharge from the Mississippi increased noticeably over much of the last half-century, rising from 200,000–500,000 tons per year in the 1950s and 1960s to an average of about 1,000,000 tons per year during the 1980s and 1990s (Figure 146-1). Large year-to-year fluctuations are also apparent. The Mississippi drains the agricultural center of the nation and contains a large percentage of the growing population, so it may not be surprising that the watershed has not been able to assimilate the nitrogen applied to crops and lawns, animal manures, nitrogen deposited from the atmosphere, and nitrogen deriving from human wastes (e.g., Rabalais and Turner, 2001).

The nitrate load in the Columbia River increased to almost twice its historical loads during the later half of the 1990s, but by the last year of record (2002), the amount of nitrate discharged had returned to levels similar to those seen in the late 1970s (Figure 146-1). The St. Lawrence River showed an overall upward trend in nitrate discharge over the period of record, while the Susquehanna does not appear to have shown an appreciable trend in either direction.

The amount of phosphorus discharged decreased in the St. Lawrence and Susquehanna Rivers over the period of record (Figure 146-2). There is no obvious trend in the Mississippi and Columbia Rivers, and the year-to-year variability is quite large. Nitrogen and phosphorus discharges tend to be significantly higher during years of high runoff, because of increased erosion and transport of the nutrients to stream channels (Smith et al., 2003).

Indicator Limitations

- The indicator does not include data from numerous coastal watersheds whose human populations are rapidly increasing (e.g., Valigura, et al., 2000).

- It does not include smaller watersheds in geologically sensitive regions, whose ability to retain nitrogen might be affected by acid deposition (e.g., Evans, et al., 2000).

- It does not include forms of nitrogen other than nitrate. Although nitrate is one of the most bioavailable forms of nitrogen from an ecological standpoint, other forms may constitute a substantial portion of the nitrogen load. Historically, nitrate data are more extensive than data on other forms of nitrogen.

- Not all forms of phosphorus included in the total phosphorus loads are equally capable of causing algal blooms.

Data Sources

Data for this indicator were collected and analyzed by USGS. Indicator derivation (project, program, organization, report): USGS, NASQAN and NAWQA programs, and the USGS Federal-State Cooperative Program. USGS data web site: http://waterdata.usgs.gov/nwis/. Additional data and modeling of recent nitrogen loads in the Mississippi and Columbia may be obtained from USGS's NASQAN website: http://water.usgs.gov/nasqan.

References

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Rabalais, N.N., and R.E. Turner (eds). 2001. Coastal Hypoxia: Consequences for Living Resources and Ecosystems. Coastal and Estuarine Studies 58. Washington, DC: American Geophysical Union.

Smith, S., et al. 2003. Humans, Hydrology, and the Distribution of Inorganic Nutrient Loading to the Ocean. BioScience 53: 235-245.

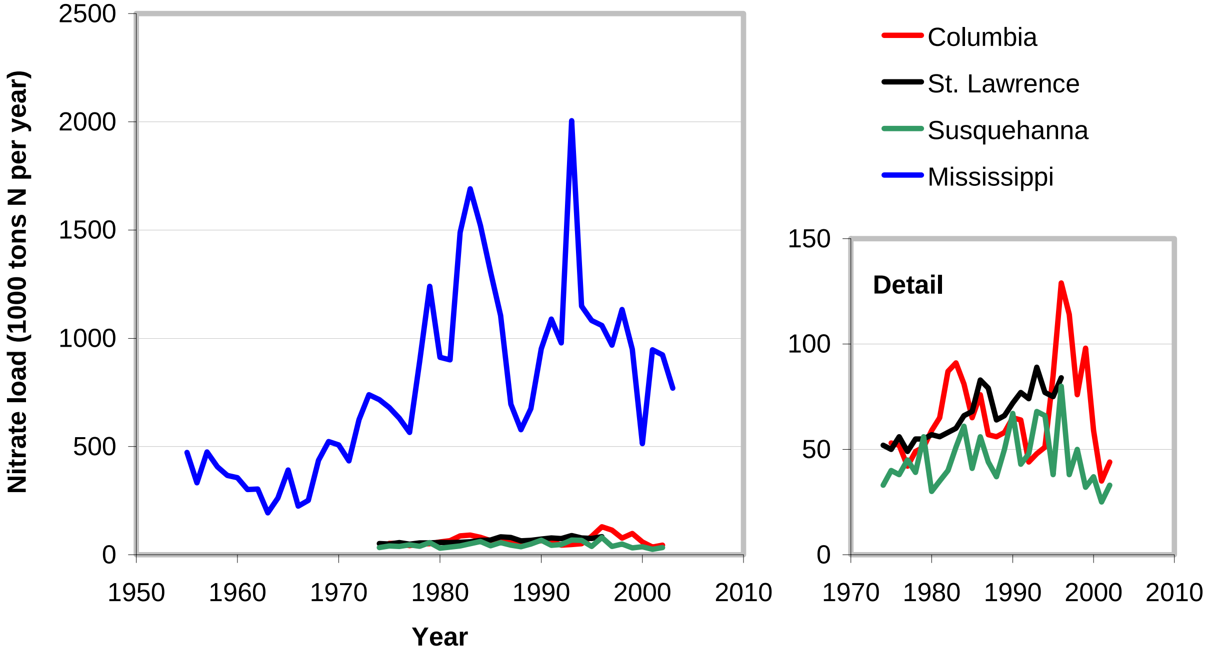
The H. John Heinz III Center for Science, Economics, and the Environment. 2003. The State of the Nation's Ecosystems: Measuring the Lands, Waters, and Living Resources of the United States. New York, NY: Cambridge University Press, September 2002. Web update 2003: http://www.heinzctr.org/ecosystems.

Valigura, R., R. Alexander, M. Castro, T. Meyers, H. Paerl, P. Stacey, and R. Turner (eds.). 2000. Nitrogen Loading in Coastal Water Bodies – An Atmospheric Perspective. Washington, DC: American Geophysical Union.

Vitousek, P., H. Mooney, L. Olander, and S. Allison. 2002. Nitrogen and nature. Ambio 31: 97-101.

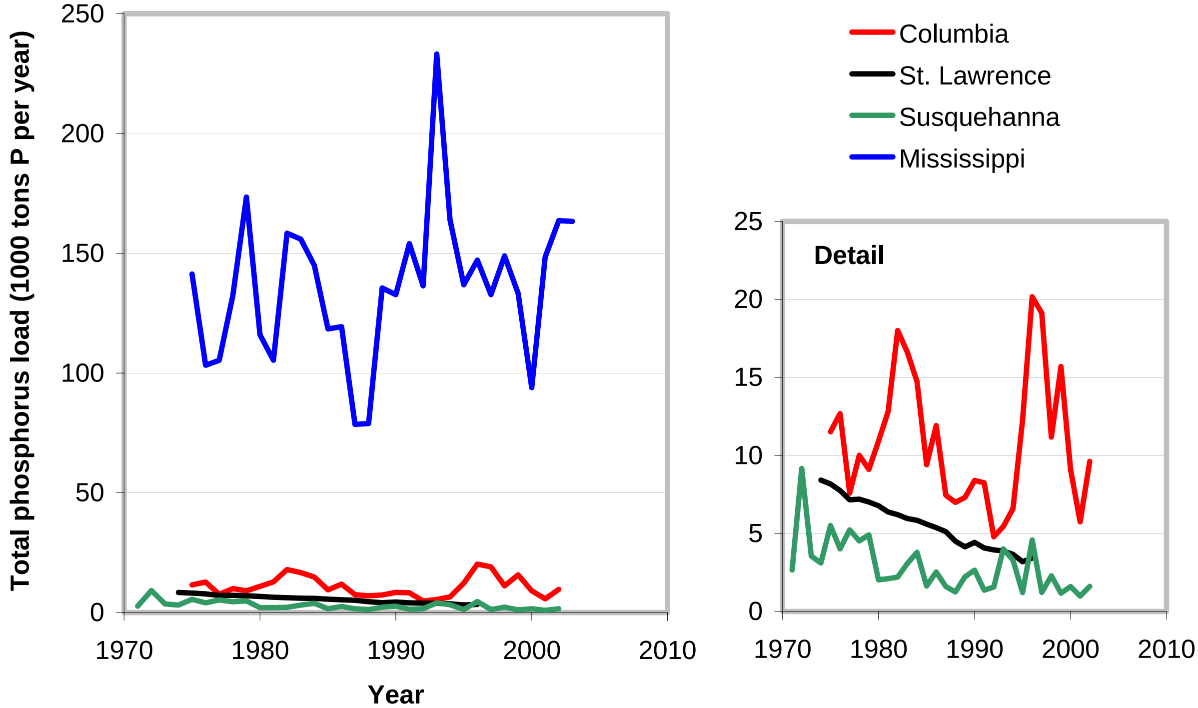
Graphics

Figure 146-1: Nitrate discharge from major rivers*



* Most of the measurements used for this indicator include nitrate plus nitrite. However, concentrations of nitrite are typically insignificant relative to nitrate; thus, the mixture is simply called "nitrate."

Figure 146-2: Total phosphorus discharge from major rivers



R.O.E. Indicator QA/QC

Data Set Name: NITROGEN AND PHOSPHORUS DISCHARGE FROM LARGE RIVERS
Indicator Number: 146 (89665)
Data Set Source: U.S. Geologic Survey
Data Collection Date: variable: 1955-2003
Data Collection Frequency: variable
Data Set Description: Nitrogen and Phosphorus Discharge from Large Rivers
Primary ROE Question: What are the trends in extent and condition of fresh surface waters in the United States?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

This indicator is based on two main sets of field measurements: streamflow characteristics (depth and flow rate) and water quality (concentration of nitrate and total phosphorus). Data were collected following standard USGS sample collection and processing protocols. Streamflow measurements are described in several USGS procedural manuals, which can be found online at http://water.usgs.gov/pubs/twri/. Field collection protocols for water quality samples are documented by Horowitz et al. (1994) [full citation below], as well as at http://water.usgs.gov/pubs/twri/. For water quality data, protocols include standard sample collection methods. Samples are analyzed at the USGS National Water Quality Laboratory in Denver, CO, and nutrient concentrations reported in units of milligrams per liter. Specific laboratory methods for recent (1996-) measurements are documented online at http://water.usgs.gov/nasqan/progdocs/wri014255/methods.dat, and complete citations for these methods can be found online at http://water.usgs.gov/nasqan/progdocs/wri014255/refs.htm. For water quality data collected between 1973 and 1995, field and laboratory methods are cited by USGS at http://water.usgs.gov/pubs/dds/wqn96cd/. According to Goolsby et al. (1999), USGS has measured nitrate concentrations since 1970 using colorimetric cadmium reduction (Fishman and Friedman, 1989). Pre-1970 nitrate levels were measured using the corimetric phenoldisulfonic acid method (Rainwater and Thatcher, 1960). Concentrations of total phosphorus were measured using Microkjeldahl digestion (EPA method 365.1; see EPA, 1993). Horowitz, A.J., Demas, C.R., Fitzgerald, K.K., Miller, T.L., and Rickert, D.A., 1994. U.S. Geological Survey protocol for the collection and processing of surface-water samples for the subsequent determination of inorganic constituents in filtered water: U.S. Geological Survey Open-File Report 94-539, 57 pp. Goolsby, Donald A., William A. Battaglin, Gregory B. Lawrence, Richard S. Artz, Brent T. Aulenbach, Richard P. Hooper, Dennis R. Keeney, and Gary J. Stensland. 1999. Flux and Sources of Nutrients in the Mississippi-Atchafalaya River Basin: Topic 3 Report for the Integrated Assessment on Hypoxia in the Gulf of Mexico. NOAA Coastal Ocean Program Decision Analysis Series No. 17. NOAA Coastal Ocean Program, Silver Spring, MD. 130 pp. Fishman, M.J., and L.C. Friedman, eds. 1989. Methods for determination of inorganic substances in water and fluvial sediments. In Techniques of water-resources investigations of the United States Geological Survey. Chapter A1. Washington, DC. Rainwater, F.W., and L.L. Thatcher. 1960. Methods for collection and analysis of water samples. U.S. Geological Survey Water Supply Paper 1454. Washington, DC. U.S. EPA. 1993. Methods for the determination of inorganic substances in environmental samples: EPA/600/R-93/100.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Because data for this indicator were collected following several different sampling plans, depending on time and location, it is hard to make a single definitive statement about the scientific validity of sample design. Nonetheless, the spatial coverage appears sufficient to characterize discharges from the four major rivers (i.e., monitoring and sampling near the mouth of each river). In general, temporal coverage seems sufficient as well, with discharge measurements taken several times a day and water quality measurements recorded several times per year over the course of at least 30 years. A basic summary of sample design follows: (1) Water depth and stream discharge were measured several times every day and reported as daily averages. USGS operates over 7,000 continuous monitoring stream gauges across the United States. This indicator incorporates flow measurements taken from 8 USGS and U.S. Army Corps of Engineers (USACE) stations near the mouths of the four major rivers. USGS's analytical model also incorporates lagged flow data from 5 USGS/USACE stations located upstream within the Mississippi River basin. A complete list of stations appears in T3Q1. (2) Water quality (nitrate and phosphorus) measurements come from samples taken at 7 USGS and USACE sampling locations, also listed in T3Q1. Some of these samples were taken at the same locations as discharge measurements; the others were taken nearby. For both discharge and water quality, USGS chose the stations that were most appropriate for measuring nitrogen and phosphorus load close to the mouth of the river -- or in the case of the St. Lawrence, near where the river leaves the United States. Susquehanna data come from two locations, one prior to 1979 and another thereafter. Totals for the Mississippi and Columbia both include data from more than one station, since additional stations were needed to characterize discharges and nutrients from a major upstream diversion (the Atchafalaya) and a major downstream tributary (the Willamette). The frequency of water quality sampling varied from year to year, as described below: From 1996 to 2000, water quality data for the Mississippi and Columbia Rivers were collected through USGS's National Stream Water Accounting Network (NASQAN) Program, described at http://water.usgs.gov/nasqan/progdocs/wri014255/backgrnd.htm. Under NASQAN, a total of 15 water quality samples were taken each year: 12 at predetermined intervals, and 3 reserved for unique events (e.g., extreme high or low flows). NASQAN's website notes that in certain locations, the twelve regular samples are not evenly distributed over time, suggesting that they may be intentionally biased towards a month or season when extreme flow is expected. NASQAN's 1996-2000 sample design is discussed in a 2001 report located online at http://water.usgs.gov/nasqan/progdocs/wri014255/: Kelly VJ, Hooper RP, Aulenbach BT, and Janet M. Concentrations and annual fluxes for selected water-quality constituents from the USGS National Stream Quality Accounting Network (NASQAN), 1996-2000. Water-Resources Investigations Report 01-4255. Reston, Virginia. 2001. NASQAN did not collect data from either the St. Lawrence or the Susquehanna after 1995, so recent data from these rivers must come from other sources within USGS, such as the National Water Quality Assessment (NAWQA), which has studied 51 watersheds since 1991 (http://water.usgs.gov/nawqa/studyu.html). USGS does not discuss the frequency or intervals of measurement at these locations. From 1973 to 1995, water quality measurements were conducted at hundreds of stations under the auspices of NASQAN. These stations are noted at http://water.usgs.gov/nasqan/progdocs/, and include all four of the rivers included in this indicator. This link also includes a general description of the program; a more detailed history of NASQAN can be found at http://water.usgs.gov/pubs/dds/wqn96cd/html/report/hiswqn.htm#NASQAN. Unlike the 1

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

In its presentation of an earlier version of this indicator, the Heinz Center reports that water depth data are first converted to streamflow (volumetric discharge) by means of a rating curve. USGS typically establishes a unique rating curve for each measuring station, in order to find the relationship between depth and discharge that is appropriate given the geometry of the specific river bed in question. Several procedures for converting depth to discharge, including the rating curve method, are documented in USGS's data-collection manuals. These are available online at http://water.usgs.gov/pubs/twri/ (specific reference: Book 3, Chapter A10). Some USGS gauging stations are equipped with current meters that measure discharge directly. The Heinz Center (2003) does not discuss how much of their USGS discharge data may have come from direct versus indirect physical measurements, but it is possible to look up each of the relevant measuring stations (see T1Q2) in USGS's online site inventory to find a list of the equipment in use at each site (http://nwis.waterdata.usgs.gov/nwis/si). The Heinz Center describes the general basis for deriving average annual nutrient flux from the data set. A regression model relates nutrient concentrations and discharge values measured on the same day, and then uses this relationship to derive an annual flux figure based on a full year's worth of discharge data. The regression model is also designed to account for possible seasonal variations in nitrate/phosphorus concentration. USGS conducted this stage of the analysis using two regression models -- LOADEST and Cohn's ESTIMATOR. Both of these models are well documented in scientific publications (see T3Q1), and are accepted as a valid means of calculating annual solute load from a limited number of water quality measurements. USGS notes that annual Mississippi River nitrate fluxes prior to 1967 were not necessarily calculated using the Estimator regression model (Richard Coupe, personal communication, 2004). Instead, annual fluxes may have been calculated simply by calculating the average relationship between nitrate load and discharge, then extrapolating based on daily discharge data for the entire year.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Nitrogen and phosphorus discharge from large rivers, with samples collected and measured as described in T1Q3, is considered a key indicator in assessing the nation's water resources. In a general sense, this indicator is relevant to the major question at hand -- namely, what are trends in extent and condition of fresh surface waters? Increased levels of nitrogen carried by rivers may indicate that nutrient cycling in upstream ecosystems is unable to handle the volume of additional nitrogen added to the environment by human activities. This not only represents an overload upstream (Vitousek, et al., 2002), but also poses a threat downstream and offshore, where excess nitrogen is linked to eutrophication, hypoxia, and other potential threats to coastal ecosystems (Galloway and Cowling, 2002). Nitrate is generally the most bioavailable form of nitrogen in large rivers. Excess phosphorus has a more direct effect in lakes and streams, where phosphorus is often the limiting nutrient for plant growth. When these water bodies become overloaded with phosphorus, it can contribute to algal blooms that deplete oxygen needed by fish and other species (U.S. EPA, 1998). These algal blooms may also give the water an unappealing appearance, taste, or odor. Galloway, J., and E. Cowling. 2002. Reactive nitrogen and the world: 200 years of change. Ambio 31:64-71. U.S. EPA. 1998. National Strategy for the Development of Regional Nutrient Criteria: EPA 822-R-98-002. Washington, DC: U.S. Environmental Protection Agency, Office of Water, June 1998. Vitousek, P., H. Mooney, L. Olander, and S. Allison. 2002. Nitrogen and nature. Ambio 31:97-101. This indicator is designed to examine four major U.S. rivers (Mississippi, Columbia, St. Lawrence, and Susquehanna), which together carry over 50 percent of freshwater flow from the lower 48 states to the ocean (Heinz Center, 2003). Sample size is sufficient; 30 years of annual data are available for comparison among the four rivers, as well as nearly 50 years of data to aid in the analysis of longer-term nitrate trends in the Mississippi River. Streamflow and water quality were measured from at least one station near the mouth of each of the four rivers; in some cases, additional stations were used to capture contributions from important tributaries or diversion channels. Depth and discharge were measured several times a day, and while nitrate and phosphorus concentrations were typically measured 15 or fewer times each year, USGS's regression models are designed to estimate an annual load that accounts for daily and seasonal variation.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Focusing on the functional implications of nitrogen loss, this indicator is more of a holistic measure of ecosystem "overloading," rather than a detailed assessment of a particular risk factor to sensitive populations or ecosystems. Because this indicator represents only four large rivers, it may not represent sensitive ecosystems or populations located in smaller watersheds. Nonetheless, this indicator might reveal that one or more of the four major watersheds -- or associated ecoregions -- may be of particular concern because of the degree to which their chemical cycling systems appear to have become overwhelmed by human inputs of nitrogen and phosphorus.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

The Heinz Report does not present any baseline data on nitrate or phosphorus flux that unambiguously reflect the state of the environment. The earliest data presented in this indicator date back to the mid-1950s, and while nitrate fluxes in most rivers have risen greatly since that time, it is still inaccurate to say that the 1950s nitrate fluxes represent background values for the natural, undisturbed state of the environment. In the United States, inorganic nitrogen fertilizer was in wide use by the 1950s, and the other major contributor to excess nitrate load -- atmospheric deposition -- was already occurring due to burning of fossil fuels (Clean Coastal Waters: Understanding and Reducing the Effects of Nutrient Pollution. Commission on Geosciences, Environment and Resources (CGER), Ocean Studies Board (OSB), 2000. pp.113-162. http://books.nap.edu/books/0309069483/html/113.html). Similarly, it is unlikely that the earliest phosphorus data represent any sort of unambiguous baseline. Thus, this indicator is most useful for year-to-year or decade-to-decade comparisons.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

(1) Sampling and laboratory methods are thoroughly documented by USGS.
Field collection protocols for stream gauging are described in USGS procedural manuals available online through http://water.usgs.gov/pubs/twri/:

Depth (stage) gauging: http://water.usgs.gov/pubs/twri/twri3-A6/ and http://water.usgs.gov/pubs/twri/twri3a7/

Conversion of depth to discharge: http://water.usgs.gov/pubs/twri/twri3-a1/ and http://water.usgs.gov/pubs/twri/twri3-a10/

Direct measurement of discharge: http://water.usgs.gov/pubs/twri/twri3a8/

The Heinz Center does not report using direct measurements of stream discharge, but USGS reports that current meters are in use at certain gauging stations. A full inventory of USGS gauging stations is available at http://nwis.waterdata.usgs.gov/nwis/si. Regardless of collection method, all streamflow data are available from USGS in the form of daily discharge measurements.

This indicator directly incorporates streamflow data from eight USGS and U.S. Army Corps of Engineers (COE) stations:

*** USGS 14105700 COLUMBIA RIVER AT THE DALLES,OREG.
*** USGS 14211720 WILLAMETTE RIVER AT PORTLAND,OREG.
*** USGS 04264331 ST. LAWRENCE R AT CORNWALL ONT NR MASSENA NY
*** USGS 01570500 SUSQUEHANNA RIVER AT HARRISBURG, PA
*** USGS 01578310 SUSQUEHANNA RIVER AT CONOWINGO, MD
*** Atchafalaya River At Simmesport, LA (07381495; COE 03045)
*** Mississippi River At Tarbert Landing, MS (07373420; COE 01100)
*** Old River Outflow Channel near Knox Landing, LA (Total Outflow; COE 02600)

These stations represent the best available stations to characterize discharge from the mouth of the river -- or in the case of the St. Lawrence, discharge near the point where the river leaves the United States. Due to the nature of gauge placement, total discharge figures for the Mississippi and Columbia require data from multiple gauges. For the Mississippi, additional gauges are located along major outflow channels (e.g., the Atchafalaya); measurements for the Columbia include flow from the Willamette, which empties into the Columbia downstream from the main stream gauge at The Dalles. Data for the Susquehanna came from Harrisburg until 1978 because data from Conowingo, further downstream, were not available until 1979.

In addition, the USGS models incorporated "lagged upstream flows" from five additional gauging stations (USGS, personal communication from Richard Coupe, 2004):

*** 05587455 Mississippi River at Grafton, IL
*** 07022000 Mississippi River at Thebes, IL
*** 03612500 Ohio River at Lock and Dam 53 near Grand Chain, IL
*** 06934500 Missouri at Hermann, MO
*** 07355500 RED R @ ALEXANDRIA, LA

(2) Water quality (nitrate and phosphorus) measurements come from samples taken at the following seven USGS and COE stations:

*** USGS 01570500 SUSQUEHANNA RIVER AT HARRISBURG, PA
*** USGS 01578310 SUSQUEHANNA RIVER AT CONOWINGO, MD
*** USGS 04264331 ST. LAWRENCE R AT CORNWALL ONT NR MASSENA NY
*** USGS 14128910 COLUMBIA RIVER AT WARRENDALE,OREG.
*** USGS 14211720 WILLAMETTE RIVER AT PORTLAND,OREG.
*** Lower Atchafalaya River at Melville, Louisiana (07381495; COE)
*** Mississippi River at St. Francisville, Louisiana (07373420; COE)

These stations do not all correspond exactly with the stream gauging stations listed above, but location differences are not significant. As with discharge measurements, nutrient data from multiple stations must be added to derive total figures for the Mississippi and Columbia.

Field collection protocols for water quality are documented in Horowitz et al. (1994) [full citation below] and in several procedural manuals located online at http://water.usgs.gov/pubs/twri/. These references discuss many aspects of sample collection, such as how to collect the sample (e.g., by boat), and in what part of the river. One manual specifically discusses how to adjust measured concentrations so they are representative of the entire cross-section of the river: http://water.usgs.gov/owq/FieldManual/Chapter6/6.0.2.html#HDR6.0.2.A.

Horowitz, A.J., Demas, C.R., Fitzgerald, K.K., Miller, T.L., and Rickert, D.A., 1994, U.S. Geological Survey protocol for the collection and processing of surface-water samples for the subsequent determination of inorganic constituents in filtered water: U.S. Geological Survey Open-File Report 94-539, 57 pp.

Water samples were tested for dissolved nitrate and total phosphorus. In some cases, the final "nitrate" figure also included nitrite (USGS, Richard Coupe, personal communication, 2004); however, the Heinz Center (2003) notes that nitrite concentrations are typically insignificant compared to nitrate. Specific laboratory methods for recent NASQAN samples (1996-) are documented at http://water.usgs.gov/nasqan/progdocs/wri014255/methods.dat, and complete citations for laboratory methodology can be found online at http://water.usgs.gov/nasqan/progdocs/wri014255/refs.htm. Additional information on NASQAN sampling and analytical procedures from 1973 to 1995 can be found at http://water.usgs.gov/pubs/dds/wqn96cd/. According to Goolsby et al. (1999), USGS has measured nitrate concentrations since 1970 using colorimetric cadmium reduction (Fishman and Friedman, 1989). Pre-1970 nitrate levels were measured using the corimetric phenoldisulfonic acid method (Rainwater and Thatcher, 1960). Concentrations of total phosphorus were measured using Microkjeldahl digestion (EPA method 365.1; see U.S. EPA, 1993).

> Goolsby, Donald A., William A. Battaglin, Gregory B. Lawrence, Richard S. Artz, Brent T. Aulenbach, Richard P. Hooper, Dennis R. Keeney, and Gary J. Stensland. 1999. Flux and Sources of Nutrients in the Mississippi-Atchafalaya River Basin: Topic 3 Report for the Integrated Assessment on Hypoxia in the Gulf of Mexico. NOAA Coastal Ocean Program Decision Analysis Series No. 17. NOAA Coastal Ocean Program, Silver Spring, MD. 130 pp.

> Fishman, M.J., and L.C. Friedman, eds. 1989. Methods for determination of inorganic substances in water and fluvial sediments. In *Techniques of water-resources investigations of the United States Geological Survey*. Chapter A1. Washington, DC.

> Rainwater, F.W., and L.L. Thatcher. 1960. *Methods for collection and analysis of water samples*. U.S. Geological Survey Water Supply Paper 1454. Washington, DC.

U.S. EPA. 1993. Methods for the determination of inorganic substances in environmental samples: EPA/600/R-93/100.

(3) USGS estimated the annual flux of nitrate and phosphorus using regression models. Nutrient loads in the Mississippi River were estimated using a model known as Cohn's "ESTIMATOR" code, applying an equation described in Goolsby et al (1999) [see citation in T1Q1]. Recent updates to this model are described at http://co.water.usgs.gov/hypoxia/html/nutrients_new.html ("USGS, 2004, New nutrient flux estimates for 2004"). The following three sources offer documentation of the ESTIMATOR model; the first two provide a theoretical basis, while the third offers a more hands-on explanation and application;

> Cohn, T.A., Delong, L.L., Gilroy, E.J., Hirsch, R.M., and Wells, D.K., 1989. Estimating constituent loads: Water Resources Research, 25(5):937-42.

> Gilroy, E.J., Hirsch, R.M., and Cohn, T.A., 1990. Mean square error of regression-based constituent transport estimates: Water Resources Research, 26(9):2069-77.
>
> Cohn, T.A., Caulder, D.L., Gilroy, D.J., Zynjuk, L.D., and Summers, R.M., 1992. The validity of a simple statistical model for estimating fluvial constituent loads: An empirical study involving nutrient loads entering Chesapeake Bay: Water Resources Research 28(9):2353-63.

In the other three rivers, USGS estimated nitrate and phosphorus loads using the LOADEST model, a similar regression tool. This model is described in Runkel et al (2004).

> Runkel, R.L., Crawford, C.G., and Cohn, T.A. 2004. Load Estimator (LOADEST): A FORTRAN Program for Estimating Constituent Loads in Streams and Rivers: U.S. Geological Survey Techniques and Methods Book 4, Chapter A5, 69 p.

According to USGS (Richard Coupe, personal communication, 2004), pre-1967 nitrate concentrations were measured from 10-to-30-day composite samples. Annual flux figures for this period were extrapolated using daily discharge data and the relationship between discharge and solute flux that was evident from the composite nitrate samples. USGS may only have used the ESTIMATOR model on data from 1967 and later, which represents a possible source of inconsistency in the Mississippi River data series.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

USGS provides free access to daily discharge data covering the entire sampling period for this indicator (http://waterdata.usgs.gov/nwis/sw). These are the raw data used by USGS in its analysis. In some cases, discharge data were originally derived from stream level measurements, which are also available from the same website. In a few cases, streamflow data were analyzed by USGS's National Stream Water Accounting Network (NASQAN) but obtained from gauges operated by the U.S. Army Corps of Engineers (USACE), not by USGS. Data from USACE stream gauges are included in NASQAN's database, which can be found at http://water.usgs.gov/nasqan/data/index.html. Water quality data (nitrate and phosphorus) are available through USGS's NWIS database (http://waterdata.usgs.gov/nwis/qw), and are also published in annual reports by state. Data used to derive this indicator can be obtained from NWIS by entering the identification numbers of the gauging and sampling stations listed in T3Q1. The data compilation that USGS created for this indicator has not been published, but could be obtained by contacting USGS directly (Bill Wilber, USGS, personal communication, 2005). USGS did publish historical nutrient flux data for the Mississippi River in a 1999 report by Goolsby et al. (citation below). Goolsby, Donald A., William A. Battaglin, Gregory B. Lawrence, Richard S. Artz, Brent T. Aulenbach, Richard P. Hooper, Dennis R. Keeney, and Gary J. Stensland. 1999. Flux and Sources of Nutrients in the Mississippi-Atchafalaya River Basin: Topic 3 Report for the Integrated Assessment on Hypoxia in the Gulf of Mexico. NOAA Coastal Ocean Program Decision Analysis Series No. 17. NOAA Coastal Ocean Program, Silver Spring, MD. 130 pp.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Reproducibility of individual measurements is limited by the fact that this indicator relies largely on historical data. However, the list of gauging and sampling stations provided in T3Q1 facilitates easy access to all the online USGS data necessary to reproduce this study. Using the regression models documented in T3Q1, it should be possible to reproduce the full analysis that went into the creation of this indicator.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The Heinz Center does not directly document quality control procedures for this indicator, but several relevant USGS references are available online. For discharge measurements, see Sauer and Meyer, "Determination of error in discharge measurements," located at http://pubs.er.usgs.gov/pubs/ofr/ofr92144. Another useful USGS resource is: Rantz et al., "Measurement and computation of streamflow: volume 1. Measurement of stage and discharge," located at http://water.usgs.gov/pubs/wsp/wsp2175/pdf/WSP2175_vol1a.pdf. General QA/QC procedures for water quality measurements associated with USGS's NASQAN Program are well documented. NASQAN outlines several general QA/QC procedures at http://water.usgs.gov/nasqan/progdocs/wri014255/methods.htm, while an additional assessment of field sampling quality control procedures can be found at http://water.usgs.gov/nasqan/progdocs/wri014255/results/qc.htm. Among other things, these documents discuss field blanks, replicates, and how outliers are treated when measuring solute concentration. Most of this information is specifically relevant to the sampling that took place under the auspices of NASQAN beginning in 1996. Quality assurance information for data sets prior to 1996 is available at http://water.usgs.gov/pubs/dds/wqn96cd/html/wqn/qasure/qasure.htm. This link includes a description of field and laboratory procedural changes that have occurred since the 1970s. In certain cases where procedures have not changed, the NASQAN QA/QC information may be applicable to data collected prior to 1996. Related information about NASQAN's Blind Sample Program (pre-1996 laboratory QA/QC) can be found at http://water.usgs.gov/pubs/dds/wqn96cd/html/wqn/bsp/bsp.htm.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

The major source of generalization in the indicator data set is the use of a regression model to calculate annual nitrate and phosphorus load. While discharge is measured on a daily basis, nitrate and phosphorus concentrations are not. The graphical representation of this indicator -- annual nitrate and phosphorus loads -- is based entirely on regression models that extrapolates from 4 to 15 water quality measurements made over the course of a given year. These models account for day-to-day variation by linking nutrient load to discharge volume, and accounts for other sources of potential variability (e.g., seasonal changes in the nitrogen cycle) by regressing around each data point. The Heinz Center (2003) reports that USGS's regression models employed "robust statistical techniques that made no assumption about the underlying statistical distribution of the data." A small degree of spatial generalization is inherent in the process of using river outflow to characterize the ecosystem health of an entire watershed. However, no attempt is made to portray data beyond the bounds of the four key watersheds measured as part of this study.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

USGS and the Heinz Center do not present exact figures for uncertainty in this indicator. However, as a general reference, USGS has published several guides for calculating uncertainty of discharge measurements (see "Determination of error in discharge measurements" by Sauer and Meyer, http://pubs.er.usgs.gov/pubs/ofr/ofr92144). In terms of a general range for uncertainty, Goolsby et al. (1999) notes that discharge measurements are typically within 10 percent of actual values, and that accuracy figures for individual stream gauges are published in annual USGS reports for each state (citation below). A general USGS resource on uncertainty in water sampling can be found at http://water.usgs.gov/pubs/twri/twri4a3/, but no specific uncertainty measurements are presented for this indicator data set. Uncertainties in laboratory measurements are described within USGS's procedural and quality control documents (see also T3Q1 and T3Q4). Although USGS has documented the number of stream gauging and water quality sampling sites used in this analysis, the fact that the number of water quality samples per year varied throughout the sample period (see T1Q2) makes it difficult to calculate uncertainty for this indicator. USGS has not reported the exact nature of any statistical uncertainty related to the regression model. Considering that 4 to 15 days of data are used to determine nutrient load figures for an entire year, one might expect uncertainty to be significant. However, USGS's regression models have been developed using many years of data, and are considered to provide at least a reliable estimation of load. Goolsby, Donald A., William A. Battaglin, Gregory B. Lawrence, Richard S. Artz, Brent T. Aulenbach, Richard P. Hooper, Dennis R. Keeney, and Gary J. Stensland. 1999. Flux and Sources of Nutrients in the Mississippi-Atchafalaya River Basin: Topic 3 Report for the Integrated Assessment on Hypoxia in the Gulf of Mexico. NOAA Coastal Ocean Program Decision Analysis Series No. 17. NOAA Coastal Ocean Program, Silver Spring, MD. 130 pp.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

USGS does not explicitly quantify all of the uncertainties related to sampling methods and regression modeling for this indicator, as discussed in T4Q2. However, the largest source of uncertainty is probably inconsistent sample design. Although nitrate data for this indicator has been collected since the 1950s (phosphorus since the 1970s), collection has taken place under the auspices of several different USGS programs, each with its own criteria for where, when, and how often to make measurements. Specific issues: " The lack of data quality information on nitrate data from the 1950s and 1960s. These early data are included in the graphic depicting Mississippi River nitrate loads, but little documentation is provided as to whether these data were measured using the same procedures employed in more recent years. These data predate USGS's procedural and quality control documents, and may even predate some of the laboratory methods that USGS now uses to quantify solute concentrations. According to USGS (Richard Coupe, personal communication, 2004), pre-1967 data for the Mississippi River were collected as 10-to-30-day composite samples, and annual fluxes during this period may have been calculated by extrapolation, not by regression (see T3Q1). " Changing frequency of data collection. Water quality data were collected under the auspices of NASQAN from 1973 to 1995. According to NASQAN's website, frequency of sampling dropped over this period as the program's funding decreased; by 1994, samples were taken on a quarterly basis (http://water.usgs.gov/nasqan/progdocs/index.html). From 1996 to 1999, a revamped NASQAN measured fewer sites, 15 times per year. " Different intervals of measurement. According to NASQAN (http://water.usgs.gov/nasqan/progdocs/index.html), prior to 1996, USGS measured solute concentrations at equal intervals throughout the year (e.g., monthly or quarterly). Beginning in 1996, the program timed most measurements to coincide with large "events" or extreme high or low flows. " Different programs in different locations. NASQAN provides information about the Mississippi and Columbia Rivers, but information on the St. Lawrence and

Susquehanna must be taken from other USGS water quality monitoring programs, such as NAWQA (National Water Quality Assessment). While sampling and QA/QC procedures are included in NASQAN's 2001 report (http://water.usgs.gov/nasqan/progdocs/wri014255/index.htm), similar information is not available at the same level of detail for NAWQA. A related concern is that the discharge and water quality station closest to the mouth of the Susquehanna, located at Conowingo, MD, did not begin collecting significant data until 1979. Data up to 1978 come from Harrisburg, PA, over 50 miles upstream. Daily and seasonal variability is inherent in discharge and solute flux data. USGS designed its regression models to capture this variability, incorporating the full range of daily and seasonal flow characteristics into an overall annual figure. Year-to-year variability is also inherent in this indicator. Nitrogen and phosphorus discharges tend to be significantly higher during years of high runoff, because of increased erosion and transport of the nutrients to stream channels (Smith et al., 2003). Thus, it is important not to read too much into inter-annual trends -- at least in terms of determining causation -- because these trends may be more attributable to climate variability than to any human influence. Smith, S., et al. 2003. Humans, Hydrology, and the Distribution of Inorganic Nutrient Loading to the Ocean. BioScience 53: 235-245.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

(1) Limited to four major rivers. This indicator does not include data from numerous coastal watersheds whose large or growing human populations may represent significant sources of excess nitrogen (e.g., Valigura, et al., 2000). It also does not include a number of small watersheds whose geological characteristics may make them particularly sensitive to nitrogen cycle disruption due to acid deposition (e.g., Evans et al., 2000). Valigura, R., R. Alexander, M. Castro, T. Meyers, H. Paerl, P. Stacey, and R. Turner (eds.). 2000. Nitrogen Loading in Coastal Water Bodies -- An Atmospheric Perspective. Washington, DC: American Geophysical Union. Evans, C.D., A. Jenkins, and R. F. Wright. 2000. Surface water acidification in the South Pennines I. Current status and spatial variability. Environmental Pollution 109(1): 11-20. (2) Limited to nitrate. This indicator does not include other forms of nitrogen, which may constitute a substantial portion of the total nitrogen load. The Heinz Center does present an alternative form of this indicator, nitrogen yield, in terms of total nitrogen lost per square mile of each watershed. These calculations are based on recent USGS water quality data that include nitrate, nitrite, ammonia, and organic nitrogen (a complete listing of nitrogen compounds included in the NAWQA database, 1991-present, can be found at http://water.usgs.gov/nawqa/constituents/nutrients.html). Total nitrogen yield is calculated using a series of regression models (Heinz Center, 2003). However, because nitrate-only measurements are available for a longer time period than total nitrogen data, the indicator is limited to nitrate only, thereby maximizing the temporal range of data available. (3) Does not break down "total phosphorus" into components. Some forms of phosphorus (e.g., phosphates) are more biologically active than others, and are therefore more worrisome from the perspective of preventing algal blooms.

Indicator: Nitrogen and Phosphorus in Wadeable Streams (280)

Nitrogen and phosphorus are essential elements in the aquatic ecosystems. Both nutrients are used by plants and algae for growth (EPA 2005). Excess nutrients can lead to increased algal production within the stream, depleted oxygen, and altered biological assemblages. Sources of excess nutrients include municipal sewage and septic tank drainfields, agricultural run-off, excess fertilizer applications, and atmospheric deposition of nitrogen (Herlihy et al 1998).

This indicator measures total phosphorus and total nitrogen based on data collected for the U.S. EPA's Wadeable Streams Assessment (WSA) (in draft). Wadeable streams are streams, creeks and small rivers that are shallow enough to be sampled using methods that involve wading into the water. They typically include waters classified as 1st through 4th order in the Strahler Stream Order classification system (based on the number of tributaries upstream). The WSA is based on a probability, design, so the results from representative sample sites can be used to make a statistically valid statement about the condition of the nation's waters. Using standardized methods, crews sampled 748, including reference sites and repeat visits, in the eastern and central U.S. Between 1999 and 2004, 839 sites were sampled in the western U.S. using the same methods. All sites were sampled between late April and mid-November. At each site, a water sample was collected at mid-depth in the stream. Detailed field methodologies and project information can be found at http://www.epa.gov/owow/monitoring/wsa/index.html.

What the Data Show

Total phosphorus concentrations in wadeable streams in the U.S. ranged from undetectable (<1 µg/L) to more than 5000 µg/L (Fig. 280-1). The percentage of wadeable stream miles for any particular phosphorus concentration can be read off the left hand y axis, and the total wadeable stream miles off the right hand y axis. The cumulative frequency distribution in the figure represents the national distribution of the data. Thresholds for favorable or unfavorable water quality vary from one part of the country to another.

Total nitrogen concentrations in wadeable streams ranged from 11 µg/L (.011 ppm) to more than 40 mg/L (Fig. 280-2). The percentage of wadeable stream miles for any particular nitrogen concentration can be read off the left hand y axis, and the total wadeable stream miles off the right hand y axis. The cumulative frequency distribution in the figure represents the national distribution of the data. Thresholds for favorable or unfavorable water quality vary from one part of the country to another.

Indicator Limitations

- Samples were taken one time from each sampling location during the index period (June –October). Although the probability sampling design results in an unbiased estimates for total N and P concentrations in wadeable streams during the study period, concentrations may be different during other seasons and years.
- Reference levels for total N and total P in streams (i.e., levels that would allow streams to be classified as to least disturbed, moderately disturbed, and most disturbed based on regional reference sites) vary from region to region; these reference levels will be available from the WSA to provide such a classification of streams nationally, but they are not available at this time.

- This is the first time that a survey on this broad scale has been conducted. The data will serve as a baseline for future surveys, but the sampling design for the current WSA design does not allow trends to be calculated over the period 1999-2004.

Data Sources

Data for this indicator were collected for the Environmental Protection Agency's (EPA) Wadeable Streams Assessment (WSA) in 2004 for the central and eastern states and from 1999-2004 for the western states. Information about the WSA can be found at http://www.epa.gov/owow/monitoring/wsa/index.html.

References

Herlihy, A.t., J. L. Stoddard and C.B. Johnson. 1998. The relationship between stream chemistry and watershed land use data in the Mi-Atlantic region, U.S. Water Air and Soil Pollution. 105:377-386.

Karr, J.R., and D.R. Dudley. 1981. Ecological Perspective on water quality goals. Environmental Management 5:55-68

U.S. EPA. 2005 National Estuary Program- Challenges Facing Our Estuaries. Key Management Issues: Nutrient Overlaoding. www.epa.gov/owow/estuaries/about3.htm

U.S. EPA. 2004. Wadeable Streams Assessment: Field Operations Manual. U.S. Environmental Protection Agency; Office of Water, Washington D.C. EPA841-B-04-005

U.S. EPA. 2004. Wadeable Streams Assessment: Water Chemistry Laboratory Methods. U.S. Environmental Protection Agency; Office of Water, Washington D.C. EPA841-B-04-008

Graphics

Fig 280-1: Cumulative distribution function for total nitrogen in wadeable streams in the United States

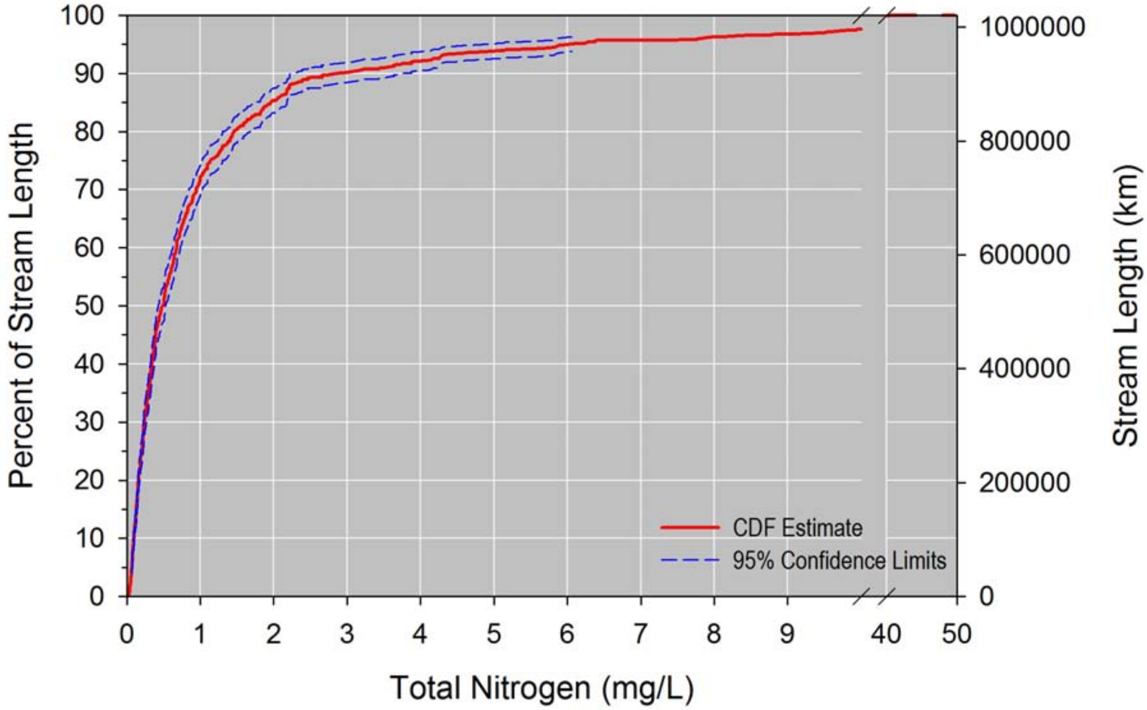
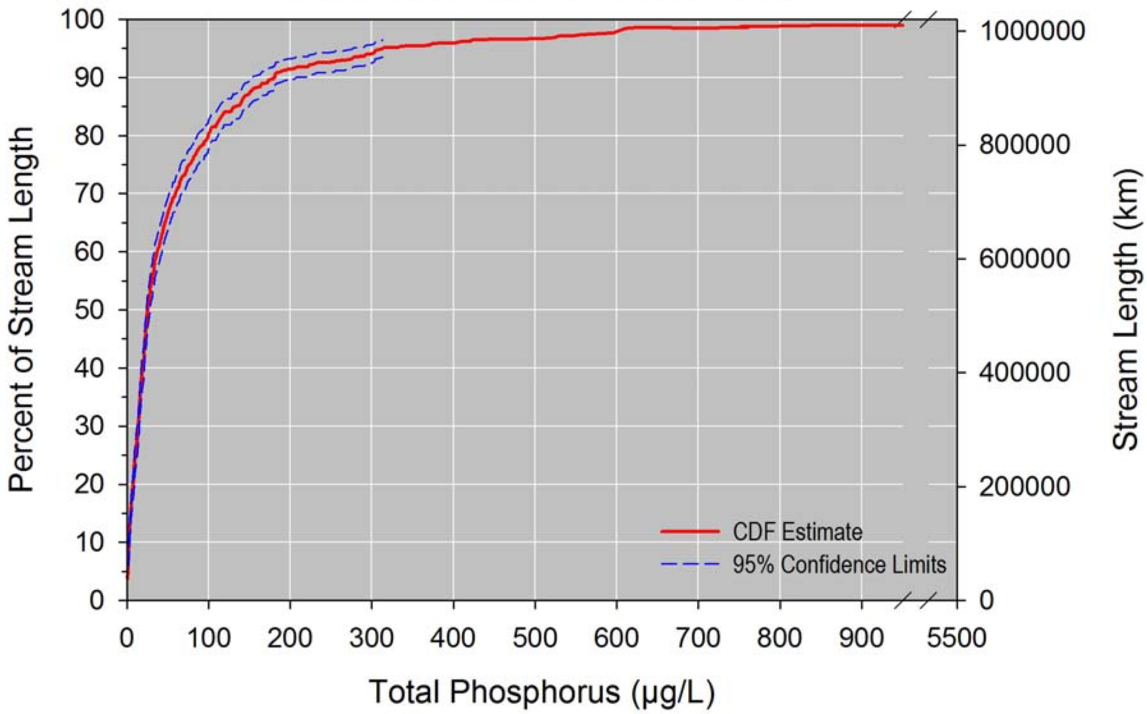


Fig 280-2: Cumulative distribution function for total phosphorus in wadeable streams in the United States



R.O.E. Indicator QA/QC

Data Set Name: NITROGEN AND PHOSPHORUS IN WADEABLE STREAMS
Indicator Number: 280 (89140)
Data Set Source:
Data Collection Date: UNKNOWN
Data Collection Frequency:
Data Set Description: Nitrogen and Phosphorus in Wadeable Streams
Primary ROE Question: What are the trends in extent and condition of fresh surface waters?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

The field methods used to collect the water chemistry data were published in the Wadeable Streams Assessment (WSA) Field Operations Manual (2004 EPA841-B-04-008) in 2004. The protocols used were initially established and published in the Environmental Assessment and Monitoring Program (EMAP). They outline the collection technique, equipment, and field processing for all samples. Trained field crews collected a single water sample from each site following the detailed methodologies laid out in the Field Operations Manual. Crews used a standardized set of field equipment provided by the EPA, and followed protocols for sample processing in the field. Laboratory methods for analyzing the water chemistry samples are published in the Wadeable Streams Water Chemistry Laboratory Methods (2004 EPA841-B-04-008) . As with the field collection methods, laboratory analysis techniques mirrored those used in the EMAP program. The standard identification process and associated QC measures ensure a high level of accuracy throughout the dataset. The centralized lab processed all chemistry samples using standardized methodologies commonly used in water chemistry. Each chemical had its own detection limit and holding time, specified in the Water Chemistry Methodologies. U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Field Operations Manual. US Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-004. U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Water Chemistry Methods. US Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-008.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

The indicator is based on data collected by the EPA's Wadeable Streams Assessment (WSA). The WSA is based on a probabilistic survey design used to make a statically valid statement about the ecological condition of the wadeable streams through the United States. Standardized field protocols were used to collect data from streams Strahler Order 1-5. Information about the probabilistic survey design and implementation can be found on the U.S. EPA website http://www.epa.gov/nheerl/arm/index.html Diaz-Ramos, S. , Stevens, D.L., Jr and Olsen, A.R. 1996. EMAP Statistical Methods Manual. EPA620-R-96-002, US Environmental Protection Agency, Office of Research and Development, NHEERL-WED, Corvallis, Oregon. Stevens, D.L., Jr, and Olsen, A.R. 1999. Spatially restricted surveys over time for aquatic resources. Journal of Agriculture, Biological and Environmental Statistics, 4, 415-28. Herlihy, A. T., D.P. Larsen, S. G. Paulsen, N.S. Urquhart, and B.J. Rosenbaum. 200. Designing a spatially balanced, randomized site selection process for regional stream surveys: The EMAP Mid-Atlantic Pilot Study. Environmental Monitoring and Assessment 63:95-113. Stevens Jr., D. L. 1997. Variable density grid-based sampling designs for continuous spatial populations. Environmetrics 8:167-195.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Herlihy, A.t., J. L. Stoddard and C.B. Johnson. 1998. The relationship between stream chemistry and watershed land use data in the Mid-Atlantic region, U.S. Water Air and Soil Pollution. 105:377-386.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The spatial and temporal aspects of this indicator are appropriate for reporting on the chemical stressors in the nation’s freshwater stream resource. Data used to generate this indicator comes from the U.S. EPA’s Wadeable Streams Assessment (WSA). The WSA is a statistically valid survey designed to make an ecological assessment if streams through the U.S. based on physical, biological and chemical features. Between 1999-2004,750 sites were sampled in the western states. In 2004, 748 sites were sampled in the eastern and central states. These sites were distributed evenly, with approximately 50 sites sampled per region. These sites represent a diverse selection of streams that vary in size, flow and type of disturbance. Because of the statistical approach to selecting these sites, the aggregated results can be extrapolated to make a statement about the target population, stream Strahler Order 1-4. Field crews collected water chemistry samples before conducting any sampling to minimize stream disturbance.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The statistically valid survey ensures spatial dispersion within the target population. All types of natural streams, and associated ecosystem characteristics, have a known probability of being included in the sample. Highly sensitive or unique ecosystems have a lower probability of being sampled due to the sparse nature of there location and the broad geographic scale of the sampling design.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Selection of reference sites was a key aspect to the analysis of the WSA data. Approximately 20 reference sites per ecoregions were selected a priori to be sampled with the same methods as the randomized sites. States and cooperators were asked to contribute their 10 best reference sites for inclusion in this pool. Additionally, the U.S Geological Survey North American Water Quality Assessment (NAQWA) identified a number of predefined reference sites from their Status and Trends Program and Hydrologic Benchmark Network to be sampled with WSA methods for this survey. Additional reference sites were contributed by the Chuck Hawkins in his STAR grant program for the Western states. Thresholds for nutrients may be taken from the Ecoregion Nutrient Criteria Guidelines (http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/rivers/index.html) suggested by the EPA.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

All sampling methodologies can be found in the U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Field Operations Manual. US Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-004. Laboratory methods used to examine this indicator can be found in the U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Water Chemistry Laboratory Methods. US Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-008. Detailed analytical procedures can be found in the Data Analysis Plan accompanying the Wadeable Streams Assessment Final Report.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

All data, including metadata, from the Wadeable Streams Assessment will be available for the public through the Storage and Retrieval (STORET) System. Information on STORET, including data downloads, can be found at http://www.epa.gov/storet/.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The description of the study design, methods to select and sample sites, and the laboratory analysis are all fully documented and available for the public (http://www.epa.gov/owow/monitoring/wsa/index.html, http://www.epa.gov/nheerl/arm/index.html). Following these documents and associated references, the study design could be replicated. Analytical methods used to examine the data are also fully documented and will be available in the final report. Using the data publicly available on the STORET warehouse, analytical procedures could also be replicated.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

An extensive Quality Assurance/Quality Control procedure was an integral part of the WSA. Full documentation of the QA/QC procedures can be found in U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Quality Assurance Project Plan. U.S. Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-005. The QAPP was reviewed by an independent EPA team with members from ORD, OW and OEI. It is available to the public on the EPA's website. http://www.epa.gov/owow/monitoring/wsa/QAPP-August18.pdf. In the field QA/QC included training all crew members in WSA methods, conducting a thorough field audit of all crews, and extensive chain of custody documentation. All information on the field audits and training sessions are currently housed at the U.S. EPA's Office of Water in the Monitoring Branch and can be distributed on request. A 48 hour holding time was used for all water chemistry samples to ensure the accuracy of the data. A throughout internal laboratory QC was used throughout the analysis, including duplicates, blanks, recalibration of equipment after 20 samples and temperature control checks on storage space. These procedures are outlined in the Water Chemistry Laboratory Methodologies (EPA 2004). U.S. EPA. 2004. Wadeable Streams Assessment (WSA: Water Chemistry Methods. US Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-008

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

The WSA is based on a probability sampling design where the results from the sampled population can be used to make a statistically valid statement about the entire population. Details about the statistical design and implementation of this approach can be found the EPA website dedicated to this topic. http://www.epa.gov/nheerl/arm/index.htm

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Measurements of uncertainty are associated with the dataset and can be found in the WSA Report (in draft). Actions were taken throughout the study to reduce the level of uncertainty throughout the dataset. The Quality Assurance Project Plan

(QAPP) for the WSA has Measurement Quality Objectives (MQOs) and Data Quality Objectives (DQOs) specified for each indicator. U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Quality Assurance Project Plan. U.S. Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-005.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

The conclusions are not impacted by variability around the indicator. Actions were taken throughout the study to reduce the level of uncertainty and increase repeatability throughout the dataset. The extensive QA procedures employed reduce the variability of the dataset. Field crews used standardized protocols and equipment to further reduce uncertainty. Information about all the QA procedures can be found at http://www.epa.gov/owow/monitoring/wsa/QAPP-August18.pdf. The extensive QC process throughout all aspects of the project ensure high quality data with low levels of uncertainty.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

This is the first time a national, statistically valid survey has been conducted for stream resources. Results from this survey will serve as a baseline to compare future surveys. Trends over time using this indicator cannot be assessed at this time.

Indicator: Streambed Stability in Wadeable Streams (342)

Streams and rivers adjust their channel shape and particle size in response to the supply of water and sediments from their drainage areas. Excess fine sediments can destabilize streambeds when the supply of sediments from the landscape exceeds the ability of the stream to move them downstream. This imbalance results from numerous human uses of the landscape, including agriculture, road building, construction, and grazing. Lower than expected streambed stability causes stressful ecological conditions (by filling in the habitat spaces between stream cobbles and boulders), and may result either from high inputs of fine sediments (from erosion) or increases in flood magnitude or frequency (hydrologic alteration). This instability can lead to channel incision and arroyo formation, and can negatively affect benthic invertebrate communities and fish spawning (Kaufmann et al., 1999). Streams that have *higher than expected* streambed stability also can be considered stressed—very high bed stability is typified by hard, armored streambeds, such as those often found below dams where fine sediment flows are interrupted, or within channels where banks are highly altered.

One measure of this interplay between sediment supply and transport is relative streambed stability (RBS). Relative Streambed Stability is calculated as the logarithm of the ratio of observed mean streambed particle diameter to the "critical diameter," the largest particle size the stream can move as bedload during stormflows. RBS is calculated from field measurements of the size, slope and other physical characteristics of the stream channel (Kaufmann et al., 1999). Expected values of the index are based on the statistical distribution of values observed in minimally disturbed reference sites. Values of the RBS Index either substantially lower (finer, more unstable streambeds) or higher (coarser, more stable streambeds) than those expected based on the range found in reference sites are considered to be indicators of ecological stress.

This indicator is based on data collected for the U.S. EPA's Wadeable Streams Assessment (WSA) (in draft). Wadeable streams are streams, creeks and small rivers that are shallow enough to be sampled using methods that involve wading into the water. They typically include waters classified as 1^{st} through 4^{th} order in the Strahler Stream Order classification system (based on the number of tributaries upstream). The WSA is a based on a probability design, so the results from representative sample sites can be used to make a statistically valid statement about the condition of the nation's waters. Using standardized methods, crews sampled 748 sites, including reference and repeat visits, in the eastern and central U.S. Between 1999 and 2004, 839 sites were sampled in the western U.S. using the same methods. All samples were collected between late April and mid- November. At each site, measurements related to stream morphology, large woody debris, riparian structure, and sediment characteristics are taken at or between eleven equally spaced transects within the sample reach. Detailed field methodologies and project information can be found at ttp://www.epa.gov/owow/monitoring/wsa/index.html.

What the Data Show

Relative streambed stability in wadeable streams in the U.S. was found to vary over six orders of magnitude, with negative values more common than higher values (indicating that stream bed material in most streams is fine enough to be moved readily by flood flows) (Figure 342-1). The percentage of wadeable stream miles for any particular index score can be read off the left hand y axis, and the total wadeable stream miles off the right hand y axis. The cumulative frequency distribution in the figure represents the national distribution of the data. Thresholds indicating favorable or unfavorable- amounts of fine sediments relative to the ability of streams to transport these sediments vary from one part of the country to another.

Indicator Limitations

- Samples were taken one time from each sampling location during the index period (June – October). Although the probability sampling design results in ~~an~~ unbiased estimates for relative streambed stability in wadeable streams during the study period, values of the index may be different during other seasons and years because of variations in hydrology.
- Reference levels for the relative streambed stability in streams (i.e., levels that would allow streams to be classified as to least disturbed, moderately disturbed, and most disturbed based on regional reference sites) vary from region to region; these reference levels will be available from the WSA to provide such a classification of streams nationally, but they are not available at this time.
- This is the first time that a survey on this broad scale has been conducted. The data will serve as a baseline for future surveys, but the sampling design for the current WSA design does not allow trends to be calculated over the period 1999-2004.

Data Sources

Data for this indicator were collected for the Environmental Protection Agency's (EPA) Wadeable Streams Assessment (WSA) in 2004 for the central and eastern states and from 1999-2004 for the western states. Information about the WSA can be found at http://www.epa.gov/owow/monitoring/wsa/index.html.

References

Barbour, M.T., J Gerritson, B.D. Snyder, J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water. Washington D.C.

Karr, J.R., and D.R. Dudley. 1981. Ecological Perspective on water quality goals. Environmental Management 5:55-68.

Kaufmann, P. R., Levine, P., Robinson, E.G., Seeliger, C. and Peck, D. 1999. Quantifying Physical Habitat in Wadeable Streams. EPA 620/R-99/003. U.S. Environmental Protection Agency, Washington D.C.

Peck, D.V., Lazorchak, J.M. and Klemm, D.J. In Press. Western Pilot Study Field Operation Manual for Wadeable Streams. U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA. 2004. Wadeable Streams Assessment: Field Operations Manual. U.S. Environmental Protection Agency; Office of Water, Washington D.C. EPA841-B-04-005.

Graphics

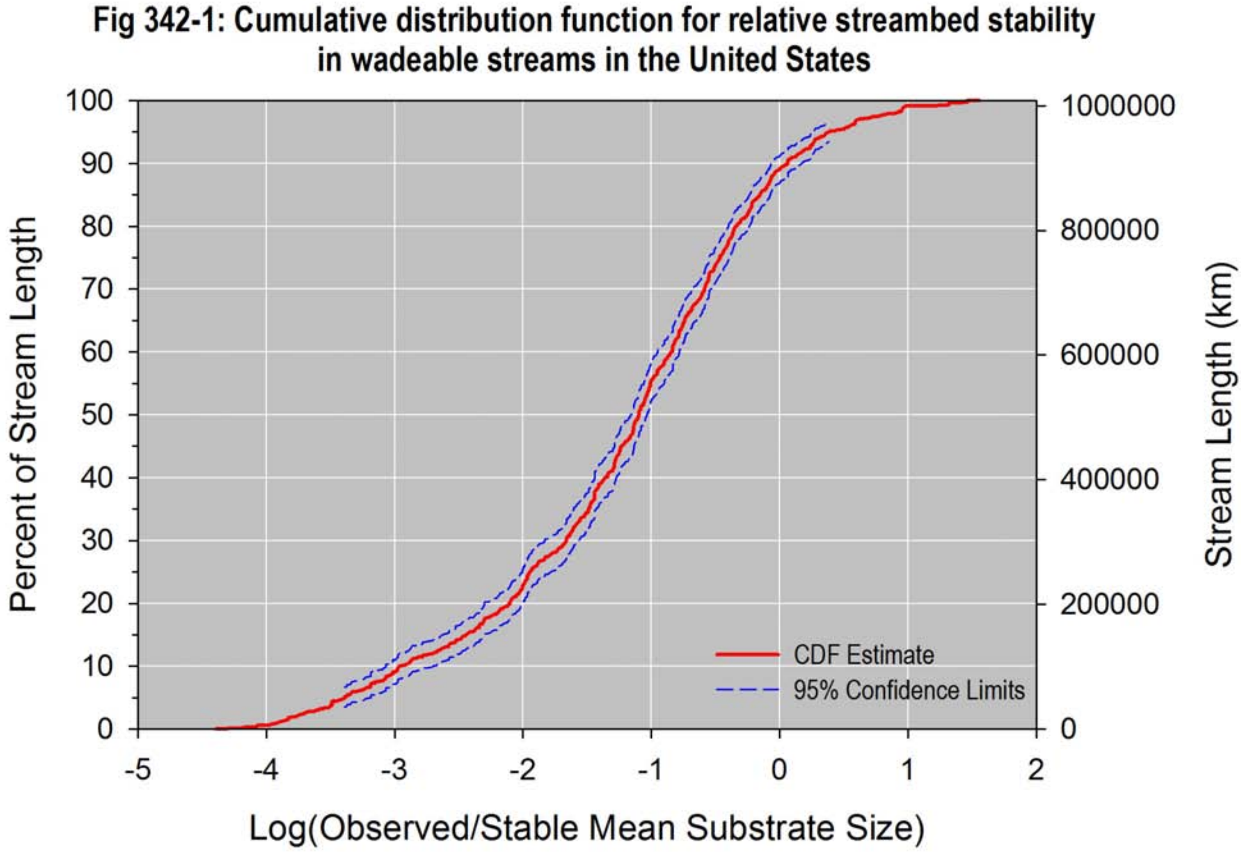


Fig 342-1: Cumulative distribution function for relative streambed stability in wadeable streams in the United States
Percent of Stream Length
Stream Length (km)
Log(Observed/Stable Mean Substrate Size)
CDF Estimate
95% Confidence Limits
100
90
80
70
60
50
40
30
20
10
0
1000000
800000
600000
400000
200000
0
-5
-4
-3
-2
-1
0
1
2

R.O.E. Indicator QA/QC

Data Set Name: STREAMBED STABILITY IN WADEABLE STREAMS
Indicator Number: 342 (89190)
Data Set Source:
Data Collection Date: UNKNOWN
Data Collection Frequency:
Data Set Description: Streambed Stability in Wadeable Streams
Primary ROE Question: What are the trends in extent and condition of fresh surface waters?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

The field methods used to collect the streambed stability data were published in the Wadeable Streams Assessment (WSA) Field Operations Manual (2004 EPA841-B-04-008) in 2004. The protocols used were initially established and published in the Environmental Assessment and Monitoring Program (EMAP). They outline the collection technique, equipment, and field processing for all samples. Trained field crews collected a single water sample from each site following the detailed methodologies laid out in the Field Operations Manual. Crews used a standardized set of field equipment provided by the EPA, and followed protocols for collecting the physical habitat data. Streambed stability is commonly used as an indicator of stream health. U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Field Operations Manual. US Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-004.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

The indicator is based on data collected by the EPA's Wadeable Streams Assessment (WSA). The WSA is based on a probabilistic survey design used to make a statically valid statement about the ecological condition of the wadeable streams through the United States. Standardized field protocols were used to collect data from streams Strahler Order 1-5. Between 1999-2004 1500 sites were sampled in the western states, and in 2004 748 sites were sampled in the eastern and central states. Information about the probabilistic survey design and implementation can be found on the U.S. EPA website http://www.epa.gov/nheerl/arm/index.html Diaz-Ramos, S., Stevens, D.L., Jr and Olsen, A.R. 1996. EMAP Statistical Methods Manual. EPA620-R-96-002, US Environmental Protection Agency, Office of Research and Development, NHEERL-WED, Corvallis, Oregon. Stevens, D.L., Jr, and Olsen, A.R. 1999. Spatially restricted surveys over time for aquatic resources. Journal of Agriculture, Biological and Environmental Statistics, 4, 415-28. Herlihy, A. T., D.P. Larsen, S. G. Paulsen, N.S. Urquhart, and B.J. Rosenbaum. 200. Designing a spatially balanced, randomized site selection process for regional stream surveys: The EMAP Mid-Atlantic Pilot Study. Environmental Monitoring and Assessment 63:95-113. Stevens Jr., D. L. 1997. Variable density grid-based sampling designs for continuous spatial populations. Environmetrics 8:167-195.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The concept of relative streambed stability is well-established in the scientific literature, though its application to synoptic survey data is relatively recent, and is described by Kaufmann et al. (1999). Relative streambed stability is calculated as the ratio of observed streambed particle size to the size of particles the stream is able to move as bedload during storms. Expectations for streambed stability will be ecoregion or stream-class specific, and will be based on values observed in minimally disturbed reference sites. Though deviations from reference condition are usually negative and due to excess sediment supply, additional data besides that contained in the index itself is necessary to interpret the whether low streambed stability relative to reference sites may be the result of the accumulation of fine sediments ("excess fines") from land erosion or from increases in the erosive power of stream channels (hydrologic alteration). Kaufmann, P. R., Levine, P., Robinson, E.G., Seeliger, C. and Peck, D. 1999. Quantifying Physical Habitat in Wadeable Streams U.S. Environmental Protection Agency, Washington D.C.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The spatial and temporal aspects of this indicator are appropriate for reporting on the suspended sediment stressor on the nation's freshwater stream resource. Data used to generate this indicator comes from the U.S. EPA's Wadeable Streams Assessment (WSA). The WSA is a statistically valid survey designed to make an ecological assessment if streams through the U.S. based on physical, biological and chemical features. Between 1999-2004, 1500 sites were sampled in the western states. In 2004, 748 sites were sampled in the eastern and central states. These sites were distributed evenly, with approximately 50 sites sampled per ecoregion. These sites represent a diverse selection of streams that vary in size, flow and type of disturbance. Because of the statistical approach to selecting these sites, the aggregated results can be extrapolated to make a statement about the target population, stream Strahler Order 1-4. Field crews collected water chemistry samples before conducting any sampling to minimize stream disturbance. A map depicting the location of the sampling sites can be found in the Graphics section.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The statistically valid survey ensures spatial dispersion within the target population. All types of natural streams, and associated ecosystem characteristics, have a known probability of being included in the sample. Highly sensitive or unique ecosystems have a lower probability of being sampled due to the sparse nature of there location and the broad geographic scale of the sampling design.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Selection of reference sites was a key aspect to the analysis of the WSA data. Approximately 20 reference sites per ecoregions were selected a priori to be sampled with the same methods as the randomized sites. States and cooperators were asked to contribute their 10 best reference sites for inclusion in this pool. Additionally, the U.S Geological Survey North American Water Quality Assessment (NAQWA) identified a number of predefined reference sites from their Status and Trends Program and Hydrologic Benchmark Network to be sampled with WSA methods for this survey. Additional reference sites were contributed by the Chuck Hawkins in his STAR grant program for the Western states.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

All sampling methodologies can be found in the U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Field Operations Manual. US Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-004 Detailed analytical procedures can be found in the Data Analysis Plan accompanying the Wadeable Streams Assessment Final Report. Documents are available on the web at http://www.epa.gov/owow/monitoring/wsa/index.html

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

All data, including metadata, from the Wadeable Streams Assessment will be available for the public through the Storage and Retrieval (STORET) System. Information on STORET, including data downloads, can be found at http://www.epa.gov/storet/.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The description of the study design, methods to select and sample sites, and the laboratory analysis are all fully documented and available for the public (http://www.epa.gov/owow/monitoring/wsa/index.html) (http://www.epa.gov/nheerl/arm/index.html). Following these documents and associated references, the study design could be replicated. Analytical methods used to examine the data are also fully documented and will be available in the final report. Using the data publicly available on the STORET warehouse, analytical procedures could also be replicated.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

An extensive Quality Assurance/Quality Control procedure was an integral part of the WSA. Full documentation of the QA/QC procedures can be found in U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Quality Assurance Project Plan. U.S. Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-005. The QAPP was reviewed by an independent EPA team with members from ORD, OW and OEI. It is available to the public on the EPA's website. http://www.epa.gov/owow/monitoring/wsa/QAPP-August18.pdf. In the field QA/QC included training all crew members in WSA methods, conducting a thorough field audit of all crews, and extensive chain of custody documentation. All information on the field audits and training sessions are currently housed at the U.S. EPA's Office of Water in the Monitoring Branch and can be distributed on request.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

The WSA is based on a probability sampling design where the results from the sampled population can be used to make a statistically valid statement about the entire population. Details about the statistical design and implementation of this approach can be found the EPA website dedicated to this topic. http://www.epa.gov/nheerl/arm/index.htm

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Measurements of uncertainty are associated with the dataset and can be found in the WSA Report (in draft). Actions were taken throughout the study to reduce the level of uncertainty throughout the dataset. The Quality Assurance Project Plan (QAPP) for the WSA has Measurement Quality Objectives (MQOs) and Data Quality Objectives (DQOs) specified for each indicator. U.S. EPA. 2004. Wadeable Streams Assessment (WSA): Quality Assurance Project Plan. U.S. Environmental Protection Agency, Office of Water, Washington D.C. EPA841-B-04-005.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

The conclusions are not impacted by variability around the indicator. Actions were taken throughout the study to reduce the level of uncertainty and increase repeatability throughout the dataset. The extensive QA procedures employed reduce the variability of the dataset. Field crews used standardized protocols and equipment to further reduce uncertainty. Information about all the QA procedures can be found at http://www.epa.gov/owow/monitoring/wsa/QAPP-August18.pdf.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

This is the first time a national, statistically valid survey has been conducted. Results from this survey will serve as a baseline to compare future surveys. Trends over time using this indicator cannot be assessed at this time.

Indicator: Population Served by Community Water Systems with No Reported Violations of Health-Based Standards (049)

Community Water Systems (CWS), public water systems that supply water to the same population year-round, served over 272 million Americans in 2004 (EPA 2005), just over 92 percent of the U.S. population (Census Bureau 2005). This indicator presents the percentage of Americans served by CWS with no reported violations of EPA health-based standards for over 90 contaminants (EPA 2004).

Health-based standards include Maximum Contaminant Levels (MCLs) and Treatment Techniques (TTs). An MCL is the highest level of a contaminant that is allowed in the finished (i.e., treated) water. A TT is a required treatment process (such as filtration or disinfection) intended to prevent the occurrence of a contaminant in treated tap water (EPA, 2004). TTs are adopted where it is not economically or technologically feasible to ascertain the level of a contaminant, as microbes which may be virulent as single organisms but are rarely present at a constant dilution. Compliance with TTs may require finished water sampling for such contaminants, along with quantitative or descriptive measurements of process performance, to gauge the efficacy of the treatment process. Because occurrence levels of MCL-regulated contaminants tend to have long-term rather than acute health effects, and vary by time of year if at all (e.g., levels of naturally-occurring chemical or radiological contaminants in ground water are relatively constant), compliance is based on averages of seasonal, annual, or less frequent sampling.

This indicator presents the total population nationally and by EPA region that is served by CWS for which no violations were reported to EPA for the period 1993-2004. It also presents the subset of that population that is served by community water systems in Indian Country in FY 2004. The indicator also presents data on the number of persons served by systems with reported violations of standards covering microbial contaminants (microorganisms that can cause disease) and disinfection byproducts (chemicals that may pose health risks and that may form when disinfectants, such as chlorine, react with naturally occurring materials in water) (EPA, 2004). The indicator is based on violations data reported quarterly by the States, EPA, and the Navajo Nation Indian Tribe, who each review monitoring results for the CWS which they oversee.

What the Data Show

The percentage of the population served by systems for which no health-based violations were reported for the entire year increased from 79% in 1993 to 94% in 2002 before declining to 90% in 2004, the latest year for which data are available (Fig. 049-1). The percentage of population served by Community Water Systems (CWS) with no reported violations of standards in 2004 was 92% or greater in seven of the ten Regions (Figure 049-2). Between 1993 and 2002, the percentage of the population served by systems with no reported violations consistently exceeded the 90% national average in six of the EPA Regions, and three more have been slightly below 90% in one of the past two years. Only one Region has been consistently below the national average since 1993, largely because of the long time-frame involved in planning and building one city's drinking water filtration plant.

In 2004, reported violations of health-based standards affecting the largest populations (Figure 049-3) involved the original and Interim Enhanced SurfaceWater Treatment Rules in systems serving over 12 million people (7.7% of the population served by surface water systems nationally), the Total Coliform Rule in systems serving 10.6 million people (4.8% of the population served nationally), and the Disinfection Byproducts Stage 1 rule, in systems serving nearly 7.4 million people (2.7% of the population served nationally). Together, 90% of the population served by systems that reported a violation in 2004~~,~~ involved these rules governing treatment to prevent waterborne diseases – the most widespread and acute threat to health from drinking water – or the contaminants created by such treatment.

The patterns in Indian Country were similar to those in the Regions, with the percentage of population served by CWS for which no violations of standards were reported being 93 percent or greater in seven out of the nine Regions (Region 3 has no federally-recognized Tribes)(Figure 049-4). Of the three with a lower percentage of population served by systems with no reported violation, Region 5 (82%) and the Navajo Nation (89%) involved only a handful of CWS in violation. Region 9 Tribes had the largest total population served by those systems for which a violation was reported.

Indicator Limitations

- This indicator does not present data for the population served by non-community water systems; these are typically relatively small systems that serve only transient populations (such as restaurants or campgrounds) or occasional local users (such as schools or office buildings).
- It does not cover domestic (home) use of drinking water supplied by private wells for about 43.5 million people (approximately 15% of the U.S. population, many of whom may, however, receive water from a CWS at their workplace or school) (USGS, 2004), which wells are not regulated unless they serve multiple households and states choose to oversee them.
- The indicator does not include bottled water, which is regulated by standards set by the Food and Drug Administration using EPA's levels.
- National data based on population served by systems can be volatile (a single very large system can sway the results by up to 2.3%). This effect becomes more pronounced when the results are broken down at the regional level, and still more so in results for a single rule.
- Data may overstate the extent of population receiving water that violates standards, because the entire population served by each system in violation is reported, while in many cases only a portion of the total population by a system in violation actually receives water that is out of compliance. Data stated on an annual basis may suggest a longer duration of violations than may be the case, as some may be as brief as an hour or a day. Data may understate the population receiving water that violates standards, because CWS that purchase water from other CWS are not always required to sample for all contaminants themselves, and CWS wholesaling water generally do not report the water quality for the population served by those other systems in the violations data.
- Under-reporting and late reporting of water system violations data by states to EPA affect the ability to accurately report the quality of our nation's drinking water. EPA last quantified the quality of violations data in 2004 for the period 1999 to 2001. Based on this analysis, EPA estimated that states were not reporting 35 percent of all health-based violations to EPA (which reflects a sharp improvement in the quality of violations data compared to the previous three-year period). EPA is continuing to verify state-reported water system data and expects to issue an updated estimate of data quality in 2006 for the period 2002-2004.
- State data verification and other quality assurance analyses indicate that the most significant data quality problem is under-reporting of monitoring and health-based violations and inventory characteristics. The most significant under-reporting occurs in monitoring violations. Even though those are separate from the health-based violations covered by the indicator, failures to monitor could mask treatment technique and MCL violations. Such under-reporting of violations limits EPA's ability to quantify accurately the number of people affected by health-based violations.

Data Sources

The underlying database for this indicator is EPA's Safe Drinking Water Information System/Federal version.
http://www.epa.gov/safewater/data/pdfs/factoids_2003.pdf [NOTE: the FY2004 factoids have been provided for this indicator, but are not yet posted online]

http://www.epa.gov/safewater/data/getdata.html

References

FY2004 factoids, currently unpublished (see data source below). Expected to be posted anytime.

EPA June 2004 Safe Drinking Water Act 30th Anniversary Fact Sheet: Drinking Water Monitoring, Compliance, and Enforcement.
http://www.epa.gov/safewater/sdwa/30th/factsheets/monitoring_compliance.html

EPA June 2004. Safe Drinking Water Act 30th Anniversary Fact Sheet: Drinking Water Standards and Health Effects.
http://www.epa.gov/safewater/sdwa/30th/factsheets/standard.html

EPA June 2004. Safe Drinking Water Act 30th Anniversary Fact Sheet: Glossary.
http://www.epa.gov/safewater/sdwa/30th/factsheets/glossary.html

U.S. Census Bureau 2005. Monthly National Population Estimates.
http://www.census.gov/popest/national/NA-EST2004-01.html
U.S. Geological Survey 2004 revision. Estimated Use of Water in the United States in 2000.
http://water.usgs.gov/pubs/circ/2004/circ1268/

Graphics

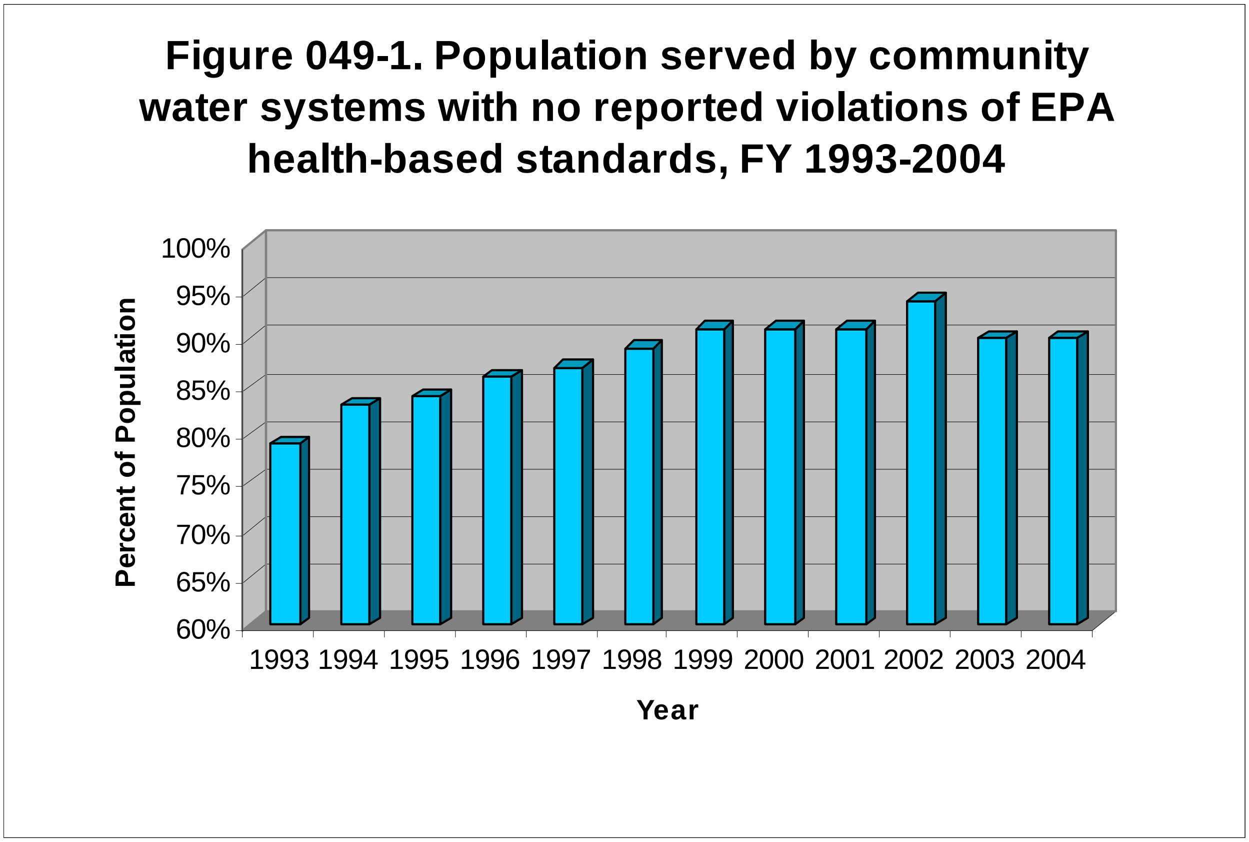
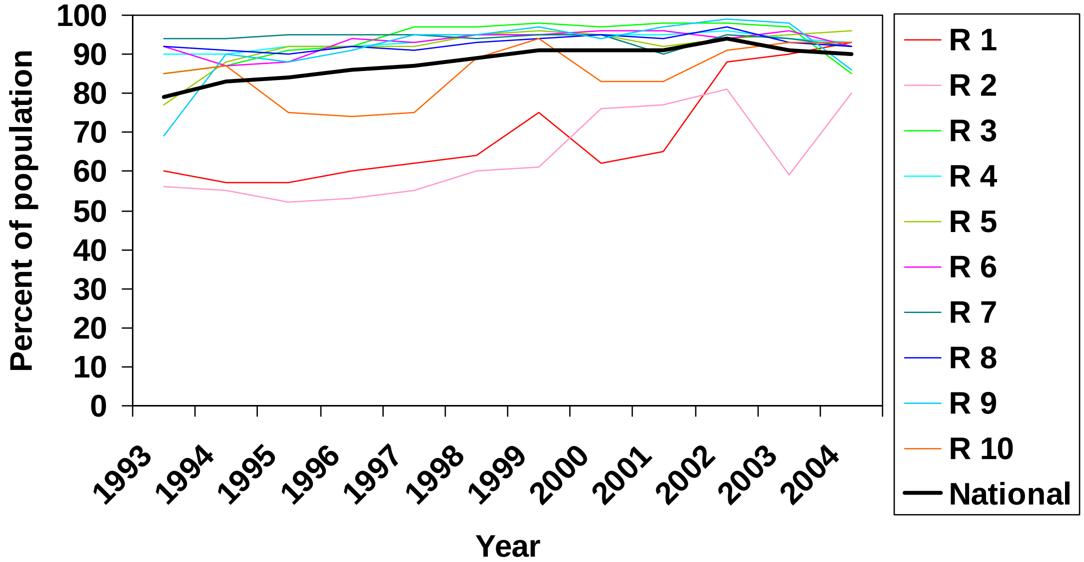


Figure 049-1. Population served by community water systems with no reported violations of EPA health-based standards, FY 1993-2004
Percent of Population
100%
95%
90%
85%
80%
75%
70%
65%
60%
1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004
Year

Figure 049-2. Population served by community water systems with no reported violations of EPA health-based standards, by EPA Region



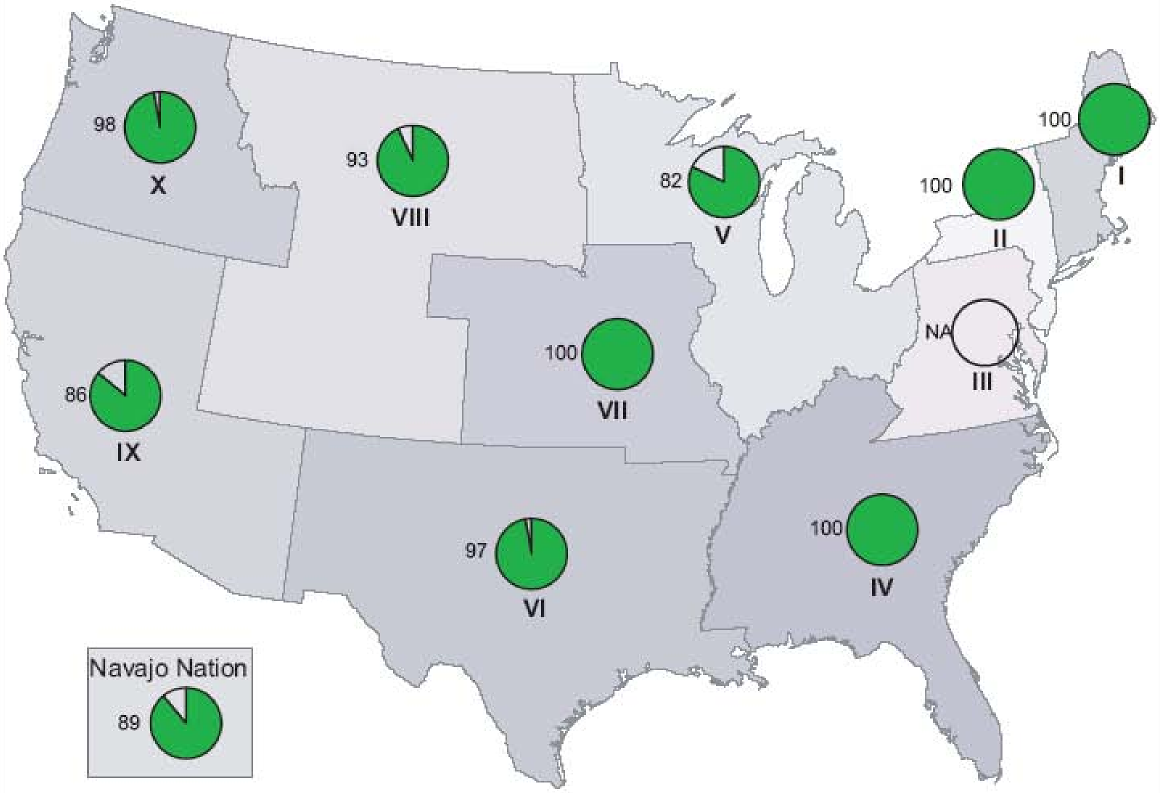
Source: US Environmental Protection Agency, Safe Drinking Water Information System, Federal Version, 2004.

Figure 049-3. Type of reported violations of EPA health-based standards for CWS in FY 2004

Type of violations	Population Served	% of the total population reporting any type of violation	% of the total population served by CWS
Total Coliform, Disinfection By Products, or Surface Water Treatment Rules	24,667,978	90	9
Any type of violation	27,285,178	100	10

Source: US Environmental Protection Agency, Safe Drinking Water Information System, Federal Version. 2004.

Figure 049-4. Percent of Population Served by CWS in Indian Country with No Reported Violations of EPA Health-Based Drinking Water Standards in 2004, by EPA Region



Indian country includes all lands within Indian reservations, all dependent Indian communities, and Indian allotments. EPA Region III has no federally recognized Indian Tribes.
CWS = Community Water Systems

Source: U.S. Environmental Protection Agency, Safe Drinking Water Information System, Federal Version, 2004.

R.O.E. Indicator QA/QC

Data Set Name: POPULATION SERVED BY COMMUNITY WATER SYSTEMS WITH NO REPORTED HEALTH-BASED VIOLATIONS
Indicator Number: 049 (89142)
Data Set Source: EPA Safe Drinking Water Information System/Federal (SDWIS/FEC)
Data Collection Date: Ongoing: 1993 - present
Data Collection Frequency: Indicator calculated annually on fiscal year basis
Data Set Description: Population served by community water systems with no reported violation of federal health-based drinking water standards.
Primary ROE Question: What are the trends in the quality of finished drinking water?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. Based on regulations under the Safe Drinking Water Act, all public water systems (PWS) are required to report monitoring results to States. States determine violations of maximum contaminant levels (MCL) and treatment techniques (TT) and are required to report all violations of Federal health-based drinking water regulations to EPA. The underlying data were developed using consistent analytical methods specified in regulation.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. There is uniform national coverage for this indicator. The underlying data were developed using consistent analytical methods, sampling locations and monitoring frequencies specified in regulation. They result from laboratory analysis following Quality Assurance plans. The data are reviewed by the PWS and then are reviewed by the State. States make determinations of whether violations occurred and report those determinations to EPA. MCLs are health-based standards for drinking water quality. The indicator represents aggregated data and is not based on a model. Sometimes data are not reported within the timeframe specified by regulations.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The indicator is based on a simple calculation that subtracts the population served by systems which have reported violations in a particular year from the total population served by community water systems, and divides the difference by the total population served by all systems.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

There are approximately 54,000 community water systems in the U.S., each of which is required to monitor and report violations according to QA plans which are based in regulation. CWS' routinely monitor and report on whether their systems are meeting standards for over 90 contaminants.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The indicator reports the entire population served by a CWS with a reported violation of a federal health-based drinking water standard. Federal drinking water standards are set to protect the most vulnerable populations.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Yes. MCLs and TTs are federal health-based standards for drinking water quality, arrived at only after scientific review, an extensive public comment period, and in some cases regulatory negotiation with stakeholders.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

For sampling and analytical requirements as listed in National Primary Drinking Water Regulations (http://www.access.gpo.gov/nara/cfr/waisidx_02/40cfr141_02.html). For analytical methods (listed by contaminant and by method number and source): http://www.epa.gov/safewater/methods/methods.html.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. http://www.epa.gov/safewater/data/getdata.html is the principal means to access SDWIS/FED data. http://www.epa.gov/safewater/sdwisfed/sdwis.htm contains numerous materials including technical and software documentation, data dictionary, fact sheets, and related documents describing, characterizing, and providing partial access to the SDWIS/FED database. The EPA website Envirofacts (http://www.epa.gov/enviro/html/sdwis/sdwis_query.html) makes a sub-set of SDWIS/FED information easily available to anyone with access to the Internet. The fact sheet entitled "Information Available From the Safe Drinking Water Information System" (http://www.epa.gov/safewater/sdwisfed/sfed2.html) provides more detailed information on the types of data that are available from SDWIS/FED. SDWIS/FED drinking water information that is not on the Internet is available to the public under the Freedom of Information Act (FOIA), except for well and intake location data which have been determined to be homeland security-sensitive and will not be released to the public. Any individual (including non-U.S. citizens), corporation or association, public interest group, and local, state or foreign government, can request SDWIS/FED information under FOIA (http://www.epa.gov/safewater/foia.html). Multidimensional aggregated data on water systems and violations is also available through MS Excel PivotTables® at http://www.epa.gov/safewater/data/pivottables.html..

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. These data are the reported system compliance and inventory results from all primacy agencies.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The procedures are documented in the Drinking Water Data Reliability Analysis and Action Plan (2003): http://www.epa.gov/safewater/data/pdfs/reports_draap_final_2003.pdf.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

N/A. This indicator does not portray data beyond the time and spatial locations where measurements were made.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No. Recent state data verification and other quality assurance analyses indicate that the most significant data quality problem is under-reporting of monitoring and health-based violations and inventory characteristics. The most significant under-reporting occurs in monitoring violations. Even though those are not covered in the health-based violation category, which is covered by the indicator, failures to monitor could mask treatment technique and MCL violations. Under-reporting of violations could result in the estimates of population served being either high or low.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Routine data quality assurance and quality control analyses of the Safe Drinking Water Information System (SDWIS) by EPA have revealed a degree of non-reporting of monitoring and reporting requirements (discussed in T4Q2, above). As a result of these data quality problems, the baseline statistic of national compliance with health-based drinking water standards likely is lower than previously reported. Currently, SDWIS serves as the best source of national information.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

While the accuracy of violations data reported to EPA continues to be very good, the data are highly incomplete, particularly for monitoring and reporting violations. Under-reporting and late reporting of water system violations data by states to EPA affect the ability to accurately report the quality of our nation's drinking water. EPA last quantified the quality of violations data in 2004 for the period 1999 to 2001. Based on this analysis, the agency estimated that 65% of the violations data that States report were complete and accurate. Failures to monitor could mask treatment technique and MCL violations. Such under-reporting of violations limits EPA's ability to: 1) accurately portray the amount of people affected by health-based violations, 2) undertake geo-spatial analysis, 3) integrate and share data with other systems, and 4) precisely quantify the population served by systems which are meeting the health-based standards. Therefore, the estimates of population served could by high or low. Also, the percentage of the population served by systems that have at least one health-based violation is very small (e.g., 24 million in 2003), and heavily influenced by four systems that together served more than 10 million customers in 2003, including one, the New York City – Croton Reservoir system (serving 6.6 million customers) that reports a Treatment Technique violation because it does not yet filter its water, as required by the Surface Water Treatment Rule, even though it hasn't measured an exceedance of an MCL or another TT.

Indicator: Coastal Fish Tissue Contaminants Index (335)

Contaminants in fish tissue not only affect their own health and ability to reproduce, but also affect the many species that feed on them. Contaminants also may make fish unsuitable for human consumption (EPA 2000).

This indicator, derived from an indicator in EPA's Coastal Condition Report (EPA 2004), is based on National Coastal Assessment (NCA) survey data from 653 estuarine sites throughout the United States (except Louisiana, Florida, and Puerto Rico). For the Great Lakes, only non-probabilistic data were available. Fish and shellfish analyzed in the survey included Atlantic croaker, white perch, catfish, flounders, scup, blue crab, lobster shrimp, whiffs, mullet, tomcod, spot, weakfish, halibut, soles, sculpins, sanddabs, basses and sturgeon. At each site, five to ten whole-body fish samples were tested for 90 contaminants, 16 of which have EPA-established risk guidelines for recreational fishers. Contaminant concentrations in fish were compared with established EPA guidelines to assess risks to human health (USEPA 2000). For most fish this is done using whole body concentrations, but for mercury, which concentrates in the edible fillet portion of the fish, a factor of 3.0 was used to correct whole-body concentrations in order to approximate fillet concentrations. The factor, 3.0, represents the median value (range 1.5-5.0) found in the available literature (Windom and Kendall 1979; Mikac et al. 1985; Schmidt and Brumbaugh 1990; Kannen et al. 1998; Canadian Council of Ministers of the Environment 1999).

Each site was rated high, moderate, or low if the fish tissue concentrations fell below, within, or above the risk guideline ranges, respectively. Regions were rated high if (1) more than 20% of the sites were in high condition and fewer than 50% were in moderate or low condition; moderate (3) if 10-20% of sites were in low condition, or fewer than 50% were in high condition; and low (5) if more than 20% of sites were in low condition.

What the Data Show

Fish tissue contamination in the nation's estuaries as a whole were rated moderate (2.7), but six EPA regions were rated - low (Figure 335-1). Only one EPA Region (4) had high fish tissue index scores, and Great Lakes fish were rated moderate. Nationwide, 22% of sites had low fish tissue scores, 15% had moderate scores, and 63% had high scores. More than 1/3 of the sites had low scores in four EPA Regions (1,3, 6, and 9).

Nationwide, PCBs were responsible for poor low condition at the most sites (18%), followed by muscle tissue mercury (17%), total DDT (12%), and total PAHs (5%) (Figure 335-2). Inorganic arsenic, selenium, chlordane, endosulfan, endrin, heptachlor epoxide, hexachlorobenzene, lindane and Mirex were below EPA guidelines for all fish sampled (Figure 335-2).

Indicator Limitations

- The coastal areas of Alaska and Hawaii have been sampled, but not yet assessed.
- Whole-body contaminant concentrations in fish overestimate the risk of consuming only the fillet portion of the fish, with the exception of mercury and cadmium (which are generally underestimated).
- Some fish samples used in the survey were non-market-size juveniles, which are known to have lower contaminant levels than larger, market-sized fish.
- Samples are collected during an index period from July – September, and the indicator is only representative of this time period , but it is not likely that contaminant or TOC levels vary from season to season.

- There is no trend data for this indicator. Fish tissue contaminants are characterized by whole-body concentrations and are compared to EPA risk-based consumption guidelines in the NCCR II. In the NCCR I, fish contaminants were based on fillet concentrations and compared to FDA criteria.

Data Sources

The data source for this indicator is the National Coastal Condition Report II, U.S. Environmental Protection Agency, 2004. http://www.epa.gov/owow/oceans/nccr/2005/downloads.html

References

Canadian Council of Ministers of the Environment (CCME). 1999. Protocol for the Derivation of Canadian Tissue Residue Guidelines for the Protection of Wildlife that Consume Aquatic Biota. Prepared by the Task Force on Water Quality Guidelines.
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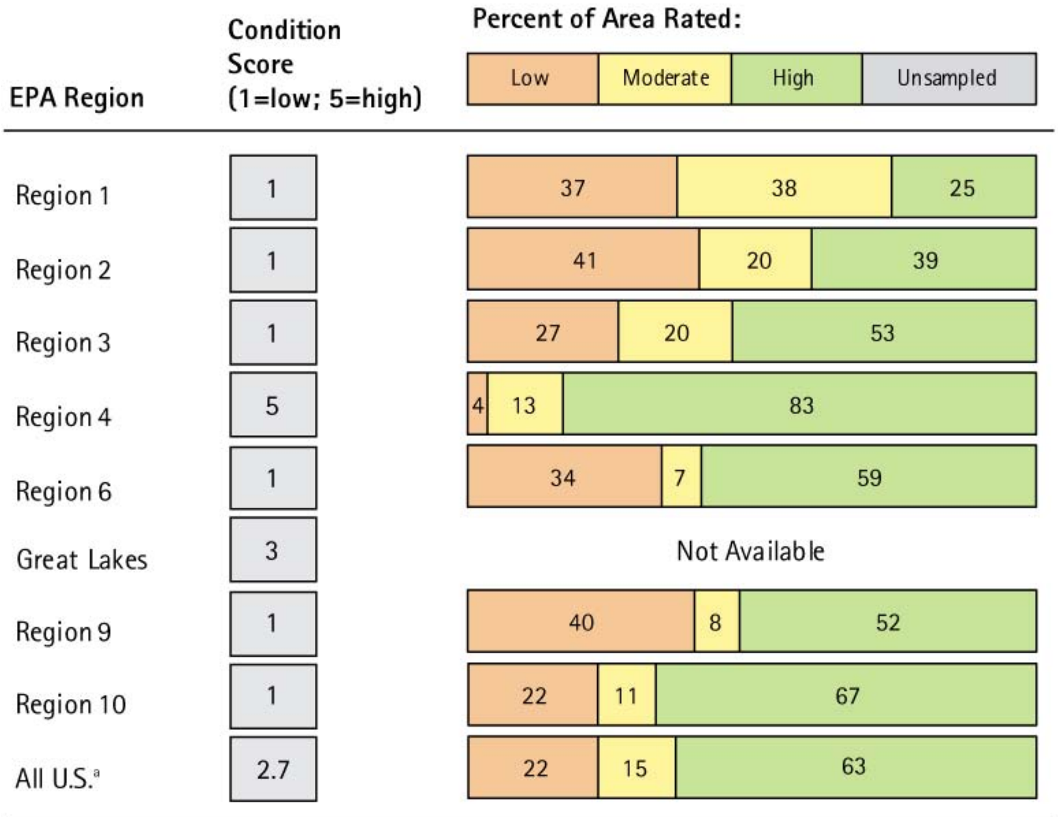
US Environmental Protection Agency. 2000. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. EPA-823-B-00-008. Available at http://www.epa.gov/waterscience/library/fish/.

Windom, H.L. and D.R. Kendall. 1979. Accumulation and biotransformation of mercury in coastal and marine biota. Pp. 303-323. In: Nriagu, J.O. (ed.) Biogeochemistry of Mercury in the Environment. Elsevier, Amsterdam.

Graphics

Figure 335-1: Overall Summary of Condition Based on the Fish Tissue Index[b]



Source: National Coastal Condition Report II, US EPA, 2004.

Notes: [a] The national score is based on an aerially weighted mean of the regional scores.

[b] The fish tissue contaminants index is based on a whole-body analysis of the fish.

Figure 335-2. Contaminant Concentrations in Fish Tissue (Percent of U.S. Sites in Each Guideline Category)[a]

Contaminant	Guideline	Percent of Sites in Guideline Category: Exceeds	Within	Below
Arsenic (inorganic)[b]	3.5 - 7.0	0	0	100
Cadmium	0.35 - 0.7	<1	<1	99
Mercury (total body)	0.12 – 0.23	<1	<1	99
Mercury (muscle tissue)	0.12 – 0.23	18	24	58
Selenium	5.9 – 12.0	0	0	100
Chlordane	0.59 – 1.2	0	0	100
DDT	.059 – 0.12	8	4	88
Dieldrin	.059 – 0.12	<1	0	99
Endosulfan	7.0 – 14.0	0	0	100
Endrin	0.35 – 0.70	0	0	100
Heptachlor Epoxide	.015 - .031	0	0	100
Hexaclorobenzene	0.94 – 1.9	0	0	100
Lindane	0.35 – 0.70	0	0	100
Mirex	0.23 – 0.47	0	0	100
Toxaphene	0.29 - 0.59	<1	0	99
PAH (Benzo(a)pyrene)	.0016-.0032	3	2	95
Total PCBs	.023 - .047	19	11	70

Risk Guidelines for Recreational Fishers for Four 8-Ounce Meals Per Month for Non-Cancer Risk (except Total PAHs which is cancer risk) (concentration in ppm) and percentage of coastal sites in US sampled by NCA within these guideline categories Source: National Coastal Condition Report II, U.S. EPA, 2004.

[a]For most contaminants, the comparison is based on whole fish body concentrations, but for mercury, which concentrates in the edible fillet portion of the fish, a factor of 3.0 was used to correct whole-body concentrations in order to approximate fillet concentrations. The factor, 3.0, represents the median value (range 1.5-5.0) found in the available literature (Windom and Kendall 1979; Mikac et al. 1985; Schmidt and Brumbaugh 1990; Kannen et al. 1998; Canadian Council of Ministers of the Environment 1999).

[b]Inorganic arsenic estimated as 2% of total arsenic.

R.O.E. Indicator QA/QC

Data Set Name: COASTAL FISH TISSUE CONTAMINANTS INDEX
Indicator Number: 285 (89143)
Data Set Source: EPA/EMAP/NCA
Data Collection Date: 1999-2000
Data Collection Frequency: annually
Data Set Description: This index reflects the levels of chemical contaminants in target fish/shellfish species using concentrations as an indicator.
Primary ROE Question: What are the trends in the contamination/quality/safety of consumablefish and shellfish contamination?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Methods described for this survey represent a combination of standard, scientifically accepted sampling and analytical methodologies. They are described in ; US EPA 2001. National Coastal Assessment: Field Operations Manual. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA 620/R-01/003. pp72. U.S. EPA. 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual-Estuaries, Volume 1: Biological and Physical Analyses. U.S. Environmental Protection Agency, Office of Research and Development , Narragansett, RI. EPA/620/R-95/008. http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

There is an entire portion of the EMAP website dedicated to principles and implementation of the NCA monitoring design and analysis. http://www.epa.gov/nheerl/arm/index.htm Diaz-Ramos, S., Stevens, D.L., Jr and Olsen, A.R. (1996) EMAP Statistical Methods Manual. Rep. EPA/620/R-96/002, U.S. Environmental Protection Agency, Office of Research and Development, NHEERL-WED, Corvallis, Oregon. Olsen, A.R., Stevens, D.L., Jr. and White, D. (1998) Application of global grids in environmental sampling. Computing Science and Statistics, 30, 279-84. Stevens, D.L., Jr. (1997) Variable density grid-based sampling designs for continuous spatial populations. Environmetrics, 8, 167-95. Stevens, D.L., Jr. and Olsen, A.R. (1999) Spatially restricted surveys over time for aquatic resources. Journal of Agricultural, Biological, and Environmental Statistics, 4, 415-28. Stevens, D.L., Jr. and Urquhart, N.S. (1999) Response designs and support regions in sampling continuous domains. Environmetrics, 11, 13-41. Stevens, D. L., Jr. and Olsen, A. R. Variance Estimation for Spatially Balanced Samples of Environmental Resources. Environmetrics 14:593-610. Stevens, D. L., Jr. and A. R. Olsen (2004). "Spatially-balanced sampling of natural resources." Journal of American Statistical Association 99(465): 262-278.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Contaminant residues are examined in the fillets, whole bodies, or specific organs of target finfish and shell fish and compared with risk-based EPA fish contaminant guidance values.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Sampling for the indicator presents available information on a national scale for the conterminous 48 states and Puerto Rico. There are 50 sites sampled each year for each of the states or territory. Data collection began in 1999 and is ongoing in 2004.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Sensitive populations or ecosystems are represented to a limited extent. The monitoring design at the scale presented is to characterize condition on a regional scale, not specific areas.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Threshold values for contaminant levels in fish and shellfish tissue are based on the consumption of four 8 ounce meals per month and assessed for noncancer and cancer health endpoints. No guidance criteria exist to assess the ecological risk of whole body contaminants for fish, but the EPA advisory guidance can be used for estimating advisory determinations. U.S. EPA. 2000c. Guidance for assessing chemical contaminant data for use in fish advisories, volume 2: Risk Assessment and Fish Consumption Limits. EPA-823-B-00-008. Office of Water, Washington, DC.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

U.S. EPA. 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual-Estuaries, Volume 1: Biological and Physical Analyses. U.S. Environmental Protection Agency, Office of Research and Development , Narragansett, RI. EPA/620/R-95/008. U.S. EPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Project Plan. . U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/002. U.S. EPA. 2001. National Coastal Assessment Field Operations Manual. U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/003.
http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

http://www.epa.gov/emap/nca/html/data/index.html Stephen Hale, U.S. EPA, Atlantic Ecology Division, (401) 782-3048

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes, Using the documentation provided for the design can be reproduced by a competent statistician. All of the field sampling and analytical methods are also well documented.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

U.S. EPA. 2001. Environmental Monitoring and Assessment Program (EMAP): National Coastal Assessment Quality Assurance Project Plan. . U.S. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Gulf Ecology Division, Gulf Breeze, FL. EPA/620/R-01/002 Hale, S., J. Rosen, D. Scott, J. Paul, and M. Hughes. 1999. EMAP Information Management Plan: 1998-2001. U.S. Environmental Protection Agency, Office of Research and Development , Narragansett, RI. http://www.epa.gov/emap/html/pubs/docs/groupdocs/estuary/index.html

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

There is an entire portion of the EMAP website dedicated to principles and implementation of the NCA monitoring design and analysis. http://www.epa.gov/nheerl/arm/index.htm Diaz-Ramos, S., Stevens, D.L., Jr and Olsen, A.R. (1996). See T1Q2.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes, measurements of uncertainty are provided with each indicator. http://www.epa.gov/nheerl/arm/index.htm

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Inconsistency in application of the design, sample collection, or sample analysis. These are controlled through standardization of methodologies, publication of operational manuals, and training of personnel involved. It is monitored through quality assurance requirements and audits.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The only data gaps would be from missing or lost samples. In this event The analyses is performed without those sites. Any error associated with the index may only increase slightly, but would be controlled by the number of sites and the survey design.

Indicator: Contaminants in Lake Fish Tissue (335)

Lakes and reservoirs throughout the United States provide important sport fisheries and other recreational opportunities. Lake ecosystems also provide critical habitat for aquatic species and support wildlife populations that depend on aquatic species for food. Lakes and reservoirs occur in a variety of landscapes (e.g., urban, agricultural, and wilderness), and they can receive contaminants from several sources, including direct discharges into the water, air deposition, and agricultural or urban runoff. A group of contaminants of particular concern are the persistent, bioaccumulative, and toxic (PBT) chemicals. These contaminants are highly toxic, long-lasting chemicals that enter lakes and reservoirs and accumulate in the fish. They can reach levels that affect the health of people and wildlife that eat fish from these environments.

This indicator is derived from fish samples collected and analyzed for EPA's National Study of Chemical Residues in Lake Fish Tissue. The data generated from this probabilistic survey (Olsen et al. 1998; EPA 1999; Stevens et al. 2003 and 2004) are designed to estimate the national distribution of the mean levels of selected persistent, bioaccumulative, and toxic chemical residues in fish tissue from lakes and reservoirs of the contiguous United States (lower 48 states). Fish samples were collected from 500 lakes and reservoirs over a four-year period (2000-2003). The sampling locations were statistically selected from the estimated 147,000 target lakes and reservoirs in the lower 48 states based on an unequal probability survey design. The lakes are divided into six size categories, with varying probabilities assigned to each category to achieve a similar number of lakes in each category. Lake sizes range from 1 hectare (about 2.5 surface acres) to over 5,000 hectares (including lakes up to 900,000 surface acres), were at least1 meter (3 feet) deep, and had permanent fish populations.

Sampling teams applied consistent materials and methods nationwide to collect composites of one predator species (e.g., bass or trout) and one bottom-dwelling species (e.g., carp or catfish) at each lake or reservoir. EPA's Field Sampling Plan for the National Study of Chemical Residues in Lake Fish Tissue (EPA 2000a) describes the procedures for fish sample collection, handling, and shipping. Composites consisted of five adult fish of similar size. A single laboratory prepared fish tissue samples for analysis in a strictly controlled environment. Fillets were analyzed for predator composites, and whole bodies were analyzed for bottom dweller composites. Predator composites provide data on edible tissue relevant to human health, and bottom dweller composites provide whole body data relevant to wildlife consumption. Analyses of the fish tissue for each chemical group (e.g., PCBs or organochlorine pesticides) were conducted by the same laboratory using the same standard analytical method for the duration of the study. Quality assurance and quality control procedures for collecting and analyzing samples for this indicator are described in quality assurance project plans (QAPPs) prepared for the study (EPA 2000b and 2000c).

The indicator consists of statistical results from analysis of predator and bottom dweller tissue concentrations for 15 chemicals or chemical groups. Fourteen of these chemicals or chemical groups also appear in the Coastal Fish Tissue indicator (285). They include mercury, arsenic (total inorganic), dioxins/furans, total PCBs, and 11 organochlorine pesticides. Statistics for the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles of the concentrations of each chemical in fish tissue are presented for predator fillets and for whole bottom-dwelling fish.

Mercury in fish can originate from a variety of sources, with the primary source being from atmospheric deposition. EPA estimates that on average over three quarters of the mercury deposited in the U.S. comes from international sources with the remaining coming from U.S. and Canadian sources (EPA 2005), although the scientific understanding of mercury atmospheric chemistry is still evolving, and there is considerable uncertainty associated with the estimates of global source impacts. In addition, production of PCBs for use ceased in 1977; chlordane was banned in 1988; DDT was banned in 1972; and known and quantifiable industrial emissions of dioxin in the United States are estimated to have been reduced by approximately 90% from 1987 levels (EPA, 2004).

What the Data Show

Mercury, polychlorinated biphenyls (PCBs), dioxins and furans, and DDT are widely distributed in lakes and reservoirs in the contiguous 48 states (Figures 335-1, 335-2). Mercury and PCBs were detected in 100% of both the predator and bottom dweller composite samples. Dioxins and furans were detected in 81% of the predator composite samples and in 99% of the bottom dweller composite samples, and DDT was detected in 78% of the predator composites and 98% of the bottom dweller composites. Median concentrations in predator fillets (i.e., half of the fish tissue samples had higher values) were as follows: mercury, 0.285 ppm; total PCBs, 2.161 ppb; dioxins and furans, 0.006 ppt [TEQ]; and total DDT, 1.473 ppb (Figure 1). Median concentrations in whole bottom-dwelling fish were lower for mercury (0.069 ppm), but higher for total PCBs (13.88 ppb), dioxins and furans (0.406 ppt [TEQ]), and total DDT (12.681 ppb) (Figure 335-2).

A number of chemicals analyzed for this study were not detected in any of the fish tissue samples. This includes 10 of the 46 pesticides (one organochlorine and all nine organophosphate pesticides) and 32 of the 40 semivolatile organic chemicals (e.g., polycyclic aromatic hydrocarbons (PAHs) and chlorobenzenes) (EPA National Lake Fish Tissue Study report in progress).

Indicator Limitations

- Survey data are only available for the contiguous 48 states.
- The Great Lakes, the Great Salt Lake, and lakes without permanent fish populations were not part of the target population.
- Due to the inaccessibility (e.g., landowner denial of access) of some target lakes, the results are representative of the sampled population of lakes (approximately 80,000) rather than the target population of lakes (approximately 147,000) in the lower 48 states.

Data Sources

The data source for this indicator is the National Study of Chemical Residues in Lake Fish Tissue, U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology. http://www.epa.gov/waterscience/fishstudy/. The report on this study is in progress.

References

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EPA. 1999. National Study of Chemical Residues in Lake Fish Tissue: Study Design. U.S. Environmental Protection Agency, Office of Science and Technology, Washington, D.C.

EPA. 2000a. Field Sampling Plan for the National Study of Chemical Residues in Lake Fish Tissue. U.S. Environmental Protection Agency, Office of Science and Technology, Washington, D.C. EPA-823-R-02-004.

EPA. 2000b. Quality Assurance Project Plan for Sample Collection Activity in the National Study of Chemical Residues in Lake Fish Tissue. U.S. Environmental Protection Agency, Office of Science and Technology, Washington, D.C. EPA-823-R-02-005.

EPA. 2000c. Quality Assurance Project Plan for Analytical Control and Assessment Activities in the National Study of Chemical Residues in Lake Fish Tissue. U.S. Environmental Protection Agency, Office of Science and Technology, Washington, D.C. EPA-823-R-02-006.

EPA. 2004. National Listing of Fish Advisories. Fact Sheet. U.S. Environmental Protection Agency, Office of Water, Washington, D.C. EPA 823-F-04-016.

EPA, 2005. Technical Support Document. Revision of December 2000 Regulatory Finding on the Emissions of Hazardous Air Pollutants From Electric Utility Steam Generating Units and the Removal of Coal- and Oil-Fired Electric Utility Steam Generating Units from the Section 112(c) List: Reconsideration. Office of Air and Radiation, Washington, D.C.

Graphics

Figure 335-1. Tissue Concentration Estimates for Predators

Chemical	Number of Samples	Number of Samples above MDL*	Percentiles for Fillet Tissue Concentrations (ppm)						
			5th	10th	25th	50th	75th	90th	95th
Mercury	486	486	0.059	0.089	0.177	0.285	0.432	0.562	0.833
Total PCBs	486	486	0.000351	0.000494	0.001000	0.002161	0.008129	0.018159	0.033161
TEQ Dioxins/Furans only	486	395	0	0	0	0.000000006	0.000000046	0.000000109	0.000000318
Total Inorganic Arsenic	486	2	0	0	0	0	0	0	0
Total Chlordane	486	96	0	0	0	0	0	0.003617	0.008266
Total DDT	486	378	0	0	0	0.001473	0.006938	0.019661	0.030568
Dicofol	486	15	0	0	0	0	0	0	0
Dieldrin	486	24	0	0	0	0	0	0	0.001193
Total Endosulfan	486	18	0	0	0	0	0	0	0
Endrin	486	3	0	0	0	0	0	0	0
Heptachlor epoxide	486	6	0	0	0	0	0	0	0
Hexachlorobenzene	485	0	0	0	0	0	0	0	0
Lindane (gamma BHC)	486	28	0	0	0	0	0	0	0.000994
Mirex	486	10	0	0	0	0	0	0	0
Toxaphene	486	0	0	0	0	0	0	0	0

* MDL = Method Detection Limit

Figure 335-2. Tissue Concentration Estimates for Bottom Dwellers

Chemical	Number of Samples	Number of Samples above MDL*	Percentiles for Fillet Tissue Concentrations (ppm)						
			5th	10th	25th	50th	75th	90th	95th
Mercury	395	395	0.019	0.020	0.039	0.069	0.124	0.220	0.247
Total PCBs	395	395	0.001579	0.002308	0.005146	0.013876	0.070050	0.130787	0.198324
TEQ Dioxins/Furans only	395	393	0.000000019	0.000000059	0.000000165	0.000000406	0.000001067	0.000001770	0.000002006
Total Inorganic Arsenic	395	36	0	0	0	0	0	0	0.037
Total Chlordane	395	197	0	0	0	0.001653	0.009313	0.025964	0.030931
Total DDT	395	388	0.001080	0.001821	0.004226	0.012681	0.035345	0.153923	0.218625
Dicofol	395	8	0	0	0	0	0	0	0
Dieldrin	395	73	0	0	0	0	0	0.003436	0.024613
Total Endosulfan	395	23	0	0	0	0	0	0	0
Endrin	395	14	0	0	0	0	0	0	0
Heptachlor epoxide	395	25	0	0	0	0	0	0	0.000676
Hexachlorobenzene	395	0	0	0	0	0	0	0	0
Lindane (gamma BHC)	395	31	0	0	0	0	0	0.000729	0.001541
Mirex	395	19	0	0	0	0	0	0	0.001866
Toxaphene	395	1	0	0	0	0	0	0	0

* MDL = Method Detection Limit

R.O.E. Indicator QA/QC

Data Set Name: CONTAMINANTS IN LAKE FISH TISSUE
Indicator Number: 335 (89141)
Data Set Source:
Data Collection Date: UNKNOWN
Data Collection Frequency:
Data Set Description: Contaminants in Lake Fish Tissue
Primary ROE Question: What are the trends in the contamination/quality/safety of consumable fish and shellfish?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

The chemical measurements upon which the indicator for the National Study of Chemical Residues in Lake Fish Tissue (or National Lake Fish Tissue Study) is based are widely accepted as scientifically and technically valid. Fish tissue samples for this study were analyzed for 268 target chemicals using a number of standard EPA analytical methods, including Method 1613B (dioxins/furans), Method 1625 (semi-volatile organics), Method 1631B (mercury), Method 1632A (arsenic), Method 1656A (organochlorine pesticides), Method 1657A (organophosphate pesticides), and Method 1668 (PCBs). A list of the target chemicals (analytes) and summary descriptions for each of the methods are posted under AFish Tissue Sampling@ on the National Lake Fish Tissue Study website at www.epa.gov/waterscience/fishstudy/. The units for chemical concentration vary, depending on the method. The units for the chemical concentrations for each chemical group are specified in the method and reported as follows: ng/kg (ppt) for dioxins/furans, ug/kg (ppb) for semi-volatile organics, ng/g (ppb) for mercury, ug/g (ppm) for arsenic, ug/kg (ppb) for pesticides, and ng/kg (ppt) for PCBs. A discussion of the uncertainty associated with the reporting thresholds is included in Section 4.2.2 of the Quality Assurance Report for the National Study of Chemical Residues in Lake Fish Tissue: Year 1 and Year 2 Analytical Data (January 2003), which is available on the National Lake Fish Tissue Study website.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

The sampling design and field sampling plan used to collect the data over time and space for the National Lake Fish Tissue Study are based on sound scientific principles. The objective of the National Lake Fish Tissue Study is to estimate the national distribution of the mean levels of selected persistent, bioaccumulative, and toxic chemical residues in fish tissue from lakes and reservoirs of the contiguous United States. An unequal probability sample design was applied to address the study objective. Probability sampling provides the basis for estimating resource extent and condition, for characterizing trends in extent or condition, and for representing spatial pattern, all with known certainty. It is an essential requirement for a program such as the National Lake Fish Tissue Study that aims to describe the condition of national resources. A total of 500 locations were sampled over a period of four years to collect fish for the National Lake Fish Tissue Study. The target population for the study is all lakes and reservoirs within the contiguous United States, excluding the Laurentian Great Lakes and the Great Salt Lake. This study defines a lake as a permanent body of water of at least one hectare (2.47 acres) in surface area with a minimum of 1,000 m2 of open (unvegetated) water and a minimum depth of one meter. The lakes in this study must also have a permanent fish population. Olsen, Stevens, and White described the procedures used to select the unequal probability sample of lakes in the following reference: Olsen, A.R., D.L. Stevens, Jr., and D. White. 1998. Application of global grids in environmental sampling. Computing Science and Statistics 30:279-284. The sampling design and lake selection process are also summarized in Section 7 of the Quality Assurance Project Plan (QAPP) for Sample Collection Activities for a National Study of Chemical Residues in Lake Fish Tissue. The final list of 500 lakes appears in Appendix A of the Sample Collection QAPP, which is available under AFish Sampling@ on the National Lake Fish Tissue website at www.epa.gov/waterscience/fishstudy/. Sampling methods and monitoring requirements are described in detail in the Field Sampling Plan for the National Study of Chemical Residues in Lake Fish Tissue, which is available under AFish Sampling@ on the National Lake Fish Tissue Study website at www.epa.gov/waterscience/fishstudy/. The study procedures for collection and preparation of fish composite samples for chemical analysis are based on recommended procedures in EPA's Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1: Fish Sampling and Analysis, Third Edition (2000), which is available under ANational Guidance@ on the Fish Advisory website at www.epa.gov/waterscience/fish/.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Not applicable.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The National Lake Fish Tissue Study is a comprehensive, representative survey of chemical contaminants in fish tissue from lakes and reservoirs in the contiguous United States. The fish study indicator provides data to describe national distributions of mean concentrations of 15 chemicals in freshwater fish tissue and assess the safety of consuming recreational fish species from lakes and reservoirs in the lower 48 states. Fish were collected for this study from 500 lakes and reservoirs in the lower 48 states over a period of four years. Each location was sampled once, and replicate fish composite samples were collected about 10% of the lakes and reservoirs. The 500 sampling locations are listed in Appendix A of the QAPP for Sample Collection Activities for a National Study of Chemical Residues in Lake Fish Tissue, which is available online at www.epa.gov/waterscience/fishstudy/. Sampling for the study began in October 1999 and ended in November 2003.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Since it is a probabilistic design, the sampling design represents sensitive populations or ecosystems in proportion to their occurrence in the natural environment.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

The proposed National Lake Fish Tissue Study indicator reports statistical summary information only; various human health screening values and consumption thresholds exist that can be applied to interpret these data (e.g., Table 5-3 in EPA's Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1: Fish Sampling and Analysis, Third Edition (2000) and Tables 4-1 through 4-25 in EPA's Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2: Risk Assessment and Fish Consumption Limits, Third Edition (2000); both fish advisory guidance documents are available online at www.epa.gov/waterscience/fish/).

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The following documents describe the sampling procedures used for the National Lake Fish Tissue Study; the first two documents are online at www.epa.gov/waterscience/fishstudy/ and the third document is online at www.epa.gov/waterscience/fish/

Sample Collection Activities QAPP:
U.S. Environmental Protection Agency (USEPA). 2000. Quality Assurance Project Plan for Sample Collection Activity in the National Study of Chemical Residues in Lake Fish Tissue. U.S. Environmental Protection Agency, Office of Science and Technology, Washington, D.C. EPA-823-R-02-005.

Field Sampling Plan:
U.S. Environmental Protection Agency (USEPA). 2002. Field Sampling Plan for the National Study of Chemical Residues in Lake Fish Tissue, First Revision. U.S. Environmental Protection Agency, Office of Science and Technology, Washington, D.C. EPA-823-R-02-004.

Fish Advisory Guidance for Fish Sampling and Analysis:
U.S. Environmental Protection Agency (USEPA). 2000. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1: Fish Sampling and Analysis, Third Edition. U.S. Environmental Protection Agency, Office of Water, Washington, D.C. EPA-823-B-00-007.

The following documents describe the analytical procedures used for the National Lake Fish Tissue Study; both documents are online at www.epa.gov/waterscience/fishstudy/

Analytical Activities QAPP:
U.S. Environmental Protection Agency (USEPA). 2000. Quality Assurance Project Plan for Analytical Control and Assessment Activities in the National Study of Chemical Residues in Lake Fish Tissue. U.S. Environmental Protection Agency, Office of Science and Technology, Washington, D.C. EPA-823-R-02-006.

Analytical QA Report (Years 1 and 2):
U.S. Environmental Protection Agency (USEPA). 2003. Quality Assurance Report for the National Study of Chemical Residues in Lake Fish Tissue: Year 1 and Year 2 Analytical Data. U.S. Environmental Protection Agency, Office of Science and Technology, Washington, D.C. EPA-823-C-04-003.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The complete National Lake Fish Tissue Study data set covering the full four years of the study is will be made publicly available as part of the peer review of the indicator, currently available for internal EPA uses only. Prior to the peer review, The Office of Science and Technology (within the Office of Water) has been providing the data in Excel files on CDs in response to requests from EPA programs. These files include metadata and data dictionaries for each of the worksheets in a file. Copies of the National Lake Fish Tissue Study data CD can be obtained from the following contact: Leanne Stahl National Lake Fish Tissue Study Manager OW/OST (4305T) U.S. EPA 1200 Pennsylvania Avenue, NW Washington, DC 20460 202-566-0404 (phone) 202-566-0409 (fax) stahl.leanne@epa.gov The first two years of the fish study data have been released to the public. The National Lake Fish Tissue Study website (www.epa.gov/waterscience/fishstudy) contains an announcement advertising the availability of the data and identifying how to obtain it. CDs are mailed to those who call or send an e-mail message to request the data.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Sufficient information is available to reproduce all components of the National Lake Fish Tissue Study, including lake selection, sample collection, tissue analysis and data analysis. The summaries below describe existing information that could be used to repeat each component of the study.

Lake Selection

The National Lake Fish Tissue Study sampling design is described in detail in the Sample Collection QAPP (*Quality Assurance Project Plan for Sample Collection Activity in the*

National Study of Chemical Residues in Lake Fish Tissue, EPA-823-R-02-005) and summarized in the Field Sampling Plan (*Field Sampling Plan for the National Study of Chemical Residues in Lake Fish Tissue*, EPA-823-R-02-004). Both documents are posted on the fish study website (www.epa.gov/waterscience/fishstudy/). A key component of the sampling design is the lake selection process. The Sample Collection QAPP provides general information about this process, including discussions of the type of survey design applied to this process (unequal probability survey design), the sample frame for the survey (River Reach File Version 3, which was the best national GIS coverage available for lakes in 1999), and the procedures used to select the unequal probability sample of lakes. A detailed explanation of the statistical site selection methodology appears in the following series of references:

Stevens, D.L., Jr. (1997) Variable density grid-based sampling designs for continuous spatial populations. Environmetrics 8: 167-95.

Stevens, D.L., Jr. and A.R. Olsen. (1999) Spatially restricted surveys over time for aquatic resources. Journal of Agricultural, Biological, and Environmental Statistics 4: 415-28.

Stevens, D.L., Jr. and A.R. Olsen. (2003) Variance estimation for spatially balanced samples of environmental resources. Environmetrics 14: 593-610.

Stevens, D.L., Jr. and A.R. Olsen. (2004) Spatially-balanced sampling of natural resources. Journal of American Statistical Association 99 (465): 262-278.

Information from these references can be combined with information from the electronic files used to generate the original and reserve fish study lake lists to re-create the lake selection process. These electronic files are archived on the Office of Research and Development's (ORD's) computer system at their Corvallis, OR facility. Determining the status of each lake selected for the study and documenting this information in an electronic spreadsheet was the final step in establishing the list of target lakes sampled for the study. The Sample Collection QAPP and the Field Sampling Plan list the criteria that a lake must meet to be included in the study. They also discuss documentation of lakes that qualify as lakes for the study, but are inaccessible due to physical barriers or landowner permission not being granted to sample lakes on private property. Electronic records of lake status are being maintained in OST by the fish study manager and in ORD by the fish study team statistician.

Sample Collection

All the critical information for fish sample collection, handling, and shipping is specified in the Standard Operating Procedure (SOP) entitled "Fish Tissue Sample Collection Procedures for a National Study of Chemical Residues in Lake Fish Tissue." This SOP is appended to both the Sample Collection QAPP and the Field Sampling Plan, and both of these documents are available on the fish study website (www.epa.gov/waterscience/fishstudy/). The SOP lists the equipment and materials needed for sample collection, provides step-by-step procedures for collecting the fish samples that include the criteria and target species lists for the two composite types (predators and bottom dwellers) being collected from each lake, and specifies detailed instructions for completing field forms, wrapping and labeling the fish, and packing the fish in coolers for shipment to the sample processing laboratory. Examples of the field forms are included in the SOP, and they could easily be reproduced from electronic files (in WordPerfect format) being maintained for the study.

Tissue Analysis

All fish tissue samples are being processed and analyzed in accordance with procedures that are documented in EPA's *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume I: Fish Sampling and Analysis, Third Edition* (EPA-823-B-00-007), in the *Quality Assurance Project Plan for Analytical Control and Assessment Activities in the National Study of Chemical Residues in Lake Fish Tissue* (EPA-823-R-02-006), and in the *Quality Assurance Report for the National Study of Chemical Residues in Lake Fish Tissue: Year 1 and Year 2 Analytical Data* (EPA-823-C-04-003). All three documents are available online at www.epa.gov/waterscience/fish/ (fish advisory guidance) and at www.epa.gov/waterscience/fishstudy/ (fish study Analytical Activities QAPP and Analytical Data QA report for Years 1 and 2). The Analytical Data QA report summarizes the fish composite processing procedures, refers to the fish advisory guidance (Volume I) for a detailed description of the procedures, and notes two exceptions to the procedures in the fish advisory guidance. The QA report also lists and describes all the analytical methods employed for tissue analysis.

Data Analysis

Statistical procedures for analysis of the National Lake Fish Tissue Study data are described in the Data Analysis QAPP, which is currently in draft form.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Two quality assurance project plans (QAPPs) have been developed for the National Lake Fish Tissue Study that describe quality assurance and quality control (QA/QC) procedures for sample collection activities and for analytical activities: (1) Quality Assurance Project Plan for Sample Collection Activities for a National Study of Chemical Residues in Lake Fish Tissue and (2) Quality Assurance Project Plan for Analytical Control and Assessment Activities in the National Study of Chemical Residues in Lake Fish Tissue. Both QAPPs are available on EPA's fish study website at the following Internet address: www.epa.gov/waterscience/fishstudy/. A third QAPP describing QA/QC procedures for statistical analyses of the study data has been drafted and is undergoing revision before submission for final approval. This QAPP is entitled Data Analysis Activities for the National Study of Chemical Residues in Lake Fish Tissue, and it will be posted on the fish study website once it is approved.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

The statistical survey method used to generalize National Lake Fish Tissue Study results to all lakes and reservoirs in the contiguous 48 states that met the study criteria is described in Section 4.2 of the Quality Assurance Project Plan for Data Analysis Activities for the National Study of Chemical Residues in Lake Fish Tissue. The Data Analysis QAPP is currently in draft form, but should be ready to submit for final approval by the end of June 2005. For this study, there is no generalization over time.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Section 7.7 of the Quality Assurance Project Plan for Data Analysis Activities for the National Study of Chemical Residues in Lake Fish Tissue discusses estimates of uncertainty related to sample size. These estimates can be readily developed for the number of samples of each composite type (predator and bottom dweller) collected for the study. During the study, replicate fish composite samples were collected at about 10% of the sampling sites. Estimates of sampling variability will be generated from the replicate sample results.

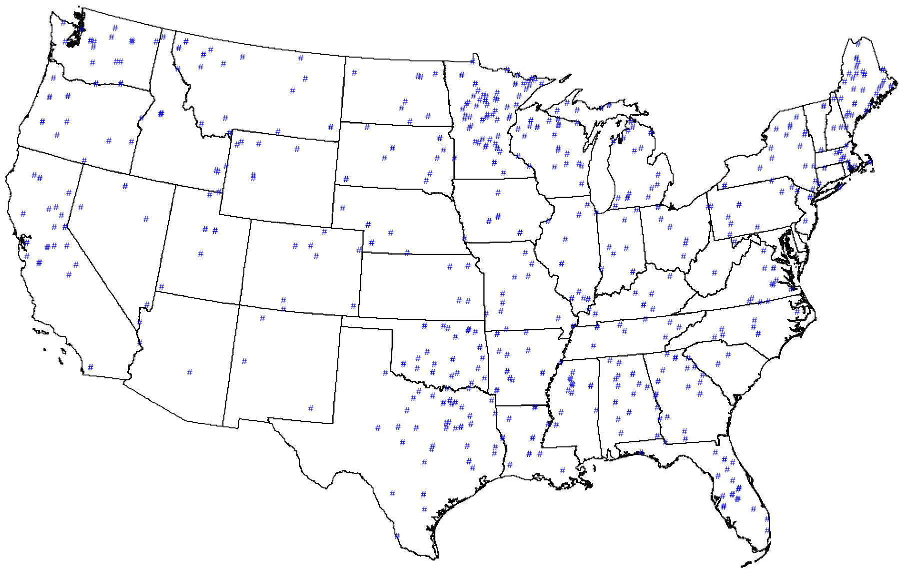
T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Section 4.0 of the Sample Collection QAPP (Quality Assurance Project Plan for Sample Collection Activity in the National Study of Chemical Residues in Lake Fish Tissue, EPA-823-R-02-005) identifies and discusses potential sources and effects of error and bias in the sampling design. Sections 5.0 (training), 7.1 (sample type), and 8.1 (target species) provide additional information about reducing sampling variability in the study. The QAPP is available on the fish study website (www.epa.gov/waterscience/fishstudy/). Results of the statistical analysis of fish tissue data from the National Lake Fish Tissue Study will include some uncertainty, but the confidence intervals will be small enough that the uncertainty will not impact conclusions for the 2006 Report on the Environment (ROE) indicator.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Data for the National Lake Fish Tissue Study are limited to the 48 contiguous United States. Alaska and Hawaii were not included in the study due to resource constraints and study design considerations. Also, in selecting lakes for the study, the Great Lakes and the Great Salt Lake were excluded from the target population. A significant number of target lakes could not be sampled due to physical inaccessibility (e.g., remote locations) or to landowner denial of access to private lakes. This created a gap between the target population and the sampled population of lakes. Therefore, conclusions from statistical analysis of the study data will be applied to the sampled population of approximately 80,000 lakes rather than the target population of approximately 150,000 lakes.

500 Sampling Sites



Charge to the Peer Reviewers: Land Chemical Indicators for the U.S. Environmental Protection Agency's 2007 *Report on the Environment* Technical Document May 20, 2005

The U.S. Environmental Protection Agency (EPA) has asked that independent peer reviewers critically review the indicators that the Agency proposes to use for its 2007 *Report on the Environment*—Technical Document (ROE07 TD). The purpose of this peer review is to ensure that the proposed indicators are appropriate, adequate, and useful for evaluating trends in chemicals used on land and their effects on human health and the environment; meet technical requirements (including the indicator definition and criteria); are properly documented; and are scientifically sound. Separate peer reviews will be conducted for the indicators proposed for each of the five main chapters in the ROE07. This charge provides background and instructions for peer review of the *land chemical* indicators. It includes the following sections and attachments:

- Section 1: Background information on ROE07 TD
- Section 2: Indicator definition and criteria
- Section 3: Charge and materials for the individual pre-workshop review
- Section 4: The peer review meeting
- Attachment 1: Questions and Proposed Indicators for the ROE07 Technical Document
- Attachment 2: Comment Sheet for Group 1 Indicators
- Attachment 3: Comment Sheet for Group 2 Indicator
- Attachment 4: Comment Sheet for General Questions for Group 1 and 2 Indicators
- Attachment 5: List of and EPA Rationale for Withdrawn ROE03 Indicators (will be posted by 6/10/05)
- Attachment 6: Indicator Materials for Review (included as subsequent sections of this binder).

Section 1: Background

In 2003, EPA published its first draft *Report on the Environment* (ROE03). ROE03 is a set of two question-driven reports comprising:

- A Technical Document (TD), which provides the scientific foundation for the ROE.
- A shorter Public Document that distills information in the TD for a non-technical audience.

These two reports were intended to identify and present the best available national-level indicators to help answer broad questions about the state of the nation's environment in five topic areas (chapters): air, water, land, human health, and ecological condition. In addition to reporting what we know, the ROE03 was also intended to point out where current data and understanding fall short of fully answering the questions in terms of delivering national, consistent, comprehensive data about the state of the nation's air, water, land, human health, and ecological condition. The ROE03 also presented some contextual information from other scientific sources in order to provide background and explain indicator data gaps.

EPA's Administrator has requested that the generation of Reports on the Environment be continued into the future. Current plans are for future reports to be developed on an approximately 3-year reporting cycle. To support the next anticipated ROE release in 2007, EPA has compiled a set of proposed indicators to help answer the questions posed for the 2007 Technical Document. EPA proposes reporting on both national-level indicators, national-level indicators that are provided at the scale of EPA regions, as well as several region-level indicators. As with ROE03, the questions are organized into five topic areas: air, water, land, human health, and ecological condition. There will be a separate chapter in the ROE07 Technical Document for each topic area. Each chapter will describe the set of questions for the topic area and the indicators that answer those questions.

Many of the indicators proposed for ROE07 were presented in ROE03, but some are new and others have new data sources. In addition, after refining the indicator definition and criteria (see boxes on the following pages), and applying both more consistently to the proposed indicator list, EPA recommends that some indicators from ROE03 not be presented in 2007.

To ensure that the indicators presented in the ROE07 TD are supported by data that are technically sound, meet the established indicator definition and criteria, and help answer the questions posed in the ROE, EPA has contracted with ERG to organize an independent peer review of the proposed ROE07 indicators.

Reviewers for the land chemical indicators are charged with four tasks:

1) Assess whether the proposed land chemical indicators are appropriate, adequate, and useful for evaluating and/or establishing an overall picture of the trends in chemicals used on land and their effects on human health and the environment.

2) Evaluate the proposed indicators with respect to their importance in terms of their ability to respond to the question.

3) Evaluate the proposed land chemical indicators and their underlying data with respect to the ROE indicator definition and criteria presented below.

4) Identify any additional *national-level* land chemical indicators that currently exist which meet the ROE indicator definition and criteria, help to answer one of the ROE questions, and for which data are readily available such that text and graphics describing the indicator could be developed within a short time frame (approximately 6 weeks).

Section 2: Indicator Definition and Criteria

Each indicator in ROE07 should conform to the following definition.

Definition: Indicator

For purposes of the ROE, an “indicator” is ***a numerical value derived from actual measurements of a pressure, ambient condition, exposure, or human health or ecological condition*** *over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment*. Indicators and their underlying data must meet criteria (see box below) for data quality, comparability, representativeness, and adequate coverage in time and space. Note that indicators rely on an underlying database or set of databases, but the databases themselves are not indicators.

In the above definition, "derived from" means that trends in *actual environmental observations* (e.g., rather than estimates or projections) must serve as the principal driver for trends in the indicators.

EPA has defined six indicator levels, as follows. Note that levels 1 and 2 are administrative indicators that measure progress in implementing environmental programs, and compliance with or response to those programs. They are *not* the subject of ROE07. Levels 3 through 6 indicators reflect environmental results/condition and are the subject of ROE07.

Description of Indicator Levels

Level 1 (Administrative—not covered by ROE07): Government Regulations/Activities. Examples: policy leadership, statutes, regulations, guidance, information.

Level 2 (Administrative—not covered by ROE07): Actions/Responses by Regulated and Non-regulated Parties. Examples: Pollution prevention and control, recycling, changes in consumer behavior, best management practices.

Level 3 (Environmental): Changes in Pressure or Stressor Quantities. Examples: Pollutants entering media, habitats altered or destroyed, hydrologic alteration.

Level 4 (Environmental): Ambient Conditions. Examples: Pollutant concentrations in media, food and drinking water, solid wastes in landfills, radiation; temperature, habitat condition, hydrology.

Level 5 (Environmental): Exposure or Body Burden/Uptake. Examples: Biological markers of uptake in people, plants, animals, or microorganisms.

Level 6 (Environmental): Changes in Human Health or Ecological Condition. Examples: Morbidity, mortality, biotic structure, and ecological processes.

Each indicator in ROE07 should conform to the following criteria:

Indicator Criteria

1) The indicator makes an important contribution to answering a question for the ROE. (In this context, “important” means that the indicator answers a substantial portion of and/or a critical part of the question.)
2) The indicator is objective. It is developed and presented in an accurate, clear, complete, and unbiased manner.
3) The underlying data are characterized by sound collection methodologies, data management systems that protect their integrity, and quality assurance procedures.
4) Data are available to describe changes or trends, and the latest available data are timely.
5) The data are comparable across time and space, and representative of the target population. Trends depicted in this indicator accurately represent the underlying trends in the target population.
6) The indicator is transparent and reproducible. The specific data used and the specific assumptions, analytic methods, and statistical procedures employed are clearly stated.

Section 3: Charge and Materials for the Individual Pre-Workshop Review

Attachment 1 lists all the ***proposed questions*** and ***associated indicators*** for the 2007 ROE by topic area. Page 7 lists the indicators to be reviewed by land chemical reviewers. Note that, for review purposes, there are two groups of indicators:

- **Group 1: Proposed Land Chemical Indicators.** Indicators that are proposed to answer the “chemicals” question posed in the land chapter *and* that will be *written up in that chapter*.

- **Group 2: One Land Chemical Indicator That Is Also Being Reviewed by Other Reviewers.** Group 2 comprises one land chemical indicator that is being given a Group 1-level review by reviewers for the health chapter. Land chemical reviewers will provide a more abbreviated review of this indicator.

The materials and instructions for reviewing each group of indicators are described below. Please conduct the review in the sequence indicated. Forms are provided as Attachments 2 through 4 to this charge to structure your review. Attachment 5 provides background for Step 3, below. The materials to be reviewed are provided in Attachment 6.

Step 1: Review Group 1 Indicators

For each indicator in Group 1, Attachment 6 provides:

- *Draft text* introducing the indicator, identifying the underlying data used to evaluate the indicator, and describing data interpretations. EPA proposes including this text in the ROE07 TD.

- *Draft graphic(s)/table(s)* to help readers visualize spatial and temporal trends in the indicator. EPA proposes including these graphics in the ROE07 TD.

- *An information quality review form* that presents detailed background information on the indicator and its supporting data (e.g., data quality, coverage, processing). EPA documents this information for the overall project record and to facilitate peer review of the indicators.

Collectively, these three items should adequately present each indicator and thoroughly document the information that EPA considered when evaluating the indicators for ROE07. For each indicator in this category, you should thoroughly review the draft text, draft graphics/tables, and information quality review forms provided. Then, document your review comments by filling out the "Comment Sheet" in Attachment 2 *for each indicator*.

This sheet asks you a series of questions about each indicator. For questions 1 through 4, you are asked to provide a numerical response on a scale of 1 to 4 and then a written explanation of the rationale for your numerical response. Question 5 asks about graphical presentation and question 6 asks you to provide any other comments, concerns, or suggestions about the indicator that you did not already cover in your responses to Questions 1 through 5. Question 7 asks you to state whether you think the indicator merits inclusion in ROE07.

Step 2: Review the Group 2 Indicator

This group comprises one land chemical indicator that is receiving a Group 1-level review by the human health indicator reviewers because it is falls within their area of expertise. For this indicator, Attachment 6 provides the draft text, associated graphic(s), and information quality review form. Note that:

- The information quality review form for this indicator is provided *as background only. You do not need to review it and you are not required to read it.* It is there for your perusal if you are interested.

- The health reviewers will be responding to the full suite of Attachment 2 review questions for this indicator. Therefore, *you do not need to consider or answer the Attachment 2 questions for this indicator*.

You are asked to read the text and graphic that present the indicator and to state:

- The extent to which you think this indicator contributes to answering the specific question in your topic area that it is referenced as answering.

- Any other comments or suggestions you may have concerning this indicator.

Attachment 3 provides a form for you to fill out for this indicator.

Step 3: Consider General Questions for Group 1 and 2 Indicators

After completing your reviews for the individual Group 1 and 2 indicators, as described above, please use Attachment 4 to answer the following two questions for these indicators:

- **General Question 1:** Considering the Group 1 and Group 2 indicators collectively, do any of these indicators clearly seem to be more appropriate, adequate, or useful for evaluating and/or contributing to an overall picture of the trends in chemicals used on land and their effects on human health and the environment than others? Do any seem to be more important than the others for answering the question they are intended to answer? Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators or if it covers an area of diminishing interest environmentally.

- **General Question 2:** Are there any additional *national-level* indicators that currently exist, but were not proposed for ROE07, that you would recommend for ROE07? Proposed indicators should meet the ROE indicator definition and criteria, be national in scale, make an important contribution to answering one of the ROE questions in your topic area, be of a quality that likely would pass this type of peer review, and have data that are readily available (e.g., could be compiled within 6 weeks or less). For any new indicators proposed, provide detailed justification for their inclusion and list references or citations for the associated underlying data sources. As you consider this question, please read Attachment 5, which provides the list of land and other indicators presented in ROE03 that EPA does not intend to carry forward to ROE07, along with EPA's rationale for withdrawing them. If you disagree with EPA's rationale and feel any of these indicators should be included in ROE07, please so indicate in your response to this question, along with your rationale for why they should be included. Note: The full text and graphics for the ROE03 indicators can be viewed on-line at: http://www.epa.gov/indicators/roe/html/tsd/tsdLand.htm

Preparing for the Peer Review Workshop

After receiving the reviewers' pre-meeting comments, ERG will compile these comments and distribute them to all peer reviewers. Please familiarize yourself with the pre-meeting comments of the other land chemical peer reviewers prior to the peer review workshop.

Note that the pre-meeting comments are preliminary in nature and are intended to help initiate discussion at the peer review meeting. Reviewers may change their comments based on discussion at the peer review meeting.

Section 4: The Peer Review Meeting

Most of the peer review meeting will take place with the peer reviewers split into breakout groups by topic area. Within each group, reviewers will consider the same questions they answered individually in their pre-meeting comments:

- Reviewers will discuss the merits of the individual Group 1 indicators based on responses provided on the "Comment Sheets" and, where possible, agree on a composite score for each indicator. They will also discuss the extent to which the Group 2 indicator contributes to answering the specific question it is referenced as answering.

- Then, considering the Group 1 and 2 indicators collectively, reviewers will identify any indicators that clearly do not seem to be on the same level of importance as the other indicators.

- Finally, reviewers will discuss and, where possible, reach agreement on any possible other national-level indicators they believe EPA should consider for the ROE07 TD.

ERG will prepare a summary report of the discussions at the peer review workshop. This report will document the peer reviewers' final conclusions and recommendations regarding the indicators for ROE07 TD. You will have a chance to check ERG's draft report of the meeting for accuracy and completeness before it is finalized.

Attachment 1:

Questions and Proposed Indicators for the ROE07 Technical Document

Attachment 2: Comment Sheet for Group 1 Indicators

Please fill out a separate sheet for each Group 1 indicator.

Your Name: ______________________________

Topic Area: **Land Chemical**

Indicator Name: ____

1) Please indicate the extent to which you think the proposed indicator is appropriate, adequate, and useful (AA&U) for evaluating and/or contributing to an overall picture of the trends in chemicals used on land and their effects on human health and the environment.

1	2	3	4
Indicator is not AA&U	Indicator is of somewhat AA&U	Indicator is largely AA&U	Indicator is completely AA&U

Comments:

2) Please indicate the extent to which you think the proposed indicator makes an important contribution to answering the specific ROE question it is intended to answer (see Attachment 1 for list of questions). (Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators, or if it covers an area of less or diminishing importance environmentally.)

1	2	3	4
Indicator is not important	Indicator is of minor importance	Indicator is important	Indicator is critical

Comments:

3) To what extent do you think the indicator meets the following <u>indicator definition</u>:

An "indicator" is ***a numerical value derived from actual measurements of a pressure, ambient condition, exposure, or human health or ecological condition*** *over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment*.

1	2	3	4
Doesn't meet the definition	Only partly meets the definition	Largely meets the definition	Fully meets the definition

Please explain:

4) To what extent do you think the indicator meets each of the following <u>indicator criteria</u>:

a) The indicator makes an important contribution to answering a question for the ROE. (In this context, "important" means that the indicator answers a substantial portion of and/or a critical part of the question.)

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

b) The indicator is objective. It is developed and presented in an accurate, clear, complete, and unbiased manner.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

c) The underlying data are characterized by sound collection methodologies, data management systems that protect its integrity, and quality assurance procedures.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

d) Data are available to describe changes or trends, and the latest available data are timely.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

e) The data are comparable across time and space, and representative[1] of the target population. Trends depicted in this indicator accurately represent the underlying trends in the target population.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

f) The indicator is transparent and reproducible. The specific data used and the specific assumptions, analytic methods, and statistical procedures employed are clearly stated.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

Please explain:

[1] An indicator seeks to describe trends in an overall target "population" (e.g., land area, type of surface water, type of emissions, U.S. population), yet data often can only be sampled from a subset of this population. The validity of the trends described by the indicator will depend on the degree to which the sampled population is representative of the target population.

5) Do you have any suggestions for more effective graphic presentation of the data?
If yes, please describe.

6) Please provide any additional comments, suggestions, or concerns regarding the indicator that you have not already noted in Questions 1 through 5. In particular, note any limitations to the indicator that you have not already described in your responses to the preceding questions.

7) Overall, this indicator:

_____ Should be included in ROE07 TD.

_____ Should be included in ROE07 TD with the modifications identified above.

_____ Should *not* be included in ROE07 TD.

Attachment 3: Comment Sheet for Group 2 Indicator

Your Name: ______________________________
Topic Area: **Land Chemical**
Indicator Name: ____

1) To what extent do you agree with this statement:

   This indicator is appropriate, adequate, and useful (AA&U) for evaluating and/or contributing to an overall picture of the trends in chemicals used on land and their effects on human health and the environment.

1	2	3	4
Indicator is not AA&U	Indicator is of somewhat AA&U	Indicator is largely AA&U	Indicator is completely AA&U

Comments:

2) To what extent do you agree with this statement:

   This indicator makes an important contribution[2] to answering the specific ROE question it is intended to answer (see Attachment 1 for list of questions).

1	2	3	4
Indicator is not important	Indicator is of minor importance	Indicator is important	Indicator is critical

Comments:

3) Please provide any additional comments, suggestions, or concerns regarding the indicator that you may have.

[2] Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators, or if it covers an area of less or diminishing importance environmentally.

Attachment 4: Comment Sheet for General Questions for Group 1 and Group 2 Indicators

Your Name: ______________________________
Topic Area: **Land Chemical**

1) Considering the Group 1 and 2 indicators *collectively*, do any of these indicators clearly seem to be more appropriate, adequate, or useful for evaluating and/or contributing to an overall picture of the trends in chemicals used on land and their effects on human health and the environment than others? Do any seem to be more important than the others for answering the question they are intended to answer? (Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators or if it covers an area of diminishing interest environmentally.)

2) Are there any additional ***national-level*** indicators that make an important contribution to evaluating trends in chemicals used on land and their effects on human health and the environment, but were not proposed for ROE07, that you would recommend? (Proposed indicators should meet the ROE indicator definition and criteria, be national in scale, be of a quality that likely would pass this type of peer review, and have data that are readily available. For any new indicators proposed, provide justification for their inclusion and list references or citations for the associated underlying data sources.)

   As you consider this question, ***please read Attachment 5***, which provides the list of land and other indicators presented in ROE03 that EPA does not intend to carry forward to ROE07, along with EPA's rationale for withdrawing them. If you disagree with EPA's rationale and feel any of these indicators should be included in ROE07, please so indicate in your response to this question, along with your rationale for why they should be included. Note: The full text and graphics for the ROE03 indicators can be viewed on-line at: http://www.epa.gov/indicators/roe/html/tsd/tsdLand.htm

Attachment 5: List of and EPA Rationale for Withdrawn ROE03 Indicators

Background:
A number of indicators were included in EPA's 2003 Draft Report on the Environment (DROE03) that are not proposed to be included in ROE07. The general reasons for these changes are described below, followed by indicator-specific explanations.

> EPA's Science Advisory Board Committee review of the DROE03 recommended EPA develop and utilize a more precise definition of "indicator" than was used for DROE03.
>
> EPA developed a set of specific indicator criteria to provide a more precise conformance to Office of Management and Budget (OMB) and EPA Information Quality Guidelines.
>
> The ROE07 introduced a Regional Pilot Project and developed and implemented a relevant process. Sub-national or regional indicators that were included in DROE03 but did not go through this pilot are not recommended to be included in ROE07.

When screened against these factors, the ROE07 development team identified a small number of the indicators in DROE03 that did not appear to conform to one or more of these requirements. A group decision was made that developing indicator write-ups, quality forms, and graphics for these indicators was not the best use of team resources. Broadly speaking, the rationales for withdrawal fall into four categories, coded as follows:

> **(D) Definition** – The indicator fails to meet the improved indicator definition for ROE07 (most often because the indicator was a level 1 or 2 indicator, rather than a level 3, 4, 5, or 6 indicator).
>
> **(C) Criteria** – The indicator fails to meet one of the six indicator criteria that were established to conform with EPA Information Quality Guidelines.
>
> **(N) New indicator** – The indicator is replaced by a "new" and superior indicator that was not available for the DROE03.
>
> **(R) Regional –** The indicator is not national in scope and is not part of the ROE07 EPA Regional Pilot Project.

The following information briefly explains the rationale for excluding specific indicators from development for the ROE07 Indicator Peer Review. Each indicator is categorized as D, C, N, or R. The indicators are organized by general peer review topic.

Air

Production of Ozone Depleting Substances - C

This DROE03 indicator presents estimates of the amount of ODSs produced worldwide in 1986 and 1999, and annual U.S. production from 1958 to 1993. This indicator is being withdrawn because of issues concerning data reliability and relevance. Global ODC production data are not reliable with respect to comparability among reporting countries. The US estimates are more reliable because of legal reporting requirements and the small number of sources. However, the data set fails to account for imports, and annual production is not a good surrogate for emissions of ODCs into the environment because of the time between production and eventual entry into the environment is highly variable among the various products and recovery systems.

Number of People Living in Counties with Ambient Air Concentrations Above the NAAQS - C

This DROE03 indicator conveyed how many people (based on census) lived in counties where air pollutant levels at times were above the level of the NAAQS during the year stated. It was intended to give the reader some indication of the number of people potentially exposed to unhealthy air. Because of changing populations and air quality standards, however, this indicator masks actual trends in the levels of air pollutants. It is not a valid exposure indicator because it is not based on measurement of an actual marker of exposure measured on individuals.

Percent of Population Living in Homes Where Someone Smokes Regularly Inside the Home - D

This DROE indicator portrayed the percentage of homes in the U.S. in which young children were exposed to tobacco smoke in 1998 versus 1957. The survey is based on a questionnaire (do children live in the home, and does someone who smokes regularly live in the home), rather than on actual measurements of the amount of smoke actually present or the degree to which children are exposed to the resulting smoke. This indicator violates the ROE indicator definition, requiring that indicators be based on actual measurements, and blood cotenine (Indicator 102) provides a better indicator of children's exposure to smoke.

Water

Altered Fresh Water Ecosystems – C
Percent Urban Land Cover in Riparian Areas – C
Agricultural Lands in Riparian Areas - C

These DROE03 indicators are based on the percentage of land within 30 m of the edge of a stream or lake that is classified as urban or agriculture based on 1991 satellite data (NLCD). Baseline data are incomplete, and there are no reference points for the appropriate percentage of such cover, and it is not clear that the indicators could be reproduced with newer satellite data. There are no data for other alterations such as damming, channelization, etc.

Number of Watersheds Exceeding Criteria for Mercury, PCBs, & Dioxin – C

This DROE03 indicator is based on voluntary reporting of Hg contamination using data that has not undergone formal QA/QC review. It is not representative of the nation, or suitable for trend monitoring.

Lake Trophic State Index – R, C

This DROE03 indicator is based on phosphorous data collected in a one-time a statistical sample of lakes in the Northeast US during 1991-94. It is not included in the ROE07 Regional Pilot Project.

Sedimentation Index – R, C

This DROE03 indicator is based on data collected on freshwater streams in the Mid Atlantic Highlands Region during a one-time 1993-94 statistical survey. It is not included in the ROE07 Regional Pilot Project.

Contaminants in Fresh Water Fish (NAWQA) – C

This DROE03 indicator is based on reported concentrations of contaminants in fish collected by the US Geological Survey NAWQA program. While the data are collected from a large number of streams and are of high and consistent quality, the sample is not statistically representative of the nation, there are no national guidelines to serve as reference values for tissue concentrations, and Cycle II of NAWQA will not include comparable routine monitoring of trace organics and trace elements in fish tissues at sampling sites across the Nation.

Fish Index of Biotic Integrity – R, C

This DROE03 indicator is based on fish community data collected on freshwater fish in the Mid Atlantic Highlands Region during a one-time1993-96 statistical survey. Condition cannot be assessed in streams where no fish were caught, because data were insufficient to indicate whether the stream had poor quality or simply no fish. It is not included in the ROE07 Regional Pilot Project.

Macroinvertebrate IBI (MAIA) – R, C

This DROE03 indicator is based on benthic macroinvertebrate community data collected in freshwater streams in the Mid Atlantic Highlands Region during a one-time 1993-96 statistical survey. It is not included in the ROE07 Regional Pilot Project.

Beach Days Open – D

Waters with Fish Consumption Advisories - D

These DROE03 indicators are based on the frequency of beach closures or fish consumption advisories as reported to EPA voluntarilyby states and local government organizations. The data are not nationally or temporally consistent because of different and changing criteria for closing beaches or issuing fish consumption advisories in the different states, many of which do not involve actual water quality measurements. They are therefore level 1 indicators and fail to meet the definition for ROE indicators.

Contaminated Sediments in Fresh Water - C

This DROE03 indicator is based on reported concentrations of sediment contaminants collected by a large number of organizations focusing particularly on places where sediment contamination is perceived to be a problem (the EPA National Sediment Inventory). The database suffers from a number of limitations: the data are heavily biased toward sites at which there is a known or suspected toxicity problem and to particular geographic areas (non-representative of the nation), the data cover different dates in different locations- making estimation of trends difficult, and the data and procedures used to assign sites to a toxicity category are not uniform from watershed to watershed. It is unsuitable for trend estimation.

Chemical Contamination in Streams and Groundwater – C

This DROE03 indicator is based on data from a large number of NAWQA watersheds. The sampling and analytical protocols (including the analytes measured) are not comparable across all NAWQA watersheds.

Nitrate in Farmland, Forested and Urban Streams and Groundwater
Phosphorus in Farmland, Forested, and Urban Streams – N

These DROE03 indicators are being replaced by two new indicators, "Nitrate, Phosphorus, and Pesticides in Streams in Agricultural Watersheds" and "Nitrate and Pesticides in Groundwater in Agricultural Watersheds." The NAWQA streams in forested and urban watersheds were based on a small sample size, and may not be representative of forested and urban streams in general.

Phosphorus in Large Rivers - C

The indicator is based on phosphorus concentrations in large rivers sampled periodically by the USGS National Stream Quality Accounting Network (NASQAN). Monitoring at many of the large river NASQAN sites has been discontinued.

Chemicals

Sediment Runoff Potential from Croplands and Pasturelands - C

This DROE03 indicator represents the estimated sediment runoff potential for croplands and pasturelands based on topography, weather patterns, soil characteristics, and land-use land cover and cropping patterns for the U.S. and the Universal Soil Loss equation www.brc.tamus.edu/swat. The indicator addresses "potential" and not actual/current condition, and relies on a model to predict ambient characteristics (level 4 indicators) based on level 3 measurements, which violates a fundamental ROE protocol on the use of models in indicators. Trends in this indicator would likely be associated only with trends in land cover, cropping practices, and weather (topography and soil type are unlikely to change). No reliable spatial trend data at the appropriate scale exist for either cropping practices or land cover, and consequently trends in this indicator would be difficult to calculate.

Potential Pesticide Runoff from Fields - C
Pesticide Leaching Potential - C

These DROE03 indicators represent the potential movement of agricultural pesticides from the site of application to ground and surface waters, based on estimates of pesticide leaching and runoff losses derived from soil properties, field characteristics, management practices, pesticide properties, and climate for 243 pesticides applied to 120 specific soils in growing 13 major agronomic crops. The indicators address "potential" and not actual/current condition, and rely on models to predict ambient characteristics (level 4 indicators) based on level 3 measurements, which violates a fundamental ROE protocol on the use of models in indicators.

Risk of Nitrogen Export - C
Risk of Phosphorus Export - C

These DROE03 indicators represent the potential movement of N and P from the site of application to surface waters, based on a large empirical dataset relating land use to N and P observed in receiving streams over several decades at a variety of locations. The indicators address "potential" and not actual/current conditions, and rely on statistical models to predict ambient characteristics (level 4 indicators) based on level 3 measurements, which violates a fundamental ROE protocol on the use of models in indicators.

Pesticide Use - C

Agricultural pesticide usage data, measured at the national aggregate level for all pesticides is very difficult to interpret, given the wide year to year changes in the types of pests being controlled for and changes in agricultural production/chemical usage from year to year. From one time period to another the mix of pesticides changes, pest pressures change, agricultural practices change, agricultural acreage changes, regulatory status of key uses changes, and many other important variables change. Moreover, the effects of pesticide usage are encountered at three levels of the product's life cycle: production, usage, and residues on foods. The geographic distribution of those effects renders difficult the interpretation of national usage levels for all pesticides, taken as a group. While it is of course possible to compare magnitudes of aggregates at different times, the real significance for the environment is in the differences in the content and geographic distribution of the aggregates, not in the magnitude of the aggregate.

Contaminated Lands

Number and Location of Superfund NPL Sites - D

This DROE03 indicator is a category 1 indicator (it represents an administrative decision to force a cleanup, rather than an amount of waste present or removed), and therefore does not meet the ROE07 indicator definition.

Number of RCRA Corrective Action Sites - D

This DROE03 indicator, by itself, is a category 1 indicator (it represents an administrative decision to force a cleanup, rather than an amount of waste present or removed), and therefore does not meet the ROE07 indicator definition. The data are being combined into a new indicator, Quantity of RCRA Hazardous Waste Generated and Managed (which combines information from several DROE03 indicators).

Radioactive Waste Storage and Disposal - C

This DROE03 indicator is based on production and inventory data collected by the Department of Energy. Although the data continue to be collected, they are no longer publicly available post-September 11, 2001; therefore ongoing data trends are not and will not in the future be available for this indicator. Moreover, the earlier data reflected two distinct periods in the history of waste generation in the nuclear weapons complex. The first reflected a period during which wastes and other materials were being generated as an integral part of the production of weapons grade nuclear materials and components. The period after 1989 reflected the cessation of large-scale production of such materials and the initiation of clean-up activities and wastes from those initiatives. Thus, even before the truncation of data in the post 9/11 period, there were significant issues with the comparability of the data over time.

Human Health

Cardiovascular Disease Prevalence - C

This DROE03 indicator was based on data from NHANES III (1988-1994). Currently, no national trend data are available on cardiovascular disease (CVD) prevalence.

Blood VOC – C

This DROE03 indicator was based on a convenience sample whose representativeness cannot be determined or necessarily used as a baseline for future sampling. The indicator is based on detects only, so there is no reference level, and VOCs are cleared from the bloodstream rapidly (~ 1hr), so there is a significant possibility of false negatives, considering that exposures tends to be associated with occupational and indoor settings.

Urinary Arsenic - R
This DROE03 indicator was based on data from EPA Region 5 only, and is not part of the ROE07 Regional Pilot.

Ecological Condition

The Farmland Landscape - C
This DROE03 indicator represents croplands and the forests or woodlots, wetlands, grasslands and shrublands, that surround or are intermingled with them, and the degree to which croplands dominate the landscape http://www.heinzctr.org/ecosystems/farm/lndscps.shtml. The indicator relies on data generated using early 1990's satellite data, and it is unclear whether the definition of "farmland landscape" is sufficiently precise to be replicated independently, especially with respect to any future satellite data availability.

Extent of Estuaries and Coastline – C
This DROE03 indicator is based on remote sensing data, but is unlikely to show trends unrelated to sea level rise and changing tides, so it is not a very useful indicator for trends.

Coastal Living Habitats - C
This DROE03 indicator is based on remote sensing data of coastal wetlands, mudflats, sea-grass beds, etc., but the only system for which a national indicator has been developed is coastal vegetated wetlands, which already is covered in another indicator.

Shoreline Types - C
This DROE03 indicator is based on NOAA's Environmental Sensitivity Index. The index is based on a standardized mapping approach, but coverage is not complete for large parts of the coastline and the data in some of the atlases are more than 15 years old. Consequently, this indicator is not appropriate for measurement of representative, national trends.

Extent of Ponds, Lakes, and Reservoirs – C
This DROE03 indicator is based on data from the USGS National Wetlands Inventory. While these data are based on a valid statistical sampling design, the total amount of surface water is less than half of the area of lakes, reservoirs and ponds greater than 6 acres in size in the USGS National Hydrography Data Set. Until this discrepancy is resolved, the indicator may not satisfy the ROE criteria.

At-Risk Native Species – C
At-Risk Native Grassland and Shrubland Species – C
At-Risk Native Forest Species – C
Populations of Representative Forest Species – C
Non-Native Fresh Water Species – C
At-Risk Fresh Water Plant Communities – C
The Ecological Condition chapter is being restructured from the DROE03 organization per the recommendation of EPA's Science Advisory Board and numerous stakeholders. As such, the chapter

no longer requires that the above indicators be broken out by ecosystem. In addition, the ability to track trends of many of these indicators is currently in question.

Population of Invasive and Non-invasive Bird Species – R

This DROE03 indicator is based on an analysis of USGS Breeding Bird Survey data in grassland and shrubland ecosystems for 5 year periods ranging from the late 1960s to 2000. Because the ecological condition questions are no longer directed at specific ecosystems types, this appears to be a regional indicator. It is not clear at this time that this indicator will be updated.

Bird Community Index – R

This DROE03 indicator is not national in scope or part of the ROE EPA Regional Pilot.

Fish Diversity – R

This DROE03 indicator is based on a statistical sample of fish trawls in Mid-Atlantic estuaries during 1997-98. This indicator is not part of the ROE07 Regional Pilot project, and EMAP is no longer collecting fish samples to support this indicator.

Fish Abnormalities - C

This DROE03 indicator is based on a statistical sample of fish trawls in estuaries in the Atlantic and Gulf, but the data are no longer being collected by EMAP to support this indicator.

Unusual Marine Mortalities – C

This DROE03 indicator is based on voluntary reporting of unusual mortality events to NOAA. Because there is no systematic requirement to report, these data are not suitable to support national trends in the indicator.

Animal Deaths and Deformities – C

This DROE03 indicator is based on data reported by a number of different organizations to USGS on incidences of death or deformities in waterfowl, fish, amphibians, and mammals. Trends are available only for waterfowl, and because data reporting is voluntary rather than systematic, the data are not adequate to determine actual trends versus trends in reporting.

Tree Condition – C

This DROE03 indicator is based on an ongoing statistical sample of forests across the conterminous US and comprises components that relate to crown (tree canopy condition), the ratio of dead to live wood, and the fire class. This indicator likely relates more to forest management practices than to environmental condition, and for this reason has low relevance value to EPA.

Processes Beyond the Range of Historic Variation – C

This DROE03 indicator is based on an analysis of recent Forest Inventory and Analysis data on climate events, fire frequency, and forest insect and disease outbreaks, which were then compared to anecdotal data for the period 1800-1850. Because the early data are anecdotal, and because the data mostly relate to forest management practices, etc., it is proposed that this indicator has low relevance and that trend data are of questionable utility as an ROE indicator.

Soil Compaction – C
Soil Erosion – C

These DROE03 indicator are based on an ongoing statistical sample of soils in forests across the conterminous US, but the actual indicators are based on models rather than measurement, and they likely relate more to forest management practices than to environmental condition, and for this reason have low relevance value to EPA.

Soil Quality Index - R

This DROE03 indicator was based on a survey of soils in the Mid Atlantic region during the 1990s, and was neither repeated and is not part of the Regional Pilot Project for ROE07.

Chemical Contamination – C

This DROE03 indicator combines data from the USGS NAWQA program that are not consistent in terms of sampling frequency or analytical protocols.

Attachment 6: Indicator Materials for Review

NOTE: ATTACHMENT 6 COMPRISES THE SUBSEQUENT SECTIONS OF THIS BINDER

Charge to the Peer Reviewers: Land Waste and Other Relevant Indicators for the U.S. Environmental Protection Agency's 2007 *Report on the Environment* Technical Document May 20, 2005

The U.S. Environmental Protection Agency (EPA) has asked that independent peer reviewers critically review the indicators that the Agency proposes to use for its 2007 *Report on the Environment*—Technical Document (ROE07 TD). The purpose of this peer review is to ensure that the proposed indicators are appropriate, adequate, and useful for evaluating our nation's lands in general; useful for answering the questions posed in ROE07; meet technical requirements (including the indicator definition and criteria); are properly documented; and are scientifically sound. Separate peer reviews will be conducted for the indicators proposed for each of the five main chapters in the ROE07. This charge provides background and instructions for peer review of the *land waste* indicators. It includes the following sections and attachments:

- Section 1: Background information on ROE07 TD
- Section 2: Indicator definition and criteria
- Section 3: Charge and materials for the individual pre-workshop review
- Section 4: The peer review meeting
- Attachment 1: Questions and Proposed Indicators for the ROE07 Technical Document
- Attachment 2: Comment Sheet for Group 1 Indicators
- Attachment 3: Comment Sheet for Group 2 Indicators
- Attachment 4: Comment Sheet for General Questions for Group 1 and 2 Indicators
- Attachment 5: List of and EPA Rationale for Withdrawn ROE03 Indicators (will be posted by 6/10/05)
- Attachment 6: Indicator Materials for Review (included as subsequent sections of this binder).

Section 1: Background

In 2003, EPA published its first draft *Report on the Environment* (ROE03). ROE03 is a set of two question-driven reports comprising:

- A Technical Document (TD), which provides the scientific foundation for the ROE.
- A shorter Public Document that distills information in the TD for a non-technical audience.

These two reports were intended to identify and present the best available national-level indicators to help answer broad questions about the state of the nation's environment in five topic areas (chapters): air, water, land, human health, and ecological condition. In addition to reporting what we know, the ROE03 was also intended to point out where current data and understanding fall short of fully answering the questions in terms of delivering national, consistent, comprehensive data about the state of the nation's air, water, land, human health, and ecological condition. The ROE03 also presented some contextual information from other scientific sources in order to provide background and explain indicator data gaps.

EPA's Administrator has requested that the generation of Reports on the Environment be continued into the future. Current plans are for future reports to be developed on an approximately 3-year reporting cycle. To support the next anticipated ROE release in 2007, EPA has compiled a set of proposed indicators to help answer the questions posed for the 2007 Technical Document. EPA proposes reporting on both national-level indicators, national-level indicators that are provided at the scale of EPA regions, as well as several region-level indicators. As with ROE03, the questions are organized into five topic areas: air, water, land, human health, and ecological condition. There will be a separate chapter in the ROE07 Technical Document for each topic area. Each chapter will describe the set of questions for the topic area and the indicators that answer those questions.

Many of the indicators proposed for ROE07 were presented in ROE03, but some are new and others have new data sources. In addition, after refining the indicator definition and criteria (see boxes on the following pages), and applying both more consistently to the proposed indicator list, EPA recommends that some indicators from ROE03 not be presented in 2007.

To ensure that the indicators presented in the ROE07 TD are supported by data that are technically sound, meet the established indicator definition and criteria, and help answer the questions posed in the ROE, EPA has contracted with ERG to organize an independent peer review of the proposed ROE07 indicators.

Reviewers for the land waste indicators are charged with four tasks:

1) Assess whether the proposed land indicators are appropriate, adequate, and useful for evaluating and/or establishing an overall picture of the trends in waste and contaminated lands and their effects on human health and the environment.

2) Evaluate the proposed indicators with respect to their importance in terms of their ability to respond to the question.

3) Evaluate the proposed land waste indicators and their underlying data with respect to the ROE indicator definition and criteria presented below.

4) Identify any additional ***national-level*** land waste indicators that currently exist which meet the ROE indicator definition and criteria, help to answer one of the ROE questions, and for which data are readily available such that text and graphics describing the indicator could be developed within a short time frame (approximately 6 weeks).

Section 2: Indicator Definition and Criteria

Each indicator in ROE07 should conform to the following definition.

Definition: Indicator

For purposes of the ROE, an “indicator” is ***a numerical value derived from actual measurements of a pressure, ambient condition, exposure, or human health or ecological condition*** *over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment*. Indicators and their underlying data must meet criteria (see box below) for data quality, comparability, representativeness, and adequate coverage in time and space. Note that indicators rely on an underlying database or set of databases, but the databases themselves are not indicators.

In the above definition, "derived from" means that trends in *actual environmental observations* (e.g., rather than estimates or projections) must serve as the principal driver for trends in the indicators.

EPA has defined six indicator levels, as follows. Note that levels 1 and 2 are administrative indicators that measure progress in implementing environmental programs, and compliance with or response to those programs. They are *not* the subject of ROE07. Levels 3 through 6 indicators reflect environmental results/condition and are the subject of ROE07.

Description of Indicator Levels

Level 1 (Administrative—not covered by ROE07): Government Regulations/Activities. Examples: policy leadership, statutes, regulations, guidance, information.

Level 2 (Administrative—not covered by ROE07): Actions/Responses by Regulated and Non-regulated Parties. Examples: Pollution prevention and control, recycling, changes in consumer behavior, best management practices.

Level 3 (Environmental): Changes in Pressure or Stressor Quantities. Examples: Pollutants entering media, habitats altered or destroyed, hydrologic alteration.

Level 4 (Environmental): Ambient Conditions. Examples: Pollutant concentrations in media, food and drinking water, solid wastes in landfills, radiation; temperature, habitat condition, hydrology.

Level 5 (Environmental): Exposure or Body Burden/Uptake. Examples: Biological markers of uptake in people, plants, animals, or microorganisms.

Level 6 (Environmental): Changes in Human Health or Ecological Condition. Examples: Morbidity, mortality, biotic structure, and ecological processes.

Each indicator in ROE07 should conform to the following criteria:

Indicator Criteria

1) The indicator makes an important contribution to answering a question for the ROE. (In this context, "important" means that the indicator answers a substantial portion of and/or a critical part of the question.)
2) The indicator is objective. It is developed and presented in an accurate, clear, complete, and unbiased manner.
3) The underlying data are characterized by sound collection methodologies, data management systems that protect their integrity, and quality assurance procedures.
4) Data are available to describe changes or trends, and the latest available data are timely.
5) The data are comparable across time and space, and representative of the target population. Trends depicted in this indicator accurately represent the underlying trends in the target population.
6) The indicator is transparent and reproducible. The specific data used and the specific assumptions, analytic methods, and statistical procedures employed are clearly stated.

Section 3: Charge and Materials for the Individual Pre-Workshop Review

Attachment 1 lists all the ***proposed questions*** and ***associated indicators*** for the 2007 ROE by topic area. Page 8 lists the indicators to be reviewed by land waste reviewers. Note that, for review purposes, there are two groups of indicators:

- **Group 1: Two Proposed Land Waste Indicators.** You are the only reviewers reviewing these indicators.

- **Group 2: Two Proposed Contaminated Lands Indicators.** These indicators are also being reviewed by reviewers who have health and water expertise. Therefore, you have fewer charge questions for these two indicators.

The materials and instructions for reviewing each group of indicators are described below. Please conduct the review in the sequence indicated. Forms are provided as Attachments 2 through 4 to this charge to structure your review. Attachment 5 provides background for Step 2, below. The materials to be reviewed are provided in Attachment 6.

Step 1: Review the Group 1 Indicators

For each indicator, Attachment 6 provides:

- *Draft text* introducing the indicator, identifying the underlying data used to evaluate the indicator, and describing data interpretations. EPA proposes including this text in the ROE07 TD.

- *Draft graphic(s)/table(s)* to help readers visualize spatial and temporal trends in the indicator. EPA proposes including these graphics in the ROE07 TD.

- *An information quality review form* that presents detailed background information on the indicator and its supporting data (e.g., data quality, coverage, processing). EPA documents this information for the overall project record and to facilitate peer review of the indicators.

Collectively, these three items should adequately present each indicator and thoroughly document the information that EPA considered when evaluating the indicators for ROE07. For each indicator in this category, you should thoroughly review the draft text, draft graphics/tables, and information quality review forms provided. Then, document your review comments by filling out the "Comment Sheet" in Attachment 2 *for each indicator*.

This sheet asks you a series of questions about each indicator. For questions 1 through 4, you are asked to provide a numerical response on a scale of 1 to 4 and then a written explanation of the rationale for your numerical response. Question 5 asks about graphical presentation and question 6 asks you to provide any other comments, concerns, or suggestions about the indicator that you did not already cover in your responses to Questions 1 through 5. Question 7 asks you to state whether you think the indicator merits inclusion in ROE07.

Step 2: Review the Group 2 Indicators

This group comprises two contaminated land indicators that are receiving a Group 1-level review by other reviewers (the human health reviewers for one indicator and water reviewers for the other) because these indicators fall within their area of expertise. For these indicators, Attachment 6 provides the draft text, associated graphic(s), and information quality review form. Note that:

- The information quality review forms for these indicators are provided *as background only. You do not need to review them and you are not required to read them.* They are there for your perusal if you are interested.

- Other reviewers will be responding to the full suite of Attachment 2 review questions for these indicators. Therefore, *you do not need to consider or answer the Attachment 2 questions for these indicators*.

You are asked to read the text and graphic that present each indicator and to state:

- The extent to which you think this indicator contributes to answering the question: What are the trends in contaminated land and their effects on human health and the environment?

- Any other comments or suggestions you may have concerning this indicator.

Attachment 3 provides a form for you to fill out for this indicator.

Step 3: Consider General Questions for Group 1 and 2 Indicators

After completing your reviews for the individual Group 1 and 2 indicators, as described above, please use Attachment 4 to answer the following two questions for the Group 1 indicators and then for the Group 2 indicators:

- **General Question 1:** Considering both indicators in each group, does either indicator clearly seem to be more appropriate, adequate, or useful for evaluating and/or contributing to an overall picture of the trends in wastes (Group 1) or the trends in contaminated lands (Group 2) than the other? Does either seem to be more important than the other for answering the question they are intended to answer? (Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators or if it covers an area of diminishing interest environmentally.)

- **General Question 2:** Are there any additional *national-level* indicators that currently exist, but were not proposed for ROE07, that you would recommend for ROE07? Proposed indicators should meet the ROE indicator definition and criteria, be national in scale, make an important contribution to answering one of the ROE questions in your topic area, be of a quality that likely would pass this type of peer review, and have data that are readily available (e.g., could be compiled within 6 weeks or less). For any new indicators proposed, provide detailed justification for their inclusion and list references or citations for the associated underlying data sources. As you consider this question, please read Attachment 5, which provides the list of land and other indicators presented in ROE03 that EPA does not intend to carry forward to ROE07, along with EPA's rationale for withdrawing them. If you disagree with EPA's rationale and feel any of these indicators should be included in ROE07, please so indicate in your response to this question, along with your rationale for why they should be included. Note: The full text and graphics for the ROE03 indicators can be viewed on-line at: http://www.epa.gov/indicators/roe/html/tsd/tsdLand.htm

Preparing for the Peer Review Workshop

After receiving the reviewers' pre-meeting comments, ERG will compile these comments and distribute them to all peer reviewers. Please familiarize yourself with the pre-meeting comments of the other land waste peer reviewer prior to the peer review workshop.

Note that the pre-meeting comments are preliminary in nature and are intended to help initiate discussion at the peer review meeting. Reviewers may change their comments based on discussion at the peer review meeting.

Section 4: The Peer Review Meeting

Most of the peer review meeting will take place with the peer reviewers split into breakout groups by topic area. Within each group, reviewers will consider the same questions they answered individually in their pre-meeting comments:

- Reviewers will discuss the merits of the individual indicators based on responses provided on the "Comment Sheets" and, where possible, agree on a composite score for each indicator.

- Then, considering both indicators within each group together, reviewers will identify whether one of the indicators clearly does not seem to be on the same level of importance as the other.

- Finally, reviewers will discuss and, where possible, reach agreement on any possible other national-level indicators they believe EPA should consider for the ROE07 TD.

ERG will prepare a summary report of the discussions at the peer review workshop. This report will document the peer reviewers' final conclusions and recommendations regarding the indicators for ROE07 TD. You will have a chance to check ERG's draft report of the meeting for accuracy and completeness before it is finalized.

Attachment 1:

Questions and Proposed Indicators for the ROE07 Technical Document

Attachment 2: Comment Sheet for Group 1 Indicators

Please fill out a separate sheet for each Group 1 indicator.

Your Name: ______________________________
Topic Area: **Land Waste**
Indicator Name: ____

1) Please indicate the extent to which you think the proposed indicator is appropriate, adequate, and useful (AA&U) for evaluating and/or contributing to an overall picture of the trends in wastes and their effects on human health and the environment.

1	2	3	4
Indicator is not AA&U	Indicator is of somewhat AA&U	Indicator is largely AA&U	Indicator is completely AA&U

Comments:

2) Please indicate the extent to which you think the proposed indicator makes an important contribution to answering the question: What are the trends in waste and their effects on human health and the environment? (Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators, or if it covers an area of less or diminishing importance environmentally.)

1	2	3	4
Indicator is not important	Indicator is of minor importance	Indicator is important	Indicator is critical

Comments:

3) To what extent do you think the indicator meets the following <u>indicator definition</u>:

An "indicator" is ***a numerical value derived from actual measurements of a pressure, ambient condition, exposure, or human health or ecological condition*** *over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment*.

1	2	3	4
Doesn't meet the definition	Only partly meets the definition	Largely meets the definition	Fully meets the definition

Please explain:

4) To what extent do you think the indicator meets each of the following <u>indicator criteria</u>:

a) The indicator makes an important contribution to answering a question for the ROE. (In this context, "important" means that the indicator answers a substantial portion of and/or a critical part of the question.)

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

b) The indicator is objective. It is developed and presented in an accurate, clear, complete, and unbiased manner.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

c) The underlying data are characterized by sound collection methodologies, data management systems that protect its integrity, and quality assurance procedures.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

d) Data are available to describe changes or trends, and the latest available data are timely.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

e) The data are comparable across time and space, and representative[1] of the target population. Trends depicted in this indicator accurately represent the underlying trends in the target population.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

f) The indicator is transparent and reproducible. The specific data used and the specific assumptions, analytic methods, and statistical procedures employed are clearly stated.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

Please explain:

[1] An indicator seeks to describe trends in an overall target "population" (e.g., land area, type of surface water, type of emissions, U.S. population), yet data often can only be sampled from a subset of this population. The validity of the trends described by the indicator will depend on the degree to which the sampled population is representative of the target population.

5) Do you have any suggestions for more effective graphic presentation of the data?
If yes, please describe.

6) Please provide any additional comments, suggestions, or concerns regarding the indicator that you have not already noted in Questions 1 through 5. In particular, note any limitations to the indicator that you have not already described in your responses to the preceding questions.

7) Overall, this indicator:

_____ Should be included in ROE07 TD.

_____ Should be included in ROE07 TD with the modifications identified above.

_____ Should *not* be included in ROE07 TD.

Attachment 3: Comment Sheet for Group 2 Indicators

Please fill out a separate sheet for each Group 2 indicator.

Your Name: ______________________________
Topic Area: **Contaminated Lands**
Indicator Name: ____

1) To what extent do you agree with this statement:

    This indicator is appropriate, adequate, and useful (AA&U) for evaluating and/or contributing to an overall picture of the trends in contaminated lands and their effects on human health and the environment.

1	2	3	4
Indicator is not AA&U	Indicator is of somewhat AA&U	Indicator is largely AA&U	Indicator is completely AA&U

Comments:

2) To what extent do you agree with this statement:

    This indicator makes an important contribution[2] to answering the question: What are the trends in contaminated lands and their effects on human health and the environment?

1	2	3	4
Indicator is not important	Indicator is of minor importance	Indicator is important	Indicator is critical

Comments:

3) Please provide any additional comments, suggestions, or concerns regarding the indicator that you may have.

[2] Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators, or if it covers an area of less or diminishing importance environmentally.

Attachment 4: Comment Sheet for General Questions for Group 1 and 2 Indicators

Please fill out a separate sheet for Group 1 and Group 2 indicators

Your Name: ______________________________
Topic Area (circle one): **Land Waste (Group 1)** or **Contaminated Lands (Group 2)**

1) Considering both indicators within each group *together*, does either indicator clearly seem to be more appropriate, adequate, or useful for evaluating and/or contributing to an overall picture of the trends in wastes and their effects on human health and the environment (Group1) or trends in contaminated land and their effects on human health and the environment (Group 2) than the other? Does either indicator seem to be more important than the other for answering the question they are intended to answer? (Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators or if it covers an area of diminishing interest environmentally.)

2) Are there any additional *national-level* indicators that make an important contribution to answering the ROE contaminated wastes or contaminated lands question, but were not proposed for ROE07, that you would recommend? (Proposed indicators should meet the ROE indicator definition and criteria, be national in scale, be of a quality that likely would pass this type of peer review, and have data that are readily available. For any new indicators proposed, provide justification for their inclusion and list references or citations for the associated underlying data sources.)

   As you consider this question, ***please read Attachment 5***, which provides the list of land and other indicators presented in ROE03 that EPA does not intend to carry forward to ROE07, along with EPA's rationale for withdrawing them. If you disagree with EPA's rationale and feel any of these indicators should be included in ROE07, please so indicate in your response to this question, along with your rationale for why they should be included. Note: The full text and graphics for the ROE03 indicators can be viewed on-line at: http://www.epa.gov/indicators/roe/html/tsd/tsdLand.htm

Attachment 5: List of and EPA Rationale for Withdrawn ROE03 Indicators

Background:
A number of indicators were included in EPA's 2003 Draft Report on the Environment (DROE03) that are not proposed to be included in ROE07. The general reasons for these changes are described below, followed by indicator-specific explanations.

> EPA's Science Advisory Board Committee review of the DROE03 recommended EPA develop and utilize a more precise definition of "indicator" than was used for DROE03.
>
> EPA developed a set of specific indicator criteria to provide a more precise conformance to Office of Management and Budget (OMB) and EPA Information Quality Guidelines.
>
> The ROE07 introduced a Regional Pilot Project and developed and implemented a relevant process. Sub-national or regional indicators that were included in DROE03 but did not go through this pilot are not recommended to be included in ROE07.

When screened against these factors, the ROE07 development team identified a small number of the indicators in DROE03 that did not appear to conform to one or more of these requirements. A group decision was made that developing indicator write-ups, quality forms, and graphics for these indicators was not the best use of team resources. Broadly speaking, the rationales for withdrawal fall into four categories, coded as follows:

> **(D) Definition** – The indicator fails to meet the improved indicator definition for ROE07 (most often because the indicator was a level 1 or 2 indicator, rather than a level 3, 4, 5, or 6 indicator).
>
> **(C) Criteria** – The indicator fails to meet one of the six indicator criteria that were established to conform with EPA Information Quality Guidelines.
>
> **(N) New indicator** – The indicator is replaced by a "new" and superior indicator that was not available for the DROE03.
>
> **(R) Regional –** The indicator is not national in scope and is not part of the ROE07 EPA Regional Pilot Project.

The following information briefly explains the rationale for excluding specific indicators from development for the ROE07 Indicator Peer Review. Each indicator is categorized as D, C, N, or R. The indicators are organized by general peer review topic.

Air

Production of Ozone Depleting Substances - C

This DROE03 indicator presents estimates of the amount of ODSs produced worldwide in 1986 and 1999, and annual U.S. production from 1958 to 1993. This indicator is being withdrawn because of issues concerning data reliability and relevance. Global ODC production data are not reliable with respect to comparability among reporting countries. The US estimates are more reliable because of legal reporting requirements and the small number of sources. However, the data set fails to account for imports, and annual production is not a good surrogate for emissions of ODCs into the environment because of the time between production and eventual entry into the environment is highly variable among the various products and recovery systems.

Number of People Living in Counties with Ambient Air Concentrations Above the NAAQS - C

This DROE03 indicator conveyed how many people (based on census) lived in counties where air pollutant levels at times were above the level of the NAAQS during the year stated. It was intended to give the reader some indication of the number of people potentially exposed to unhealthy air. Because of changing populations and air quality standards, however, this indicator masks actual trends in the levels of air pollutants. It is not a valid exposure indicator because it is not based on measurement of an actual marker of exposure measured on individuals.

Percent of Population Living in Homes Where Someone Smokes Regularly Inside the Home - D

This DROE indicator portrayed the percentage of homes in the U.S. in which young children were exposed to tobacco smoke in 1998 versus 1957. The survey is based on a questionnaire (do children live in the home, and does someone who smokes regularly live in the home), rather than on actual measurements of the amount of smoke actually present or the degree to which children are exposed to the resulting smoke. This indicator violates the ROE indicator definition, requiring that indicators be based on actual measurements, and blood cotenine (Indicator 102) provides a better indicator of children's exposure to smoke.

Water

Altered Fresh Water Ecosystems – C
Percent Urban Land Cover in Riparian Areas – C
Agricultural Lands in Riparian Areas - C

These DROE03 indicators are based on the percentage of land within 30 m of the edge of a stream or lake that is classified as urban or agriculture based on 1991 satellite data (NLCD). Baseline data are incomplete, and there are no reference points for the appropriate percentage of such cover, and it is not clear that the indicators could be reproduced with newer satellite data. There are no data for other alterations such as damming, channelization, etc.

Number of Watersheds Exceeding Criteria for Mercury, PCBs, & Dioxin – C

This DROE03 indicator is based on voluntary reporting of Hg contamination using data that has not undergone formal QA/QC review. It is not representative of the nation, or suitable for trend monitoring.

Lake Trophic State Index – R, C

This DROE03 indicator is based on phosphorous data collected in a one-time a statistical sample of lakes in the Northeast US during 1991-94. It is not included in the ROE07 Regional Pilot Project.

Sedimentation Index – R, C

This DROE03 indicator is based on data collected on freshwater streams in the Mid Atlantic Highlands Region during a one-time 1993-94 statistical survey. It is not included in the ROE07 Regional Pilot Project.

Contaminants in Fresh Water Fish (NAWQA) – C

This DROE03 indicator is based on reported concentrations of contaminants in fish collected by the US Geological Survey NAWQA program. While the data are collected from a large number of streams and are of high and consistent quality, the sample is not statistically representative of the nation, there are no national guidelines to serve as reference values for tissue concentrations, and Cycle II of NAWQA will not include comparable routine monitoring of trace organics and trace elements in fish tissues at sampling sites across the Nation.

Fish Index of Biotic Integrity – R, C

This DROE03 indicator is based on fish community data collected on freshwater fish in the Mid Atlantic Highlands Region during a one-time1993-96 statistical survey. Condition cannot be assessed in streams where no fish were caught, because data were insufficient to indicate whether the stream had poor quality or simply no fish. It is not included in the ROE07 Regional Pilot Project.

Macroinvertebrate IBI (MAIA) – R, C

This DROE03 indicator is based on benthic macroinvertebrate community data collected in freshwater streams in the Mid Atlantic Highlands Region during a one-time 1993-96 statistical survey. It is not included in the ROE07 Regional Pilot Project**.**

Beach Days Open – D
Waters with Fish Consumption Advisories - D

These DROE03 indicators are based on the frequency of beach closures or fish consumption advisories as reported to EPA voluntarilyby states and local government organizations. The data are not nationally or temporally consistent because of different and changing criteria for closing beaches or issuing fish consumption advisories in the different states, many of which do not involve actual water quality measurements. They are therefore level 1 indicators and fail to meet the definition for ROE indicators.

Contaminated Sediments in Fresh Water - C

This DROE03 indicator is based on reported concentrations of sediment contaminants collected by a large number of organizations focusing particularly on places where sediment contamination is perceived to be a problem (the EPA National Sediment Inventory). The database suffers from a number of limitations: the data are heavily biased toward sites at which there is a known or suspected toxicity problem and to particular geographic areas (non-representative of the nation), the data cover different dates in different locations- making estimation of trends difficult, and the data and procedures used to assign sites to a toxicity category are not uniform from watershed to watershed. It is unsuitable for trend estimation.

Chemical Contamination in Streams and Groundwater – C

This DROE03 indicator is based on data from a large number of NAWQA watersheds. The sampling and analytical protocols (including the analytes measured) are not comparable across all NAWQA watersheds.

Nitrate in Farmland, Forested and Urban Streams and Groundwater
Phosphorus in Farmland, Forested, and Urban Streams – N

These DROE03 indicators are being replaced by two new indicators, "Nitrate, Phosphorus, and Pesticides in Streams in Agricultural Watersheds" and "Nitrate and Pesticides in Groundwater in Agricultural Watersheds." The NAWQA streams in forested and urban watersheds were based on a small sample size, and may not be representative of forested and urban streams in general.

Phosphorus in Large Rivers - C

The indicator is based on phosphorus concentrations in large rivers sampled periodically by the USGS National Stream Quality Accounting Network (NASQAN). Monitoring at many of the large river NASQAN sites has been discontinued.

Chemicals

Sediment Runoff Potential from Croplands and Pasturelands - C

This DROE03 indicator represents the estimated sediment runoff potential for croplands and pasturelands based on topography, weather patterns, soil characteristics, and land-use land cover and cropping patterns for the U.S. and the Universal Soil Loss equation www.brc.tamus.edu/swat. The indicator addresses "potential" and not actual/current condition, and relies on a model to predict ambient characteristics (level 4 indicators) based on level 3 measurements, which violates a fundamental ROE protocol on the use of models in indicators. Trends in this indicator would likely be associated only with trends in land cover, cropping practices, and weather (topography and soil type are unlikely to change). No reliable spatial trend data at the appropriate scale exist for either cropping practices or land cover, and consequently trends in this indicator would be difficult to calculate.

Potential Pesticide Runoff from Fields - C
Pesticide Leaching Potential - C

These DROE03 indicators represent the potential movement of agricultural pesticides from the site of application to ground and surface waters, based on estimates of pesticide leaching and runoff losses derived from soil properties, field characteristics, management practices, pesticide properties, and climate for 243 pesticides applied to 120 specific soils in growing 13 major agronomic crops. The indicators address "potential" and not actual/current condition, and rely on models to predict ambient characteristics (level 4 indicators) based on level 3 measurements, which violates a fundamental ROE protocol on the use of models in indicators.

Risk of Nitrogen Export - C
Risk of Phosphorus Export - C

These DROE03 indicators represent the potential movement of N and P from the site of application to surface waters, based on a large empirical dataset relating land use to N and P observed in receiving streams over several decades at a variety of locations. The indicators address "potential" and not actual/current conditions, and rely on statistical models to predict ambient characteristics (level 4 indicators) based on level 3 measurements, which violates a fundamental ROE protocol on the use of models in indicators.

Pesticide Use - C

Agricultural pesticide usage data, measured at the national aggregate level for all pesticides is very difficult to interpret, given the wide year to year changes in the types of pests being controlled for and changes in agricultural production/chemical usage from year to year. From one time period to another the mix of pesticides changes, pest pressures change, agricultural practices change, agricultural acreage changes, regulatory status of key uses changes, and many other important variables change. Moreover, the effects of pesticide usage are encountered at three levels of the product's life cycle: production, usage, and residues on foods. The geographic distribution of those effects renders difficult the interpretation of national usage levels for all pesticides, taken as a group. While it is of course possible to compare magnitudes of aggregates at different times, the real significance for the environment is in the differences in the content and geographic distribution of the aggregates, not in the magnitude of the aggregate.

Contaminated Lands

Number and Location of Superfund NPL Sites - D

This DROE03 indicator is a category 1 indicator (it represents an administrative decision to force a cleanup, rather than an amount of waste present or removed), and therefore does not meet the ROE07 indicator definition.

Number of RCRA Corrective Action Sites - D

This DROE03 indicator, by itself, is a category 1 indicator (it represents an administrative decision to force a cleanup, rather than an amount of waste present or removed), and therefore does not meet the ROE07 indicator definition. The data are being combined into a new indicator, Quantity of RCRA Hazardous Waste Generated and Managed (which combines information from several DROE03 indicators).

Radioactive Waste Storage and Disposal - C

This DROE03 indicator is based on production and inventory data collected by the Department of Energy. Although the data continue to be collected, they are no longer publicly available post-September 11, 2001; therefore ongoing data trends are not and will not in the future be available for this indicator. Moreover, the earlier data reflected two distinct periods in the history of waste generation in the nuclear weapons complex. The first reflected a period during which wastes and other materials were being generated as an integral part of the production of weapons grade nuclear materials and components. The period after 1989 reflected the cessation of large-scale production of such materials and the initiation of clean-up activities and wastes from those initiatives. Thus, even before the truncation of data in the post 9/11 period, there were significant issues with the comparability of the data over time.

Human Health

Cardiovascular Disease Prevalence - C

This DROE03 indicator was based on data from NHANES III (1988-1994). Currently, no national trend data are available on cardiovascular disease (CVD) prevalence.

Blood VOC – C

This DROE03 indicator was based on a convenience sample whose representativeness cannot be determined or necessarily used as a baseline for future sampling. The indicator is based on detects only, so there is no reference level, and VOCs are cleared from the bloodstream rapidly (~ 1hr), so there is a significant possibility of false negatives, considering that exposures tends to be associated with occupational and indoor settings.

Urinary Arsenic - R
This DROE03 indicator was based on data from EPA Region 5 only, and is not part of the ROE07 Regional Pilot.

Ecological Condition

The Farmland Landscape - C
This DROE03 indicator represents croplands and the forests or woodlots, wetlands, grasslands and shrublands, that surround or are intermingled with them, and the degree to which croplands dominate the landscape http://www.heinzctr.org/ecosystems/farm/lndscps.shtml. The indicator relies on data generated using early 1990's satellite data, and it is unclear whether the definition of "farmland landscape" is sufficiently precise to be replicated independently, especially with respect to any future satellite data availability.

Extent of Estuaries and Coastline – C
This DROE03 indicator is based on remote sensing data, but is unlikely to show trends unrelated to sea level rise and changing tides, so it is not a very useful indicator for trends.

Coastal Living Habitats - C
This DROE03 indicator is based on remote sensing data of coastal wetlands, mudflats, sea-grass beds, etc., but the only system for which a national indicator has been developed is coastal vegetated wetlands, which already is covered in another indicator.

Shoreline Types - C
This DROE03 indicator is based on NOAA's Environmental Sensitivity Index. The index is based on a standardized mapping approach, but coverage is not complete for large parts of the coastline and the data in some of the atlases are more than 15 years old. Consequently, this indicator is not appropriate for measurement of representative, national trends.

Extent of Ponds, Lakes, and Reservoirs – C
This DROE03 indicator is based on data from the USGS National Wetlands Inventory. While these data are based on a valid statistical sampling design, the total amount of surface water is less than half of the area of lakes, reservoirs and ponds greater than 6 acres in size in the USGS National Hydrography Data Set. Until this discrepancy is resolved, the indicator may not satisfy the ROE criteria.

At-Risk Native Species – C
At-Risk Native Grassland and Shrubland Species – C
At-Risk Native Forest Species – C
Populations of Representative Forest Species – C
Non-Native Fresh Water Species – C
At-Risk Fresh Water Plant Communities – C
The Ecological Condition chapter is being restructured from the DROE03 organization per the recommendation of EPA's Science Advisory Board and numerous stakeholders. As such, the chapter

no longer requires that the above indicators be broken out by ecosystem. In addition, the ability to track trends of many of these indicators is currently in question.

Population of Invasive and Non-invasive Bird Species – R

This DROE03 indicator is based on an analysis of USGS Breeding Bird Survey data in grassland and shrubland ecosystems for 5 year periods ranging from the late 1960s to 2000. Because the ecological condition questions are no longer directed at specific ecosystems types, this appears to be a regional indicator. It is not clear at this time that this indicator will be updated.

Bird Community Index – R

This DROE03 indicator is not national in scope or part of the ROE EPA Regional Pilot.

Fish Diversity – R

This DROE03 indicator is based on a statistical sample of fish trawls in Mid-Atlantic estuaries during 1997-98. This indicator is not part of the ROE07 Regional Pilot project, and EMAP is no longer collecting fish samples to support this indicator.

Fish Abnormalities - C

This DROE03 indicator is based on a statistical sample of fish trawls in estuaries in the Atlantic and Gulf, but the data are no longer being collected by EMAP to support this indicator.

Unusual Marine Mortalities – C

This DROE03 indicator is based on voluntary reporting of unusual mortality events to NOAA. Because there is no systematic requirement to report, these data are not suitable to support national trends in the indicator.

Animal Deaths and Deformities – C

This DROE03 indicator is based on data reported by a number of different organizations to USGS on incidences of death or deformities in waterfowl, fish, amphibians, and mammals. Trends are available only for waterfowl, and because data reporting is voluntary rather than systematic, the data are not adequate to determine actual trends versus trends in reporting.

Tree Condition – C

This DROE03 indicator is based on an ongoing statistical sample of forests across the conterminous US and comprises components that relate to crown (tree canopy condition), the ratio of dead to live wood, and the fire class. This indicator likely relates more to forest management practices than to environmental condition, and for this reason has low relevance value to EPA.

Processes Beyond the Range of Historic Variation – C

This DROE03 indicator is based on an analysis of recent Forest Inventory and Analysis data on climate events, fire frequency, and forest insect and disease outbreaks, which were then compared to anecdotal data for the period 1800-1850. Because the early data are anecdotal, and because the data mostly relate to forest management practices, etc., it is proposed that this indicator has low relevance and that trend data are of questionable utility as an ROE indicator.

Soil Compaction – C
Soil Erosion – C

These DROE03 indicator are based on an ongoing statistical sample of soils in forests across the conterminous US, but the actual indicators are based on models rather than measurement, and they likely relate more to forest management practices than to environmental condition, and for this reason have low relevance value to EPA.

Soil Quality Index - R

This DROE03 indicator was based on a survey of soils in the Mid Atlantic region during the 1990s, and was neither repeated and is not part of the Regional Pilot Project for ROE07.

Chemical Contamination – C

This DROE03 indicator combines data from the USGS NAWQA program that are not consistent in terms of sampling frequency or analytical protocols.

Attachment 6: Indicator Materials for Review

NOTE: ATTACHMENT 6 COMPRISES THE SUBSEQUENT SECTIONS OF THIS BINDER

Indicator: Trends in Forest Extent, Types, and Age Class (108 & 109)

The forests of the U.S. cover extensive lands in both the eastern and western thirds of the country. Forest lands are managed by a complex array of interests to meet multiple purposes, including providing ecological habitat and timber resources. While the amount of forest land has remained nearly unchanged since the beginning of the 20th century, regional changes both in amount and types of forest cover have occurred as a result of changing patterns of agriculture and development. The distribution of various forest cover types is a critical determinant of the condition of forest ecosystems.

This indicator is based on data from the USDA Forest Service Forest Inventory Analysis (FIA) system. The FIA program, using a statistical survey design and comparable methods across the U.S., collects a variety of data that help assess the extent, type, age, and health of forestland in the United States. Because the surveys are repeated over time, the FIA data provide an indication of trends in the extent of forestland.

What the Data Show

The amount of forest and percentage of forestlands used for timber have remained relatively constant in recent years (Figure 108.1). Overall, FIA reports that the amount of forestland in the U.S. in 2001 was estimated at 749 million acres, a decrease of about 10 million acres from a century ago and 7 million acres half a century ago, but an increase of more than 5 million acres in the last quarter of a century (USDA, *Forest Resources of the United States, 2002).*

EPA Regions vary significantly in the percentage of forestland that is used for timber, with significant acreage of low productivity or reserved forestlands in the Regions of the west (e.g., Regions 8, 9, and 10) and nearly 100 percent of forestland used for timber production in Regions 1, 2, 3, 4, 5, and 7 (Fig 108.2).

Figure 108.3 shows the changes in forestland acreage in the different EPA Regions during the periods 1907-38, 1938-53, 1953-77, and 1977-2001. Between the first and last time periods, forestland acreage declined by roughly 22 million acres in Region 6 (25% of the forestland acreage in the Region in 1907) and more than 12 million acres in Region 9 Over the same period, forestland acreage in Region 3 increased by 13 million acres and in Region 5 by 10 million acres Forestland acreage in Region 2 nearly doubled in the time frame (USDA, *Forest Resources of the United States, 2002).*.

The types of forests that occur in the western and eastern U.S. and acreage change during the period 1992 - 2001 (Fig 108.4) Eastern and western forest lands support different species (these data do not represent all forestland, only timberland as defined by FIA data collection procedures. The largest change in acreage occurred in Maple-Beech-Birch, gaining 438,800 acres since 1992. The acreage of White-Red-Jack Pine and Spruce-Fir both declined by approximately 260,000 acres.

In the west, several species exist in very small areas, including Western Redwood. Larch, and Western White Pine. Redwood and white pine acreage declined 36 and 44 percent respectively, while Fir-Spruce, other softwoods and western hardwoods all increased by significant amounts.

Younger trees (<60 years) dominate in the eastern U.S. and trees older than 60 years dominate in the west (Fig 108.5).

Indicator Limitations

- In 1998, Congress mandated that the FIA be switched from periodic to annual inventories. While the data are collected more often, fewer data are collected. The quality and reliability of national estimates may be reduced, ~~as~~ because area estimates are based on a smaller sample size.

- Data on extent of forest land have an uncertainty of 3 to 10 percent per million acres for data reported since 1953.

Data Sources

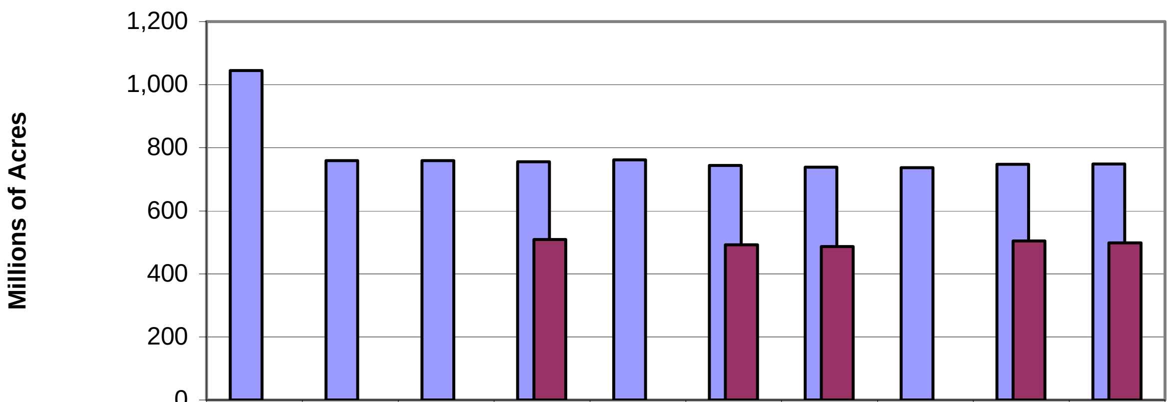
USDA Forest Service, Forest Inventory Analysis. http://www.fia.fs.fed.us/

Smith, W. Brad, Patrick D. Miles, John S. Vissage, Scott A. Pugh, *Forest Resources of the United States, 2002,* USDA Forest Service. http://ncrs.fs.fed.us/pubs/gtr/gtr_nc241.pdf

USDA Forest Service, *Draft Resources Planning and Assessment Tables*
http://ncrs2.fs.fed.us/4801/fiadb/rpa_tabler/Draft_RPA_2002_Forest_Resource_Tables.pdf

Graphics

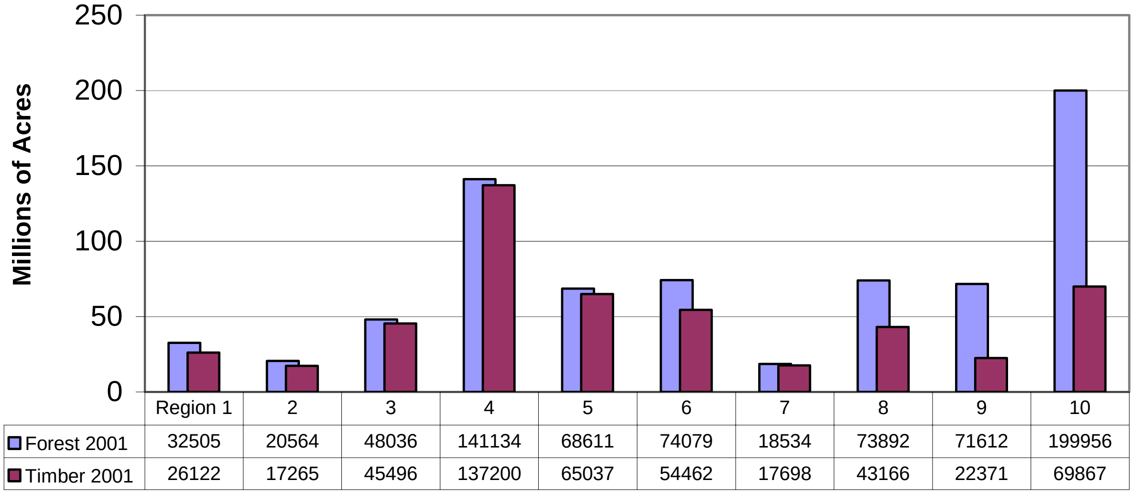
Figure 108.1: Acres of Forestland and Timberland, 1630–2002



	1630	1907	1938	1953	1963	1977	1987	1992	1997	2002
Forestland	104543	759140	759814	756167	761936	743633	737750	736684	746958	748923
Timberland				508855		492359	486317		503665	498684

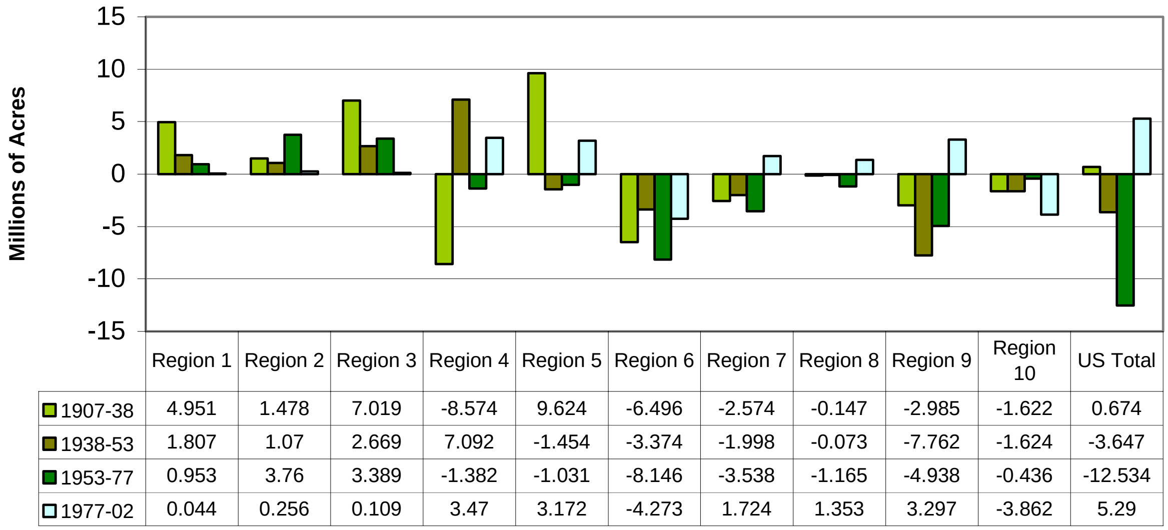
Forestland Timberland

Figure 108.2: Forest and Timber Land by EPA Region 2001



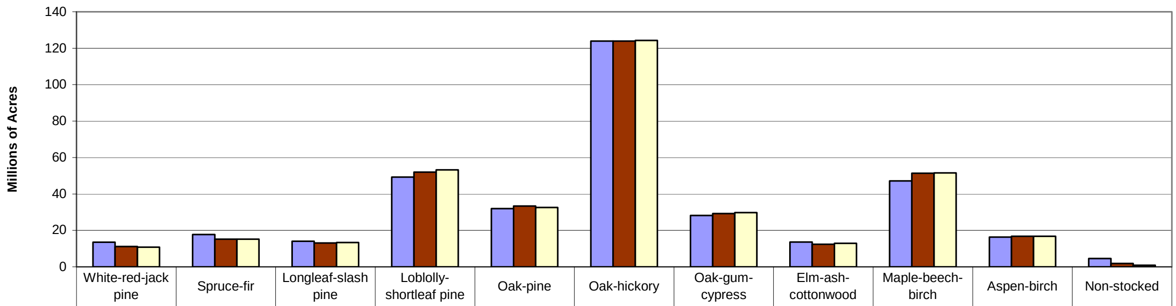
	Region 1	2	3	4	5	6	7	8	9	10
Forest 2001	32505	20564	48036	141134	68611	74079	18534	73892	71612	199956
Timber 2001	26122	17265	45496	137200	65037	54462	17698	43166	22371	69867

Figure 108.3: Change in Forestland Extent by EPA Region (1907-2002)



	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10	US Total
1907-38	4.951	1.478	7.019	-8.574	9.624	-6.496	-2.574	-0.147	-2.985	-1.622	0.674
1938-53	1.807	1.07	2.669	7.092	-1.454	-3.374	-1.998	-0.073	-7.762	-1.624	-3.647
1953-77	0.953	3.76	3.389	-1.382	-1.031	-8.146	-3.538	-1.165	-4.938	-0.436	-12.534
1977-02	0.044	0.256	0.109	3.47	3.172	-4.273	1.724	1.353	3.297	-3.862	5.29

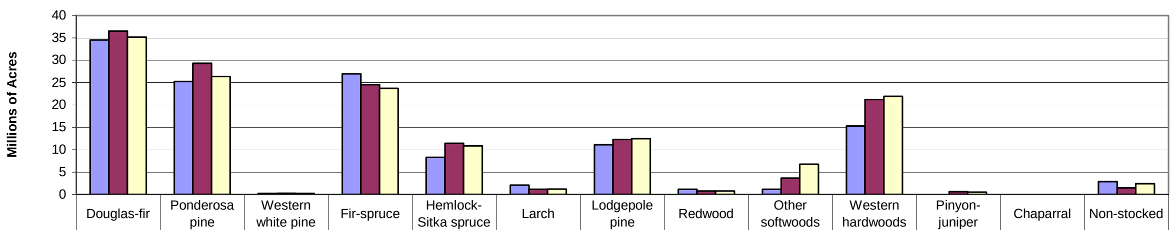
Figure 108.4a: Timberland Area in the Easern US by Forest Type, 1992–2001



	White-red-jack pine	Spruce-fir	Longleaf-slash pine	Loblolly-shortleaf pine	Oak-pine	Oak-hickory	Oak-gum-cypress	Elm-ash-cottonwood	Maple-beech-birch	Aspen-birch	Non-stocked
1992	13516	17765	14130	49324	31955	123958	28186	13671	47139	16385	4599
1997	11157	15196	13129	51962	33404	123992	29265	12299	51356	16818	1835
2001	10882	15167	13345	53178	32640	124297	29822	12850	51527	16840	838

1992 1997 2001

Figure 108.4b: Timberland Area in the Western US by Forest Type, 1992–2001



	Douglas-fir	Ponderosa pine	Western white pine	Fir-spruce	Hemlock-Sitka spruce	Larch	Lodgepole pine	Redwood	Other softwoods	Western hardwoods	Pinyon-juniper	Chaparral	Non-stocked
1992	34535	25252	203	26945	8290	2091	11103	1148	1164	15306	7	0	2873
1997	36534	29305	278	24557	11411	1161	12269	738	3671	21210	638	0	1460
2001	35151	26350	214	23691	10834	1177	12483	735	6719	21944	494		2359

1992 1997 2001

Figure 108.5a: Age Classes of Eastern Timberlands, 1997-2001

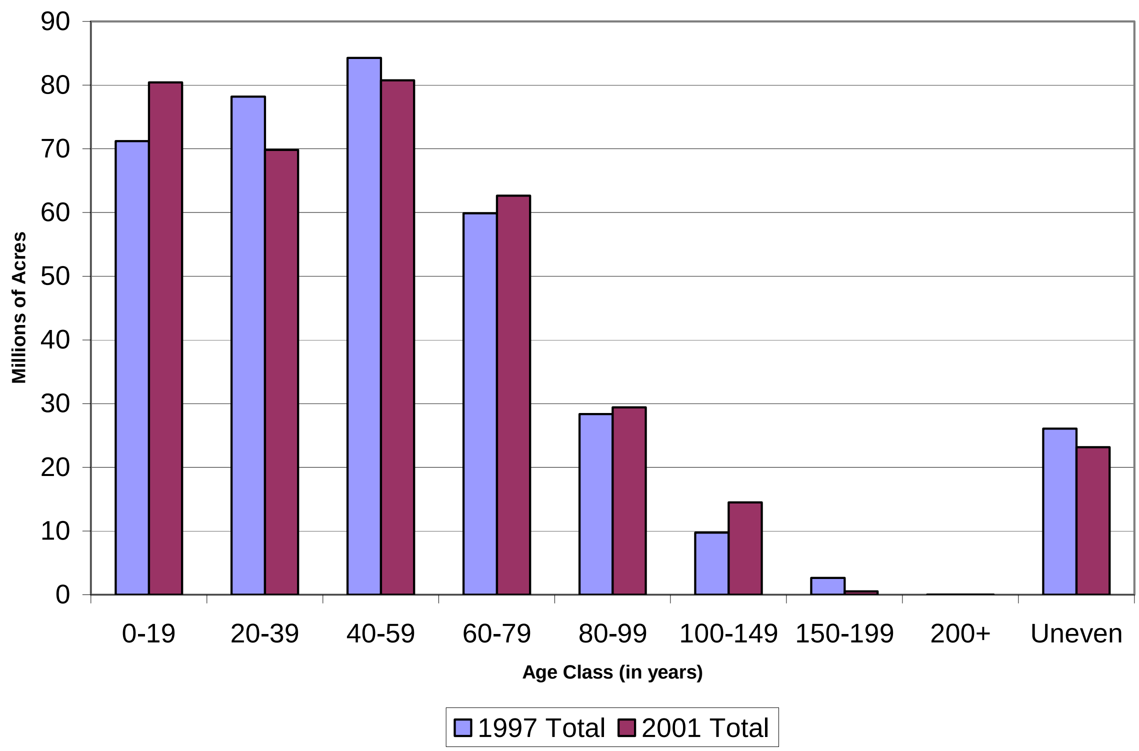
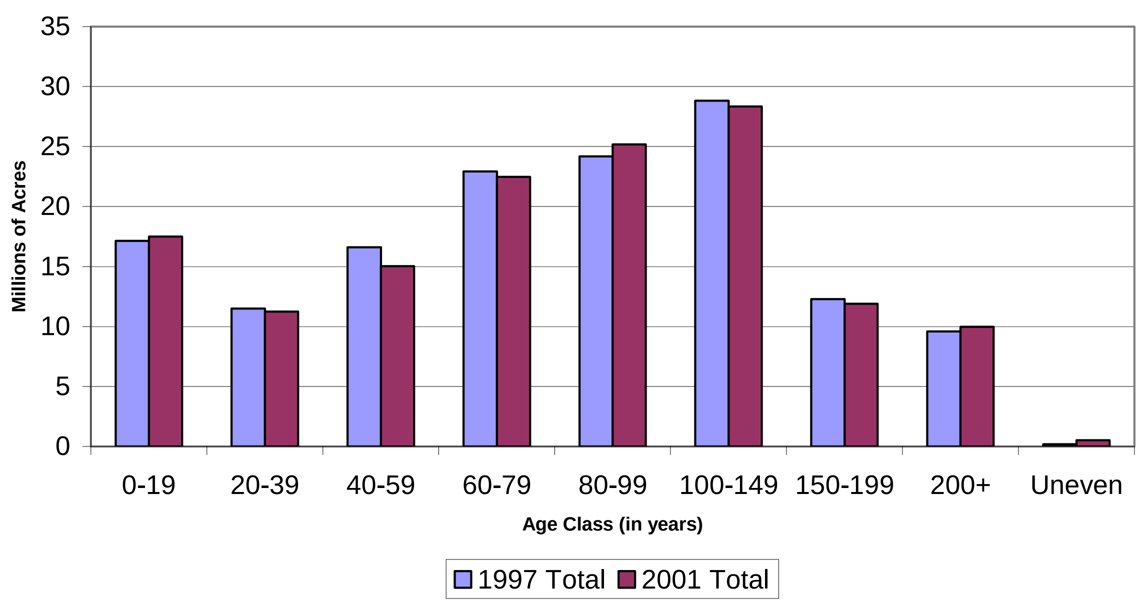


Figure 108.5b: Age Classes of Western Timberlands, 1997-2001



R.O.E. Indicator QA/QC

Data Set Name: FOREST EXTENT AND TYPE
Indicator Number: 108 (89603)
Data Set Source: Forest Inventory Analysis - FIA (USDA USFS)
Data Collection Date: 1982 to present
Data Collection Frequency: some annually
Data Set Description: Forest Extent and Type
Primary ROE Question: What are the trends in land cover and their effects on human health and the enviornment

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The Forest Inventory Analysis (FIA), the nation's forest census, is the best dataset available from which to establish national and regional trends in the amount, type, and condition of forested land. The annual inventory of forest land allows for acreage estimates, as well as other forest characteristics, to be generated on a yearly basis. The Forest Inventory Analysis (FIA) is the nation's forest census, and is acknowledged as the most reliable dataset from which to establish national and regional trends in the amount, type, and condition of forested land. Data are collected based on a multi-phase sample, as described below. The annual inventory of forest land allows for acreage estimates, as well as other forest characteristics.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The FIA uses a double probability sample. Remote sensing imagery or aerial photography is first used to classify land as forest or non-forest, and then sampling sites are chosen on a forest ecosystem data is collected from sampling sites. Phases I and II of the annual FIA inventory allows for estimates of forest cover to be generated, from which patterns and trends in forested land cover acreage and health can be deduced. A detailed discussion of the sampling design can be found at http://fia.fs.fed.us/program-features/basic-forest-inventory/ and see Smith et al. (2002): http://ncrs.fs.fed.us/pubs/gtr/gtr_nc241.pdf.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. Phases I and II of the annual FIA inventory allows for estimates of forest cover to be generated, from which patterns and trends in forested land cover acreage and health can be deduced. The FIA does conduct peer review for its analysis products (see http://fia.fs.fed.us/library/fact-sheets/data-collections/Sampling%20and%20Plot%20Design.pdf).

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

FIA consists of a nationally consistent core program which can be enhanced at the regional, state or local level to address special interests. A nationally uniform cell grid has been super-imposed over the set of sample locations, in order to provide a uniform basis for determining the annual set of measurement plots. Within the approximately 750 million acres of forested land in the United States, there are approximately 125,000 permanent sampling plots for the FIA inventory, or one sampling plot for every 6,000 acres of forest identified by Phase I points, which are evaluated for every 240 acres of land in the United States. An FIA plot consists of a cluster of four circular subplots spaced out in a fixed pattern. The plot is designed to provide a sampling frame for all P2 and P3 measurements. Phase I remote sensing activities classify forest based on a photo point which defines land as forested if it has 10% or more coverage by forest. With the federal mandate calling for 20% of plots for each state to be sampled every year, each plot should be sampled every 5 years. At present, this number is closer to every 6-10 years, based on a 10% sampling intensity in western lands and 15% in eastern states. A typical plot usually takes a 2-3 person field crew one full day to complete. These numbers do vary from state to state. The most recent annual inventory is based on 2002 data.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

To the extent that they are found in the forest population identified by Phase I sampling points. There is no attempt to oversample sensitive sites.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator simply measures extent – there are no reference points as to what the extent of different forest types should be in the modern landscape.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

What documentation clearly and completely describes the underlying sampling and analytical procedures used? Several fact sheets published by the Forest Service describe the sampling and analytical procedures used and are available on the FIA Library website (http://fia.fs.fed.us/library). Data collection: http://fia.fs.fed.us/library/fact-sheets/data-collections/FIA_Data_Collection.pdf; http://www.fs.fed.us/ne/fia/methodology/p1.html. Sampling and Plot Design: http://fia.fs.fed.us/library/fact-sheets/data-collections/Sampling and Plot Design.pdf.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Raw data for each state for recent inventory years is available at http://www.ncrs2.fs.fed.us/4801/fiadb/fiadb17_dump/fiadb17_dump.htm. The website does point out many things: 1) The annual inventory is several to many years later than the last periodic inventory (depending on the state) so that substantial changes may have occurred to the forest resources during that time. 2) The annual inventory uses a different plot design (fixed plot) than that used by the periodic inventories (variable radius plot). 3) The annual inventory samples all lands whereas some of the periodic inventories did not sample certain lands such as national parks. Forest Inventory Analysis: http://www.fia.fs.fed.us/. FIA Data is included in the Forest Resources of the United States, 2002 (http://ncrs.fs.fed.us/pubs/gtr/gtr_nc241.pdf).

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. With adequate funding, personnel, and access to USDA forest service sampling sites, the survey design is clear enough as to allow it to be reproduced.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

QA/QC is made available in several USDA Forest Service publications, both at the national and region levels (http://fia.fs.fed.us/library/fact-sheets/data-collections/QA.pdf). QA/QC results for the Northeast region are available at http://www.fs.fed.us/ne/fia/methodology/p2/NEQAresults/index.html.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. Of the approximately 125,000 permanent sampling plots located in the United States, approximately 10-15% are sampled each inventory year. Sampling for FIA Phase II inventory estimates is cyclical, so every sampling plot is measured every 7-10 years, with USDA Forest Service hoping to reduce this to every five years, once the sample size reaches the Congress mandated 20%.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Inventories conducted by FIA are designed to meet the following statistical guidelines for accuracy within one standard deviation at the 67 percent level for each State: ± 3-5 percent per million acres of timberland ± 10 percent per million acres of all other forestland. Region totals generally have errors of less than ± 2 percent. Smith,WB; Miles, PD; Vissage, JS; and SA Pugh. 2004. Forest Resources of the United States, 2002. USDA Forest Service, North Central Forest Experiment Station. Appendix C.

http://ncrs.fs.fed.us/pubs/gtr/gtr_nc241.pdf (p. 30);
http://www.fs.fed.us/ne/fia/methodology/p2/design4.html.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

While a change in methodology/sampling since 1998 results in different reliability levels for state by state forest inventory data, FIA is still the best inventory of forest in the United States, even with the change in sampling procedure. The comprehensive sampling and monitoring design ensures that statistically reliable data is generated.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

In 1998, Congress mandated that the FIA be switched from periodic to annual inventories. While the data is collected more often, less data is collected. So, the quality and reliability of national estimates has reduced, as it is based on a smaller sample size. So, comparing pre and post-1998 data presents some issues of differing reliability and accuracy. However, improvements in satellite imagery have resulted in higher resolution imagery from which to determine and classify forest cover for Phase I estimates.

Indicator: Land Cover (324)

Land cover is the ecological and physical structure of vegetation (or other materials where vegetation is non-existent) on the land surface. Land cover is also often described as what can be seen on land when viewed from above. Land cover represents one means to categorize landscape patterns and characteristics, which are important in understanding the dispersion and effects of chemicals and other pollutants in and on the environment. For the purposes of this indicator, land cover is described in terms of six major classes: forestland, grassland, shrubland, developed land, agricultural land, and other (includes ice/snow, bare rock, quarries/mines, and "transitional" areas of sparse vegetative cover (less than 25 percent of cover) that are dynamically changing from one land cover to another, often because of land use activities such as clearcuts or fire). Water acreages are noted, but are discussed elsewhere in this report. Developed and agricultural land trends and details are discussed under the "Land Use" indicator, while forestland details are included in the "Forest Extent and Type" indicator.

In 1992, several federal agencies agreed to operate as a consortium - known as the Multi-Resolution Land Characteristics (MRLC) Consortium, to acquire and analyze satellite-based remotely sensed data for environmental monitoring programs (http://www.mrlc.gov/mrlc2k_partners.asp). The initial result of the MRLC was development of the 1992 National Land Cover Database (NLCD), which is the only synoptic recent classification of land cover in the continental United Sates.

This indicator represents data from the 1992 NLCD and the U.S. Forest Service Forest Inventory Analysis (FIA). The 1992 NLCD provides a synoptic classification of land cover for the U.S., but does not include Alaska and Hawaii, thereby classifying only 1.92 billion acres out of the estimated 2.3 billion acres of land in the U.S. Therefore, data from the 1992 FIA were used to provide forestland estimates in those two states (130.9 million acres). The twenty-one land cover classes created in the NLCD were aggregated into six major cover types (and water), sometimes called ecosystems (see http://www.heinzctr.org/ecosystems/national/eco_ext.shtml), that are discussed in this indicator.

What the Data Show

Figure 324.1 shows the distribution of five major land cover types (note – this map is from the Heinz Report and combines grassland and shrubland cover types. Other options may exist for aggregating classes.) as well as major water features. The national acreages for these cover types are shown in Figure 324.2. The combination of the NLCD for the lower 48 states and FIA for forestland estimates in Alaska and Hawaii show approximately 694 million acres of forestland, 510 million acres of agricultural, 350 million acres of shrubland, and 307 million acres of grassland, and 41 million acres of developed land.

NLCD has also been summarized by EPA region as is shown in Figure 324.3. This figure depicts the variation in cover types nationwide, with forestland dominating in Regions 1, 2, 3, 4, and 10; agriculture in Regions 5 and 7; grassland in Region 8: and shrubland in Region 9. Region 6 consists of nearly equal coverage of grass, shrub, agriculture, and forestland. More than two-thirds of the grasslands in the nation are located in Regions 6 and 8, nearly two-thirds of shrublands are in Regions 6 and 9, and nearly half the forestlands in Regions 4 and 10.

Trend data for forest, developed, and agricultural lands are discussed in other indicators, using other data sets (FIA for forestland and the USDA Natural Resources Conservation Service National Resources Inventory – NRI for developed and agricultural lands). There are no trend data that specifically address grasslands and shrublands.

Indicator Limitations

- The only land cover data that cover the entire nation at adequate resolution to support this indicator are dated (1992). The MRLC is developing a circa 2001 data base, but until this project is completed, there are no consistent, synoptic data to describe trends in land cover at the national or EPA Regional levels.
- The NLCD data do not include Alaska and Hawaii.
- FIA estimates of forestland in 1992 are nearly 8 percent above NLCD, NRI estimates for developed land are 110 percent above NLCD, and NRI estimates for agriculture land are less than 1 percent below NLCD. There is more variation in a data set comparison at the regional level, with FIA estimating almost 42 percent (9 million acres) more forestland in Region 9 than NLCD, NRI estimating more than 213 percent (3.7 million acres) more developed land in Region 8 than NLCD and 158 percent (8 million acres) more in Region 6, and NRI estimating 8 percent (10 million acres) less agricultural land in Region 5 than NLCD.

Data Sources

National Land Cover Dataset (NLCD – MRLC), 1992
http://landcover.usgs.gov/natllandcover.asp

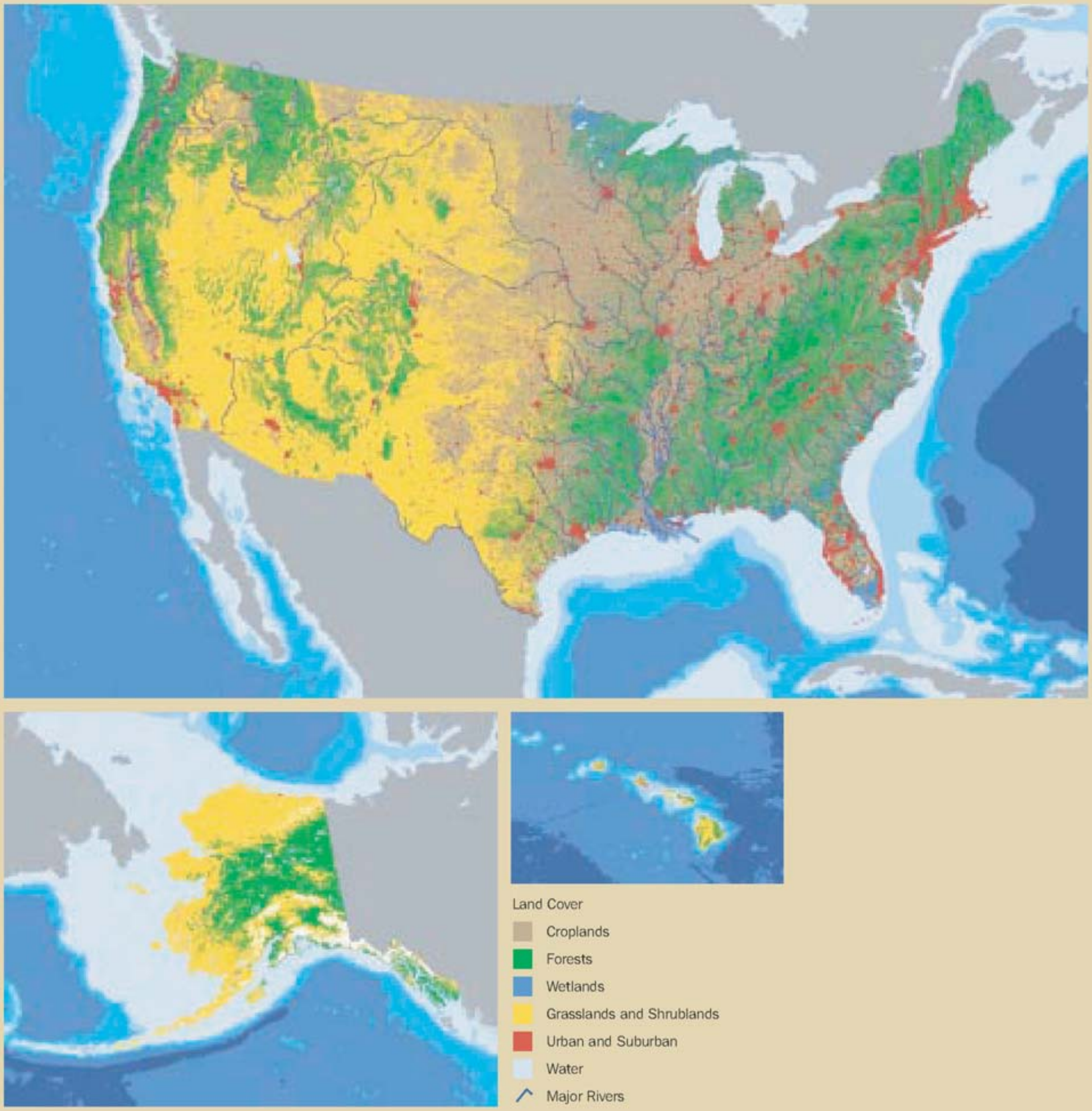
USDA, U.S. Forest Service 1992 Resources Planning Act, Forest Inventory Analysis (FIA)
http://www.fs.fed.us/rm/pubs_rm/rm_gtr234/rm_gtr234_02.pdf

USDA, Natural Resources Conservation Service, National Resources Inventory (NRI) – 1992
http://www.nrcs.usda.gov/technical/land/nri02

Graphics

Figure 324-1: U.S. Land Cover

324.1: U.S. Land Cover



This map uses satellite remote sensing information to show the distribution of the ecosystems described in this report. It covers forests, croplands (including pastures and haylands), grasslands and shrublands, urban and suburban areas, most wetlands, and rivers with flows that exceed 1000 cubic feet per second.

Data Source: lower 48 states: Multi-Resolution Land Characterization (MRLC) Consortium; Alaska: Flemming (1996); anaylsis by USGS EROS Data center.

Figure 324.2: U.S. Land Cover Types (In Millions of Acres Based on 1992 NLCD and FIA for HI and AK)

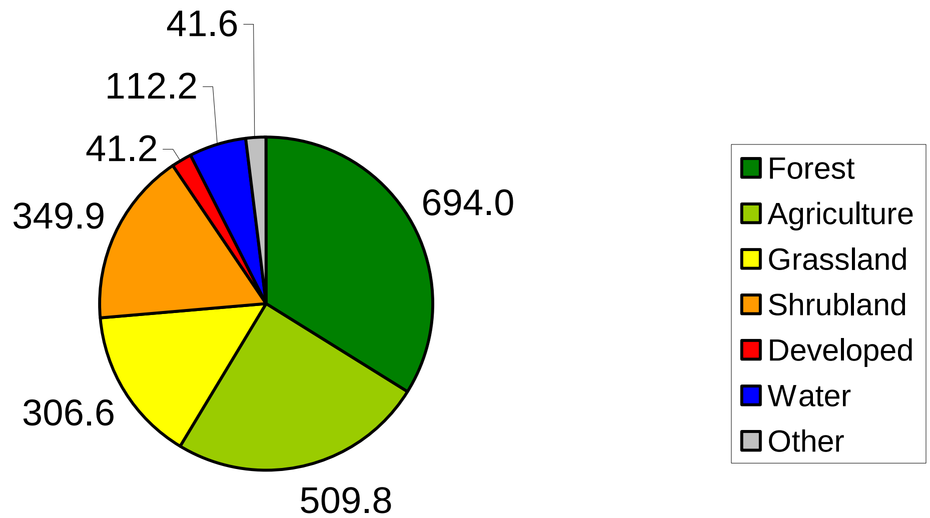
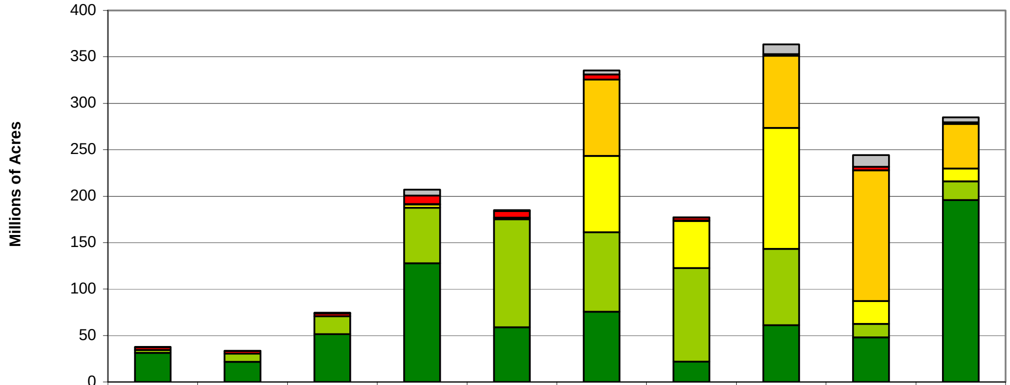


Figure 324.3: Acreage of Cover Types by EPA Region (Based on 1992 NLCD)



	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
Other	0.6912	0.10176	0.94976	6.26688	0.77888	4.208	0.27712	10.33408	12.51968	5.45408
Developed	2.63936	2.94464	3.0432	9.23584	7.27168	5.60512	3.07072	1.76896	3.8976	1.70304
Shrubland	0.1216	0	0	0.30656	0.28928	82.18624	0.70912	77.59872	140.76672	47.91808
Grassland	0	0	0	3.5712	1.37152	82.13248	50.6176	130.39936	24.68288	13.83232
Agricultural	2.99648	8.6464	19.17312	59.74016	116.10368	85.61856	100.77824	82.16256	14.32128	20.27712
Forest (includes '92 FIA for HI and AK)	31.45024	21.70496	51.57952	127.82784	58.97792	75.6064	21.84576	61.04448	48.1224	195.8286

EPA Region
(1992 FIA Forestland estimates are used for Hawaii in R9 and Alaska in R10)

Forest (includes '92 FIA for HI and AK) | Agricultural | Grassland | Shrubland | Developed | Other

R.O.E. Indicator QA/QC

Data Set Name: LAND COVER
Indicator Number: 324 (89167)
Data Set Source: NLCD (described herein), NRI (see #325), FIA (see #108)
Data Collection Date: 1992
Data Collection Frequency: infrequent
Data Set Description: Land Cover Extent
Primary ROE Question: What are the trends in land cover and their effects on human health and the enviornment

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The NLCD 1992 categorizes all land in the conterminous United States by land cover type, providing a snapshot of land cover acreage. (Alaska and Hawaii are not classified). Land cover acreage is available by state and EPA region, allowing for analysis of state and regional differences throughout the country. http://landcover.usgs.gov/accuracy/index.asp#methods The FIA and NRI data are described under the Land Use Trends Indicator and are both widely accepted as scientifically and technically valid. They are compliant with standards established by the Federal Geographic Data Committee, a 19 member interagency committee composed of representatives from the Executive Office of the President, Cabinet-level and independent agencies. The FGDC is developing the National Spatial Data Infrastructure (NSDI) in cooperation with organizations from State, local and tribal governments, the academic community, and the private sector. The NSDI encompasses policies, standards, and procedures for organizations to cooperatively produce and share geographic data

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

The data are an inventory derived from early to mid-1990s Landsat Thematic Mapper satellite data, and yield a 21-class land cover classification scheme applied consistently over the United States. Land was classified into 21 land cover types using a specific procedure, and generated estimates at the national, regional, and state level. The general NLCD procedure was to: (1) mosaic sub-regional TM scenes and classify them using an unsupervised clustering algorithm, (2) interpret and label the clusters/classes using aerial photographs as reference data, (3) resolve the labeling of confused clusters/classes using the appropriate ancillary data source(s), and (4) incorporate land cover information from other data sets and perform manual edits to augment and refine the "basic" classification developed above. The spatial resolution of the data is 30 meters. Data went through extensive accuracy assessment. http://landcover.usgs.gov/accuracy/index.asp#methods

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

There is no conceptual model to transfer these data to an indicator. The indicator consists of the statistics generated from the NLCD.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The NLCD was developed specifically to produce a consistent and seamless National Land Cover Data set (NLCD) for the conterminous United States (http://landcover.usgs.gov/accuracy/index.asp). The data are not a sample. Imagery exists for the entire nation, except for Alaska and Hawaii. The NLCD is not available to establish trends as the indicator calls for. Future processing of imagery will greatly enhance the value of the data to support the indicator. NLCD 2001 is currently under development, and will provide an updated assessment of land cover status in the United States, and will include Hawaii, Mexico, and Puerto Rico.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Not applicable.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

The NLCD is a one-time assessment of land cover status in the United States. An updated NLCD dataset will allow for a comparison of land cover estimates, and the ability to establish trends. The status of the 2001 NLCD (http://www.mrlc.gov/nlcd_overall_status.asp) is available online. Until that time, threshold values or reference points cannot be established.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Extensive documentation is available on the sampling and analytical procedures used in the NLCD on the USGS/MRLC website. http://landcover.usgs.gov/mapping_proc.asp Peer reviews of the dataset also provide good summaries of the procedures involved in developing the NLCD data set, including: Vogelmann, J.E., S.M. Howard, L. Yang, C. R. Larson, B. K. Wylie, and J. N. Van Driel, 2001, Completion of the 1990 s National Land Cover Data Set for the conterminous United States, Photogrammetric Engineering and Remote Sensing 67:650-662. The study and analytical procedures involved in the 2001 NLCD dataset can be found online (http://www.mrlc.gov/pdfs/July_PERS.pdf), as well in peer reviewed articles such as the one below. Vogelmann, J.E. and Wickham, J., 2000, Implementation strategy for production of national land cover data (NLCD) from the Landsat 7 Thematic Mapper Satellite, EPA/600/R-00/051 (NTIS PB2001-101756), Las Vegas, NV.: U.S. EPA.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. The NLCD are provided on a state-by-state basis, with state data sets cut out from larger "regional" data sets that are mosaics of Landsat TM scenes. At this time, all of the NLCD state files are available for free download as 8-bit binary files and some states are also available on CD-ROM as a Geo-TIFF. Each state data set can be downloaded, as well as FGDC metadata, from the USGS website. http://edc2.usgs.gov/scripts/mapserv.exe?map=d%3A%5CInetpub%5Cwwwroot%5Clccp%5Cnlcd%5Cnlcd.map&zoomsize=2 NLCD land cover class definitions are also available on the NLCD website (http://landcover.usgs.gov/classes.asp) A summation of NLCD metadata is available online as well. http://mcmcweb.er.usgs.gov/tnm_metadata/USGS_NLCD_metadata.html

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes, the study design is clear and complete, and with adequate access to MRLC data sources, could be reproduced.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

QA/QC of NLCD data can easily be found on the NLCD website (http://landcover.usgs.gov/accuracy/index.asp), as well as numerous other sources. The accuracy assessment of NLCD is achieved with: 1) a probability (two-stage cluster) sampling design; 2) a response design for reference data evaluation; and 3) an analysis procedure for estimation of accuracy parameters.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Data collection for NLCD is based on an inventory of satellite imagery, not by sampling. As it is based on a one-time inventory of land cover in the lower 48 states, generalization beyond time or spatial locations cannot be made.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Accuracy results are reported using several definitions of agreement between the map and primary or alternate reference land cover labels. EPA conducted an accuracy assessment for the 1992 NLCD regions and classifications (http://www.epa.gov/mrlc/accuracy.html). An accuracy assessment is done on all NLCD on a Federal Region basis following a revision cycle that incorporates feedback from MRLC Consortium partners and affiliated users. The accuracy assessments are conducted by private sector vendors under contract to the USEPA. A protocol has been established by the USGS and USEPA that incorporates a two-stage, geographically stratified cluster sampling plan (Zhu e al., 1999) utilizing National Aerial Photography Program (NAPP) photographs as the sampling frame and the basic sampling unit. In this design a NAPP photograph is defined as a 1st stage or primary sampling unit (PSU), and a sampled pixel within each PSU is treated as a 2nd stage or secondary sampling unit (SSU). PSU's are selected from a sampling grid based on NAPP flight-lines and photo centers, each grid cell measures 15' X 15' (minutes of latitude/longitude) and consists of 32 NHAP photographs. A geographically stratified random sampling is performed with 1 NAPP photo being randomly selected from each cell (geographic strata), if a sampled photo falls outside of the regional boundary it is not used. Second stage sampling is accomplished by selecting SSU's (pixels) within each PSU (NAPP photo) to provide the actual locations for the reference land cover classification. The SSU's are manually interpreted and misclassification errors are estimated and described using a traditional error matrix as well as a number of other important measures including the overall proportion of pixels correctly classified, user's and producer's accuracies, and omission and commission error probabilities.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

At the local level, USGS/EPA have noted that data quality affects the ability to infer results or trends, stating Users are cautioned who intend to apply the data to highly localized studies, such as over a small urban-suburban setting or a watershed of only tens of square miles. The land cover data quality of such a small geographic extent is unknown and the users should carefully examine the NLCD product in the local context to determine its utility. (http://landcover.usgs.gov/accuracy/index.asp#conclusion)

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The NLCD is a one-time snapshot of land cover of the United States, and is now more than 10 years old. An updated dataset is currently being created (NLCD 2001) with an anticipated completion date of 2006 or 2007, but the land cover classifications have changed slightly, as has the Landsat imagery from which the dataset is largely based (Landsat 7 vs. Landsat 5). The NLCD does not include Hawaii and Alaska. NLCD 2001 will include estimates for Hawaii and Alaska, as well as Puerto Rico.

Indicator: Land Use (325)

(Note: Some, but not all of these data sources revise their estimates annually – between Dec 2004 and the publication of the ROE, numbers may be updated and reported trends may change.)

Land use is one of the most visible effects of human inhabitation of the planet and can have effects on both human health and ecological systems. For example, land use changes may affect the potential of land to erode, the condition or contiguity of habitat, the hydrologic characteristics of a watershed, or the spread of vector-borne diseases.

This indicator tracks trends in area associated with a number of the most important land uses over the period 1977 – 2002 using a number of different data sources. These sources do not always represent the same time frame, sample the same resource or geography, or use the same definitions.

The National Resources Inventory (NRI) conducted by the USDA Natural Resources Conservation Service was used to track trends in "crop and pasture" and "developed" land (residential, commercial, industrial, and transportation uses). Between 1977 and 1997 the NRI developed estimates every five years on non-federal lands in the contiguous U.S. Since 2001 NRI has developed annual estimates, based on a smaller sample size. NRI does not address federal lands (representing 647 million out of 2.3 billion acres). Because relatively little agricultural and urban development occur on federal lands, however, the NRI data likely offer a reasonable approximation of national trends in these categories.

The Forest Inventory Analysis (FIA) surveys conducted by the USDA Forest Service were used to track trends in forest and timberlands. FIA surveys include both private and public land in all states. The FIA typically assesses timberland acreage every ten years.

The USDA National Agricultural Statistical Service (NASS) Census of Agriculture was used to track trends in the extent of "crop and pasture" land and "farm rangeland" (typically "improved" pasture). NASS data are available only for 1997 and 2002. The USDA Economic Research Service (ERS) has data on the extent grass and forested rangeland (typically unimproved grazing land) for 1997 only.

What the Data Show

Crop and farm rangeland has declined since 1997, developed land has increased, and timberland has remained approximately constant (Figure 325-1). The remaining categories have too few years of data to establish a trend. As of 2002, based on both NRI data for cropland and pastureland and NASS data for cropland and pastureland on farms, 19-21% of the land in the U.S. was used for crop production. NRI row crops, orchards, and pasture declined by nearly 66 million acres (12%) between 1982 and 2002, and by 10 million additional acres (2%) between 1997 and 2002. According to the NASS estimate, the amount of land in farms in 2002 as 938 million acres, about 2% less acreage than in 1997 (955 million acres), and the number of farms decline by 87,000. Of the land in farms in 2002, approximately 434 million acres were harvested cropland or cropland used for pasture/grazing (the remainder includes woodlands, buildings, and other non-crop pasture). Of this 434 million acres, slightly more than half a million acres were used to produce organic crops.
Based on NRI data, in 2002 nearly five percent of the country was considered developed, increasing by 34.5 million acres since 1982, or 47%.

In 2001, lands supporting timber production comprised approximately 22% of the U.S. While forestland is a land *cover* classification, "timberland" is a land *use* classification that reflects forestland capable of producing at least 20 cubic feet per acre per year of industrial wood and not withdrawn from timber utilization by statute or regulation. Two-thirds of the 749 million acres of U.S. forestland, or 504 million acres, qualified as timberland in 2001, 10 percent or 77 million acres of forest land were reserved, and the remainder, 168 million acres were characterized as unproductive. Since 1952, the variation between the maximum and minimum area of timberland has been approximately 30 million acres, or roughly 6% of the total. Between 1987 and 2001, timberland acreage increased nearly 19 million acres. This increase is attributed to a combination of tree planting done under the Conservation Reserve Program and reclassification of some National Forest lands to align with classifications used on other land ownerships.

The NASS estimates that grazing and range use on lands considered farms declined by less than 1% to 395 million acres in 2002. The broader ERS estimate of rangeland use, including grassland and shrubland pasture and grazed forestlands, indicates that nearly a third of the U.S. fell into this land use in 1997.

Land use varies substantially by EPA Region (Figure 325-2). The data range from 1997 to 2002, depending on the source of the data. Grazing and rangelands in Regions 6, 8, and 9 represent more than three-quarters of the total nationwide, while Region 4 holds the largest portion (27%) of timberland. Trends also vary widely among regions (Figure 235-3). Nearly 84% of the cropland lost between 1987 and 1997 was in Regions 4 through 8. Although increases in developed land are responsible for part of this decline (e.g., developed land nearly doubled in between 1982 and 1997 in Region 4), much of it can be attributed to the federal Conservation Reserve Program (CRP), established by the Food Security Act of 1985 to assist private landowners in converting highly erodable cropland to vegetative cover for 10 years. Since 1985, 31.6 million acres of former cropland have been enrolled in CRP, potentially accounting for as much as 60% of the loss of cropland from 1985 to 1997.

Protecting lands for certain uses is a form of land use. A Conservation Biology Institute/ World Wildlife Fund study found that about 5.0% of land mass in the US is strictly protected (GAP 1), and another 5.3% in slightly more relaxed types of protection (GAP 2). These results include Alaska, which has more than 35% of its land in GAP 1 or GAP 2. Only 5.1% of the conterminous United States is protected in areas classified as GAP 1 or 2, and most occurs in the Western States (http://www.gap.uidaho.edu/default.htm).

Indicator Limitations

- Estimates have been derived from a variety of inventories and samples, taken in different time frames and for different purposes, limiting the ability to integrate and track changes over time.
- NRI only includes a breakdown by land use type for non-federal land, while federal land accounts for more than 20% of total land in the contiguous United States, and can contain many of the same land uses as non-federal land.
- Changes in NRI sampling design currently limit the amount of sub-national data available (e.g., estimates are not available for states in the 2001-2002 timeframe, as they have been previously in five-year increments: 1982, 1987, 1992, 1997)
- GAP data are largely unavailable for private, county, and city lands, so the Protected Areas Database is largely an assessment of protected state and federal lands.
- Some land uses may not be physically visible, but only designated administratively (e.g., lands that are reserved for parks or wilderness may appear similar to lands that are managed for natural resources).
- Land use designations and management are most frequently managed and monitored by local governments in the U.S., each using different approaches and classifications making national summaries difficult.
- The extent of lands used for energy production, resource extraction or mining is not known and represents a significant data gap.
- Lands specifically protected for certain uses such as wilderness or parks, have been periodically inventoried for the nation. These statistics are currently not reported in a form that allows comparison with other statistics.

Data Sources

Conservation Biology Institute, Protected Areas Database, Second Edition. (A recently updated Third Edition is available online at http://www.consbio.org/cbi/applied_research/pad_2005/pad2005.htm).

The H. John Heinz III Center for Science, Economics and the Environment. *The State of the Nation's Ecosystems*. 2002. http://www.heinzctr.org/ecosystems/urban/imprv_area.shtml.

USDA Natural Resources Conservation Service, National Resource Inventory http://www.nrcs.usda.gov/technical/NRI/.

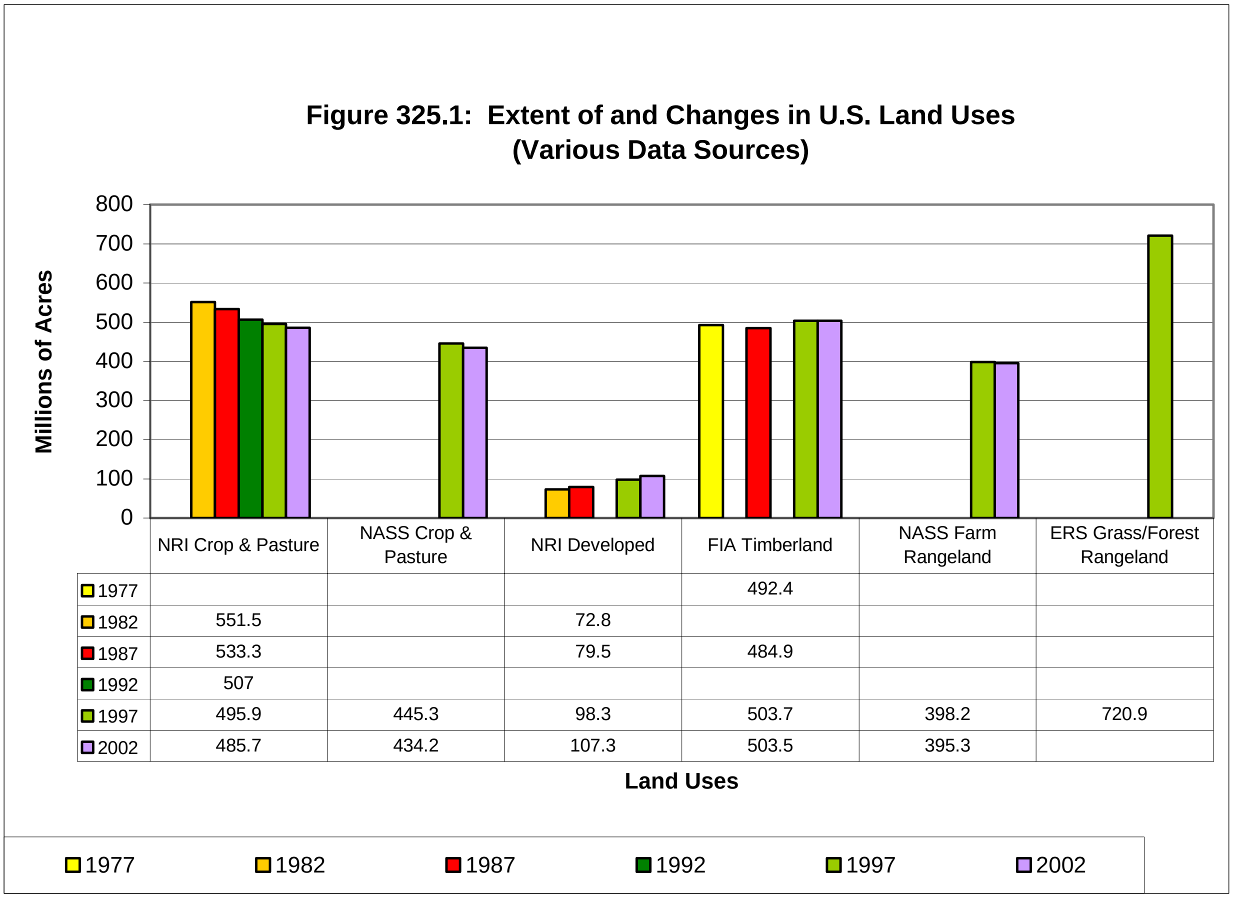
USDA, 2000. *Summary Report: 1997 NRI (Revised December 2000)*, Natural Resources Conservation Service, Washington, DC, and Statistical Laboratory, Iowa State University, Ames, Iowa, 89 pp.

USDA, National Agricultural Statistical Service, 2002 Census of Agriculture, June 2004 http://www.nass.usda.gov/census/census02/volume1/us/us2appxc.pdf (QA/QC) http://www.nass.usda.gov/census/census02/volume1/USVolume104.pdf.

USDA Forest Service, Forest Inventory Analysis (http://www.fia.fs.fed.us). FIA Data is included in the *Forest Resources of the United States,2002.* http://ncrs.fs.fed.us/pubs/gtr/gtr_nc241.pdf.

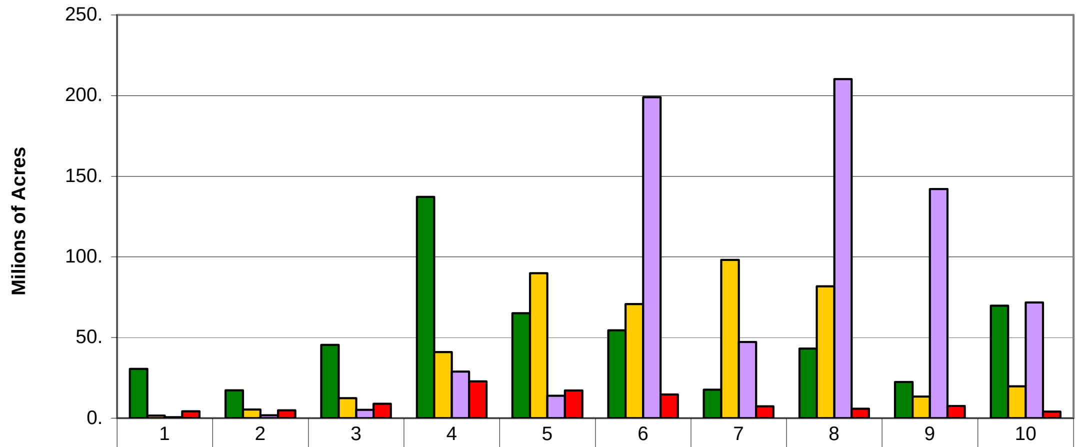
USDA, Economic Research Service; Major Uses of Land in the United States, 1997 Marlow Vesterby and Kenneth S. Krupa, Statistical Bulletin No. (SB973) 60 pp, September 2001. http://www.ers.usda.gov/publications/sb973/sb973.pdf.

Graphics



	NRI Crop & Pasture	NASS Crop & Pasture	NRI Developed	FIA Timberland	NASS Farm Rangeland	ERS Grass/Forest Rangeland
1977				492.4		
1982	551.5		72.8			
1987	533.3		79.5	484.9		
1992	507					
1997	495.9	445.3	98.3	503.7	398.2	720.9
2002	485.7	434.2	107.3	503.5	395.3	

Figure 325.2: Land Use within EPA Regions

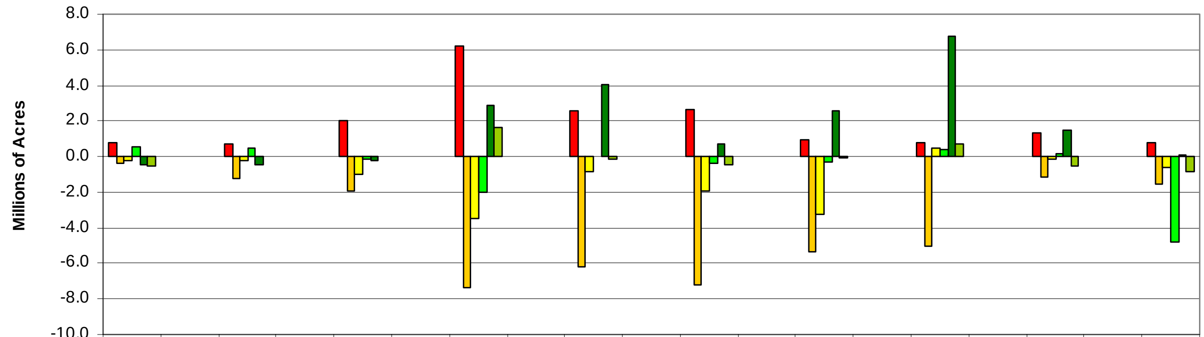


	1	2	3	4	5	6	7	8	9	10
FIA Timberland (01)	30604	17265	45496	137200	65037	54462	17698	43166	22371	69867
NASS Cropland (02)	1635.649	5389.035	12432.29	41094.92	89946.15	70723.76	98101.11	81727.97	13407.52	19706.63
ERS Rangeland (97)	698	1808	5154	28994	13839	198988	47323	210332	142098	71703
NRI Developed (97)	4171.8	4961.8	8943.8	22930.2	17201.5	14678.9	7365.3	5940.8	7508.6	4042.2

EPA Region

FIA Timberland (01) NASS Cropland (02) ERS Rangeland (97) NRI Developed (97)

Figure 325.3a: Acreage Change in Land Use by EPA Region

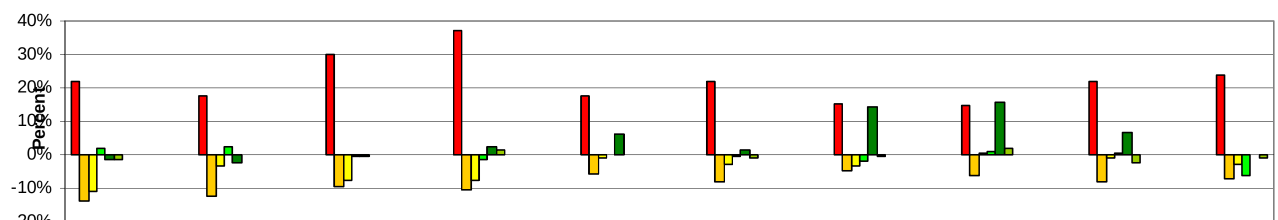


	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
NRI Developed (87-97)	752.4	736.9	2063.2	6235.9	2557.4	2615.7	967.5	763.2	1359.4	774.4
NRI Crop & Pasture (87-97)	-393.4	-1241.8	-1918.5	-7389	-6210.8	-7206.8	-5308.3	-5018.8	-1167.8	-1544.5
NASS Crop & Pasture (97-02)	-202.25	-185.42	-1011.8	-3491.4	-835.88	-1952.5	-3236.3	500.05	-149.49	-594.68
FIA Timber (77-87)	570	450	-117	-1993	-7	-359	-330	387	141	-4784
FIA Timber (87-97)	-455	-442	-240	2916	4026	692	2545	6761	1472	73
FIA Timber (97-01)	-496	-5	-25	1631	-118	-456	-46	733	-523	-818

EPA Region

NRI Developed (87-97) NRI Crop & Pasture (87-97) NASS Crop & Pasture (97-02) FIA Timber (77-87) FIA Timber (87-97) FIA Timber (97-01)

Figure 325.3b: Percent Change in Land Use by EPA Region



	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
NRI Developed (87-97)	0.2200386	0.1744183	0.2998576	0.3735347	0.1746369	0.216833	0.1512239	0.1474042	0.2210694	0.236979
NRI Crop & Pasture (87-97)	-0.13749	-0.1231932	-0.0952539	-0.1063896	-0.0561446	-0.0792959	-0.0487421	-0.0595455	-0.082523	-0.0703699
NASS Crop & Pasture (97-02)	-0.1100427	-0.0332628	-0.075258	-0.0783072	-0.0092076	-0.0268663	-0.0319363	0.0061561	-0.0110265	-0.0292926
FIA Timber (77-87)	0.018396	0.0260688	-0.0025295	-0.0148018	-0.0001145	-0.0065769	-0.0212506	0.0109678	0.0066256	-0.0634516
FIA Timber (87-97)	-0.0146302	-0.0255935	-0.0052291	0.0215093	0.0617911	0.0126006	0.1434288	0.1593335	0.0642963	0.0010328
FIA Timber (97-01)	-0.0159486	-0.0002895	-0.0005447	0.0120308	-0.0018111	-0.0083033	-0.0025924	0.0172743	-0.0228444	-0.0115725

EPA Region

NRI Developed (87-97) NRI Crop & Pasture (87-97) NASS Crop & Pasture (97-02)
FIA Timber (77-87) FIA Timber (87-97) FIA Timber (97-01)

R.O.E. Indicator QA/QC

Data Set Name: LAND USE
Indicator Number: 325 (89168)
Data Set Source: NRI (see below), FIA (see #108), NASS (see # 063), ERS (see below)
Data Collection Date: Varies (1977-2002)
Data Collection Frequency: Varies (1 yr, 5 yrs)
Data Set Description: Extent and Trends in Land Use
Primary ROE Question: What are the trends in land use and their effects on human health and the environment?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The Natural Resources Inventory (NRI) generates estimates, in million of acres, of the amount of nonfederal land in the United States. Nonfederal land includes land that is either privately owned, or managed by Native American tribes, in a trust, or by a state or local government. In 2002, this estimate was approximately 1.49 billion acres. Comparing the data from 2002 to previous data (NRIs were conducted in 1982, 1987, 1992, and 1997) allows for comparisons that establish trends in non-federal land use in the United States. With the advent of the annual NRI, yearly trends and changes will be able to be generated in the future. Uncertainty measurements for the 2002 NRI have yet to be calculated, as the national estimates were based on a smaller sampling size than previous NRIs and state by state estimates have not been concluded yet. In 1997, the NRI estimated that there were 98.3 million acres of developed land, with an estimated margin error of 884,000 acres, or less than 1% at the 95% confidence interval. For cultivated cropland, the total national estimate was 326.8 million acres, with a margin of error of 1.8 million acres, or about 0.5% at the 95% confidence interval.. Uncertainty thus depends on the category of land use, and the geography of the land that is computed. Further details on the current study methodology are available on the NRI website: http://www.nrcs.usda.gov/technical/land/nri02/) For ERS: Data are from: USDA, ERS. 2001. Major Uses of Land in the United States, 1997. Statistical Bulletin No. 973. Table 10: Pasture and range, by type and region, 1997 and Appendix table 3: Pasture and range, by region and State, 1997. http://www.ers.usda.gov/publications/sb973/ The ERS data are estimates based on composites of several published and unpublished data sources. Published sources are: " BLM, Public Land Statistics: 1997. Vol.182. BLM/BC/ST-99/001+1165 " Forest Service, Forest Inventory and Analysis Resources Planning Act (RPA) Assessment Database Retrieval System (1997) " Forest Service, Report of the Forest Service: Fiscal Year 1997 " NASS, 1997 Census of Agriculture. Vol. 1: Part 51, Chapt. 2, AC97-A-51. " NRCS, Summary Report, 1997 National Resources Inventory (revised, December 2000) Unpublished data sources used are cited but not described in the ERS document. The 1997 publication noted above claims: “ERS remains the only source of consistent major land use estimates for all 50 States.” (pg. ii, http://www.ers.usda.gov/publications/sb973/)

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

The sampling and monitoring plan for previous NRI data is based on sound scientific principles. Approximately 800,000 total sample sites in every county of every state in the country were included, and cross-indexed data gathering, instructions, and survey instruments were developed to foster consistent data gathering standards, practices, and procedures. USDA is currently transitioning to a fully implemented annual NRI, with reliability levels approaching those of the 1997 NRI. State and regional estimates have yet to be released, and national estimates were based on much smaller sampling size. Until reliability levels approach those of previous surveys, differences in methodology and reliability must be accounted for. Differences in methodology between 97/02 can be viewed at http://www.nrcs.usda.gov/technical/NRI/1997/data_gathering.html ERS data are based on various published and unpublished data, including NRI, NASS, BLM, USFS, and NRCS. Sampling schema vary in all cases. ERS states: "ERS has been a source of major land use estimates in the United States for over 50 years, and the related U.S. cropland series dates back to 1910. The major land use (MLU) series is the only consistent accounting of all major uses of public and private land in the United States. The consistent series was started in 1945, and has since been published every 5 years, coinciding with the Census of Agriculture. It contains acreage estimates of major uses by region and States for each census of agriculture year from 1945 through 1997. Data from all 12 Major Land Use reports have been combined into a set of files showing major land uses from 1945 to 1997. Gaps in continuity (identified as "Not available") occur only in categories with no data on which to base an estimate. This is the case in Alaska and Hawaii prior to statehood in 1959-1960. Since Alaska contains such vast acreage, 50-State totals in all categories prior to 1959 may appear to change precipitously."

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

There is no specific conceptual model for NRI or ERS – they are compilations of acreages gathered through various inventory efforts to track land use.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The NRI uses a stratified two-stage unequal probability area sample to ensure that sample sites are located in all counties and parishes of the 50 states and in Puerto Rico, the Virgin Islands, the District of Columbia, and selected portions of the Pacific Basin. The primary sample unit, or PSU, is the area or segment of land, from which one or more points are selected. In 1997, data was gathered from approximately 800,000 points in 300,000 PSUs. As mentioned earlier, the methodology has been changed in an attempt to expedite the generation of national estimates. 2002 NRI data was collected from 150,000 sampling sites between July 2002 and March 2003. http://www.nrcs.usda.gov/technical/land/nri02/ For ERS: Definitions of rangeland can vary across the underlying data sources used. ERS states that the "major land use series is the only consistent accounting of all major uses of land in the United States, public and private." "A consistent series was started in 1945, and has since been published at intervals coinciding with the periodic censuses of agriculture."

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The NRI and ERS data do not specifically address sensitive populations.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

No.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Statistical reliability and methodology of the 1997 NRI is available at (http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/appendices1.html), while changes in methodology and reliability for the annual NRIs can be viewed at http://www.nrcs.usda.gov/technical/land/nri02/. The most notable difference that is documented is the change in the number of sampling sites that are included, a decrease of nearly 75%. The precision of NRI estimates depends upon the number of samples within the region of interest, the distribution of the resource characteristics across the region, the sampling procedure, and the statistical estimation techniques. There are some limited descriptions of ERS data sources and approaches in the publication describing land use trends, but no details on statistical sampling procedures. (see: http://www.ers.usda.gov/publications/sb973/sb973.pdf)

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Complete NRI data files are not available on the website, but can be obtained on CD-ROM (for the 1982-1997 NRIs) from the USDA (see http://www.nrcs.usda.gov/technical/NRI/1997/obtain_data.html). The processing fee is $50. What data are available can be accessed via: http://www.nrcs.usda.gov/technical/NRI/ ERS - data tables can be downloaded at http://www.ers.usda.gov/data/majorlanduses/

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The survey design and description of the NRI is clear and complete, including the difference in data sources and methodology that have occurred since the shift to the annual NRI. The statistical design, data gathering, and estimation procedures are all available on the NRI website (http://www.nrcs.usda.gov/technical/NRI/). ERS: The methodology used by ERS to derive its published estimates from the various sources is not described.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The appendices of the 1997 NRI are readily available on the NRI website (http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/) and discuss issues related to reliability, as well as protocols for quality assurance and control. ERS: No documentation described for ERS methodology, although some data sources are described elsewhere (e.g., NASS).

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

The 1997 NRI was based on 800,000 sample sites, in every county of every state in the country, in an attempt to generate an accurate picture of land use/land cover at a state and national level. Annual NRIs compiled since 2000 have been based on a subset of approximately 150,000 to 200,000 sample sites, but starting in 2005, it is anticipated that the annual NRI will approach the reliability of the 1982 through 1997 Five-Year NRIs. Generalization is still possible, but the margin of error in national estimates has gone up, and margins of error for state estimates are not yet available. ERS: Details unknown about extrapolations, other than for data sets described elsewhere (NASS).

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

For the 1997 NRI and prior data, uncertainty measurements are included in the appendices to the reports. The margin of error for the 1997 annual NRI was approximately twice the estimated standard error, and could be used to construct a 95 percent confidence interval for most states. http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/appendices1.html ERS: No

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Possibly, the amount of developed and agricultural land is based on NRI data. Until 1997, data were generated from approximately 800,000 sample sites throughout the country. However, the 2002 annual NRI is based on 150,000 sample sites, as a smaller sample was needed to allow for more timely reporting of results. Reliability levels for the annual NRIs (national and state level data) are not expected to approach those of the 1997 Five-Year NRI until 2005. http://www.nrcs.usda.gov/technical/land/nri02/) ERS: unknown

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The NRI is a statistical survey of land use and natural resources trends on U.S. non-federal lands. The 2002 NRI estimates that about 401.9 million acres in the contiguous United States are federal land, more than 20% of the 1.9 billion contiguous acres. Lack of data for Alaska and the District of Columbia are also limiting. The shift in sampling size between the 1997 NRI and recent annual NRIs might impact the strength of the conclusions that can be drawn in trying to establish trends over the year. However, while statistical reliability has decreased, the results are still statistically valid at a high level of certainty ERS: there are gaps in the ERS data, but they are difficult to identify specifically given the lack of detail on exact origins of the data used to estimate rangeland. They are a summary of data available nationally, and appear to be the best data available.

Indicator: Urbanization and Population Change (256)

Population change is a major driver affecting numerous environmental outcomes. The total number of people and their distribution on the landscape can affect the condition of the environment in many ways; for example, increasing population often means increased urbanization, including conversion of forest, farm, and other lands for housing, transportation, and commercial purposes. In recent years many communities in the U.S. have seen an increase in developed land area that outpaces population growth. This pattern is of concern for numerous health and environmental reasons. For example, studies indicate that when land consumption rates exceed the rate of population growth, per capita air pollutant emissions from driving tend to be higher (Frank, 2004). In addition, urbanization and population growth tend to increase the amount of impervious surfaces and the quantity and types of products that humans produce, use, and discard, thereby affecting waste generation and management, water quality, and chemical production and use.

The information presented in this indicator is based on population data collected and analyzed on a decadal basis by the U.S. Census Bureau, and data collected by the USDA Natural Resources Conservation Service National Resources Inventory (NRI) to track "developed" land (residential, commercial, industrial, and transportation uses). Between 1977 and 1997 the NRI developed estimates every five years on non-federal lands in the contiguous U.S. Since 2001 NRI has developed annual estimates, based on a smaller sample size.

What the Data Show

Figure 256.1 shows absolute U.S. population growth from 1790 to 2000, including the amount of urban population change. During the past half-century (1950-2003), the population of the United States nearly doubled going from 150.7 to 290.8 million people (U.S. Census, December 2004).

In Figure 256.2, trends in urbanization and population are compared by displaying the amount of developed land relative to the amount of population change. Between 1982 and 2002, the amount of developed land in the U.S. grew by more than 34 million acres, representing a cumulative increase of approximately 47 percent (U.S.D A, Natural Resources Conservation Service, April 2004). The Census Bureau estimates that during the same period, the population of the U.S. (not including Alaska and the District of Columbia) grew by slightly more than 56 million people, or just over 24 percent (U.S. Census Bureau, December, 2004). Thus, the amount of developed land increased at nearly twice the rate of the population.

Performing the same comparison by EPA Region highlights substantial variations in population and development trends in different parts of the U.S.. Figure 256.3 shows Regional changes in population growth and developed land between 1982 and 1997. During this time, Region 4 experienced a 27 percent increase in population (10.8 million people) and a 55 percent increase in the amount of developed land. This increase in developed land represents over 8 million acres and nearly 33 percent of the total US increase in acreage developed during that time (U.S.D.A, December 2000). In general among the Western Regions (8, 9, and 10), the amount of land developed closely matched population growth. In fact, the developed acres per capita decreased in the much of the west (Regions 8 and 9). In the Northeast, in contrast, the rate of increase in developed land was nearly four times that of population (Regions 1, 2, and 3). Regions in the Midwest and South (Regions 4-7) fell in-between with percent increase in developed land ranging from 1.6 to 3.2 times the rate of population change.

Figure 256.4 shows the change in population density by EPA Region and for the U.S. as a whole from 1950 to 2003. In 2003, Region 2 had the highest density at more than 509 people per square mile. For the last fifty years, Region 2 has consistently maintained more than twice the population density of all other

Regions. The least dense Region in 2003 was Region 10, with an average of slightly more than 14 people per square mile (including Alaska). The national average in 2003 was 82.2 people per square mile. The largest population increase in both absolute and percent change between 1950 and 2003 occurred in Region 9 where population increased by nearly 33 million people, a 272% change. (U.S. Census Bureau, November 2002 and July 2004). In that same time frame, 32 million people were added to Region 4 for a 133% increase. (U.S. Census Bureau, November 2002 and July 2004).

Indicator Limitations

Census data:

- Inter-censal figures are estimates based on sampling, and thus differ from the decennial census data in methodology and accuracy.
- There are sampling and non-sampling errors for all Census data as a result of errors that occur during the data collection and processing phases of the census.
- Puerto Rico and Virgin Island data are not available for all years, and thus have not been included, affecting the accuracy of the statistics for Region 2.
- The criteria for estimating urban population have changed over time as defined by the Census Bureau.

Natural Resources Inventory (NRI) data:

- NRI sampling procedures changed in 2000 to an annual survey of fewer sample sites than had previously been sampled (starting in 1977, NRI sampled 800,000 points every five years). Fewer sample points means increased variance and uncertainty and an inability to develop estimates on a state or regional basis. (These estimates will be available in the future as more points are sampled annually.)
- NRI collects some data across the entire nation, including Puerto Rico and the Virgin Islands. Land use statistics, however, are not reported on federal lands or for Alaska and the District of Columbia.

Data Sources

Frank, Larry, *et al.* SMARTRAQ. Georgia Institute of Technology and the University of British Columbia, 2004.

U. S. Census Bureau, *Population Estimates, July 2003 Data*. Washington DC: U.S. Census Bureau, July 2004.
http://www.census.gov/popest/states/tables/NST-EST2003-01.xls

U.S. Census 2000, Summary File 4, Technical Documentation. Washington, DC: U.S. Census Bureau, June 2004, SF4/09 (RV). http://www.census.gov/prod/cen2000/doc/sf4.pdf.

U.S. Census Bureau Section 515 Information Quality Guidelines. Washington DC: U.S. Census Bureau. http://www.census.gov/qdocs/www/quality_guidelines.htm.

U.S. Census Bureau, *Demographic Trends in the 20th Century: Census 2000 Special Reports.* Washington DC: U.S. Census Bureau, November 2002. http://www.census.gov/prod/2002pubs/censr-4.pdf

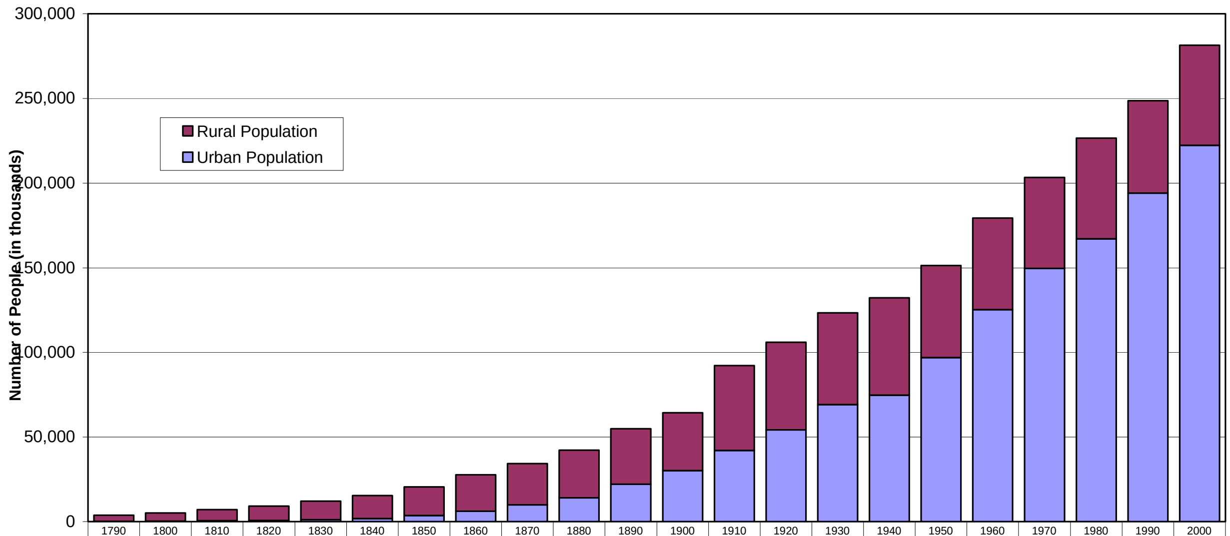
U. S. Census Bureau, *Statistical Abstract of the United States 2004-2005: The National Data Book.* Washington DC: U.S. Census Bureau, December, 2004. http://www.census.gov/statab/www/.

U. S. Department of Agriculture, *2002 Annual NRI: Land Use*. Washington DC: U.S. Department of Agriculture, Natural Resources Conservation Service, April 2004. http://www.nrcs.usda.gov/technical/land/nri02/landuse.pdf

U. S. Department of Agriculture, *1997 Five-Year NRI: Acreage and Percentage of Non-Federal Land Developed* . Washington DC: U.S. Department of Agriculture, Natural Resources Conservation Service, December 2000. http://www.nrcs.usda.gov/technical/land/meta/t5846.html

Graphics

Figure 256.1: Population Growth and Urbanization, 1790-2000

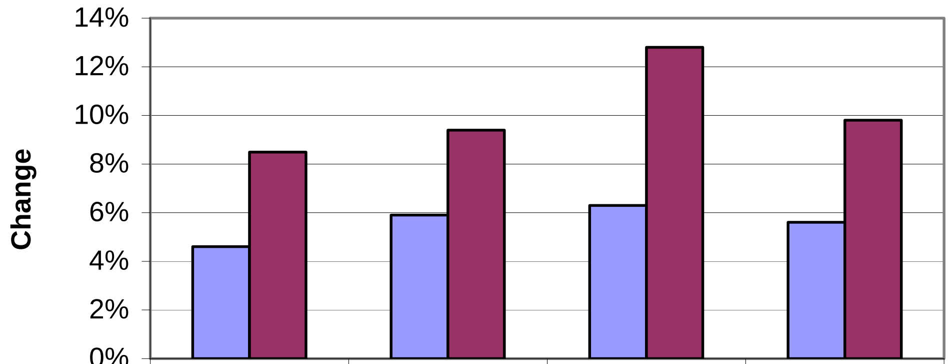


	1790	1800	1810	1820	1830	1840	1850	1860	1870	1880	1890
Rural Population	3606.843	4783.024	6546.626	8511.206	11015.65	13488.86	16975.36	21540.96	24428.64	28082.94	32764.93
Urban Population	201.655	322.371	525.459	693.255	1127.247	1845.055	3574.496	6216.518	9902.361	14129.74	22106.27
total	3929.214	5308.483	7239.881	9638.453	12860.7	17063.35	23191.88	31443.32	38558.37	50189.21	62979.77

	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Rural Population	34148.17	50164.5	51768.26	54253.28	57459.23	54478.98	54054.43	53655.41	59491.21	54621	59061
Urban Population	30214.83	42064	54253.28	69160.6	74705.34	96846.82	125268.8	149646.6	167051	194097	222361
total	76212.17	92228.5	106021.5	123202.6	132164.6	151325.8	179323.2	203302	226542.2	248718	281422

Year

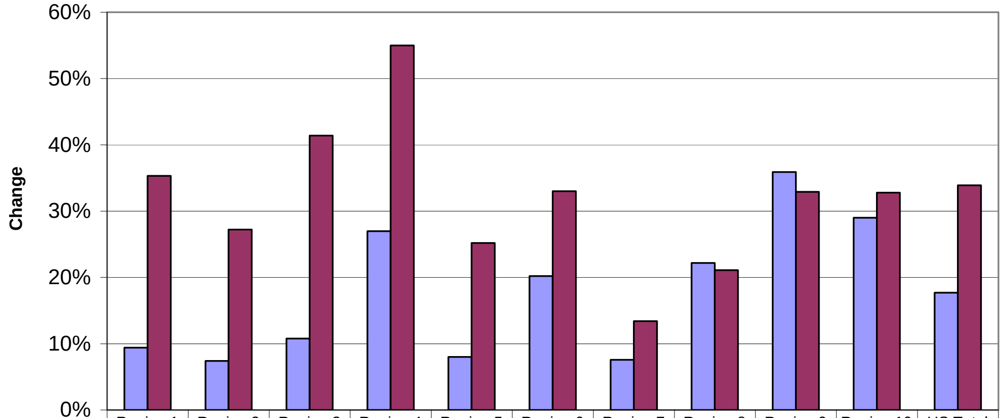
Figure 256.2: Percent Change in Population and Developed Land in the U.S., 1982-2002



	1982-87	1987-92	1992-97	1997-2002
Change in Population	4.6%	5.9%	6.3%	5.6%
Change in Developed Land	8.5%	9.4%	12.8%	9.8%

Change in Population   Change in Developed Land

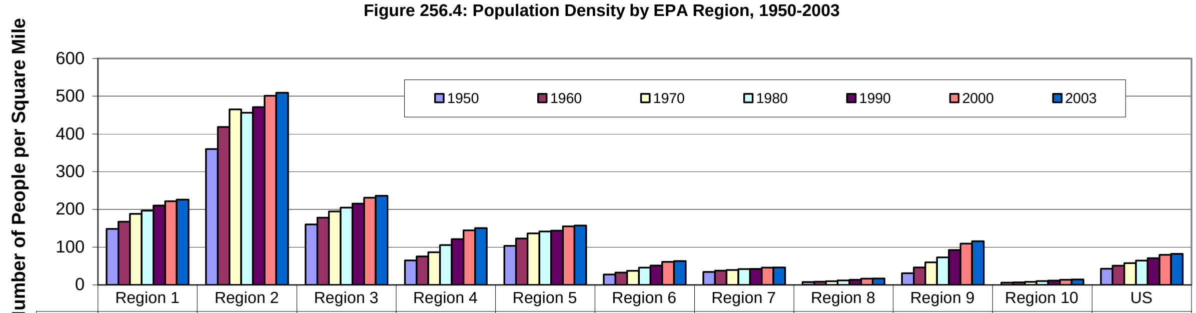
Figure 256.3: Percent Change in Population and Developed Land by EPA Region, 1982 to 1997



	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10	US Total
Change in Population	9.4%	7.4%	10.8%	27.0%	8.0%	20.2%	7.6%	22.2%	35.9%	29.0%	17.7%
Change in Developed Land	35.3%	27.2%	41.4%	55.0%	25.2%	33.0%	13.4%	21.1%	32.9%	32.8%	33.9%

Change in Population   Change in Developed Land

Figure 256.4: Population Density by EPA Region, 1950-2003



	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10	US
1950	148.3	360.0	160.3	64.7	103.3	27.8	34.6	7.3	31.1	5.7	42.8
1960	167.3	418.2	178.4	75.5	122.7	32.7	37.6	8.7	46.5	6.7	50.7
1970	188.6	465.2	194.8	86.3	136.4	37.2	39.6	9.7	59.6	8.0	57.5
1980	196.6	456.2	204.6	105.3	141.6	45.8	41.5	12.1	73.0	9.9	64.0
1990	210.3	470.8	215.5	121.1	143.5	51.5	42.2	13.3	92.6	11.3	70.3
2000	221.7	501.4	231.3	144.2	155.0	60.8	45.6	16.3	109.4	13.7	79.6
2003	226.2	509.4	236.6	150.6	157.5	63.4	46.3	17.0	115.5	14.3	82.2

R.O.E. Indicator QA/QC

Data Set Name: URBANIZATION AND POPULATION CHANGE
Indicator Number: 326 (89170)
Data Set Source: NRI (see # 325 for metadata) and US Census (see # 256)
Data Collection Date: 1982, 1987, 1992, 1997 (2002)
Data Collection Frequency: NRI - annually-5 years
Data Set Description: Comparison of population change and change in developed lands
Primary ROE Question: What are the trends in land use and their effects on human health and the environment?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes, to the extent that Census data are viewed as "physical measurements," the Census Bureau statistical sampling is viewed as valid. Similarly, the NRI data collected as an inventory are accepted as valid for the estimation of various non-federal land uses. Yes. The Natural Resources Inventory (NRI) generates estimates, in million of acres, of the amount of nonfederal land in the United States. Nonfederal land includes land that is either privately owned, or managed by Native American tribes, in a trust, or by a state or local government. In 2002, this estimate was approximately 1.49 billion acres. Comparing the data from 2002 to previous data (NRI surveys were conducted starting in 1977 and every five years thereafter) allows for comparisons that establish trends in non-federal land use in the United States. With the advent of the annual NRI, yearly trends and changes will be able to be generated in the future. Uncertainty measurements for the 2002 NRI have yet to be calculated, as the national estimates were based on a smaller sampling size than previous NRIs and state by state estimates have not been concluded yet. In 1997, the NRI estimated that there were 98.3 million acres of developed land, with an estimated margin error of 884,000 acres, or less than 1% at the 95% confidence interval. Further detail on the current study methodology are available on the NRI website: http://www.nrcs.usda.gov/technical/land/nri02/

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Decennial census data are based on a comprehensive survey of the entire resident U.S. population. Census data are derived from information provided by the Census questionnaire. An analysis of the data collection procedures of Census 2000 can be found at http://www.census.gov/pred/www/rpts/TR13.pdf. Annual July population estimates are generated by a formula that uses 2000 census data to calculate change. This formula uses births to U.S. resident women, based on data supplied by the National Center for Health Statistics; registered deaths to U.S. residents, also estimated from data from the NCHS; net international migration, calculated from Census 2000 Supplementary Surveys and the Demographic Analysis and Population Estimates (DAPE) project; and net movement of U.S. Armed Forces, based on overseas strength statistics supplied by the five branches of the Armed Forces in the Departments of Defense (Army, Navy, Marines, and Air Force) and Transportation (Coast Guard). The US Census Bureau has adopted and follows Section 515 information quality guidelines as mandated by the Office of Management and Budget (OMB) to ensure the highest level of data accuracy possible. http://www.census.gov/qdocs/www/quality_guidelines.htm The sampling and monitoring plan for NRI is based on sound scientific principles. Approximately 800,000 total sample sites in every state in the country are included, and cross-indexed data gathering, instructions, and survey instruments were developed to foster consistent data gathering standards, practices, and procedures. USDA is currently transitioning to a fully implemented annual NRI, with reliability levels approaching those of the 1997 NRI. State and regional estimates have yet to be released, and national estimates were based on much smaller sampling size. Until reliability levels approach those of previous surveys, differences in methodology and reliability must be accounted for. Differences in methodology between 97/02 can be viewed at http://www.nrcs.usda.gov/technical/NRI/1997/data_gathering.html.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. Decennial census data are the primary and authoritative source for national, regional, state, and local population data in the United States. As such, the data are reliable for establishing an indicator that seeks to report the status of population growth, and establish trends in population change. When coupled with measurements of land area, these data provide a reliable indicator of population density change.Yes. The NRI has the ability to track changes over a finite time frame in the amount of land used for specific uses.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Decennial census population data, while not a sample, are collected every ten years, and thus allow a view of both status and trends related to population growth and change. Annual population estimates are based on a formula that utilizes reliable data sources. Thus, analyzing both status and trends based on yearly estimates can be done with a high level of confidence.The NRI uses a stratified two-stage unequal probability area sample to ensure that sample sites are located in all counties and parishes of the 50 states and in Puerto Rico, the Virgin Islands, the District of Columbia, and selected portions of the Pacific Basin. The primary sample unit, or PSU, is the area or segment of land, from which one or more points are selected. In 1997, data was gathered from approximately 800,000 points in 300,000 PSUs. As mentioned earlier, the methodology has been changed in an attempt to expedite the generation of national estimates. 2002 NRI data was collected from 150,000 sampling sites between July 2002 and March 2003. http://www.nrcs.usda.gov/technical/land/nri02/. Land use data are not reported on federal lands or for Alaska and the District of Columbia.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Not applicable for Census or NRI data.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

No.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Data collection and analytical procedures can be found throughout the Census 2000 website, including http://www.census.gov/prod/cen2000/doc/sf1.pdf and http://www.census.gov/pred/www/rpts/TR13.pdf. Census data sets are known to contain errors, outlined in the Census Bureau's statement on statistical quality, available on its website. http://www.census.gov/main/www/policies.html#quality Statistical reliability and methodology of the 1997 NRI is available at (http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/appendices1.html) while changes in methodology and reliability for the annual NRIs can be viewed at http://www.nrcs.usda.gov/technical/land/nri02/. The most notable difference that is documented is the change in the number of sampling sites that are included, a decrease of nearly 75%. The precision of NRI estimates depends upon the number of samples within the region of interest, the distribution of the resource characteristics across the region, the sampling procedure, and the statistical estimation techniques.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. Metadata regarding quality assurance and quality control issues, as well as data dictionaries and definitions can be found throughout the Census website. Confidentiality is not an issue for the level of resolution required in the ROE. Metadata and definitions are available for specific geographic areas, including metropolitan areas. (http://www.census.gov/geo/www/cob/ma_metadata.html)Complete NRI data files are not available on the website, but can be obtained on CD-ROM (for the 1982-1997 NRIs) from the USDA (see http://www.nrcs.usda.gov/technical/NRI/1997/obtain_data.html). The processing fee is $50. What data are available can be accessed via: http://www.nrcs.usda.gov/technical/NRI/. There are metadata available.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes, the study design is clear. The methodology, including the operations and questionnaires used by Census takers, can be found on the FAQ section of the Census website (http://www.census.gov/dmd/www/refroom.html).The survey design and description of the NRI is clear and complete, including the difference in data sources and methodology that have occurred since the shift to the annual NRI. The statistical design, data gathering, and estimation procedures are all available on the NRI website (http://www.nrcs.usda.gov/technical/NRI/).

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

As mentioned earlier, the Census Bureau has adopted Section 515 Information Quality guidelines published on the website. Other procedures for quality assurance and quality control are contained in technical documentation available on the website.The appendices of the 1997 NRI, readily available on the NRI website (http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/), discuss issues related to reliability, as well as protocols for quality assurance and control.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes, appropriate methods are used. The decadal census is a comprehensive sample. Inter-censal analyses were described previously. The 1997 NRI was based on 800,000 sample sites on non-federal lands, in every state in the country, in an attempt to generate an accurate picture of land use/land cover at a state and national level. Annual NRIs compiled since 2000 have been based on a subset of approximately 150,000 to 200,000 sample sites, but starting in 2005, it is anticipated that the annual NRI will approach the reliability of the 1982 through 1997 Five-Year NRIs. Generalization is still possible, but the margin of error in national estimates has gone up, and margins of error for state estimates are not yet available. Generalization to federal lands is not possible.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. As noted in the Census Bureau's statement on statistical quality (referenced above), "all survey and census results contain measurement error and may contain sampling error", with "available information about these potential errors& provided or referenced in data products as they are presented".Yes. For the 1997 and prior data, uncertainty measurements are included in the appendices to the reports. The margin of error for the 1997 annual NRI was approximately twice the estimated standard error, and could be used to construct a 95 percent confidence interval for most states. http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/appendices1.html

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not in any major way. Census data are the most accurate, exhaustive, and time-consuming method for collecting information that aims to determine the status of, and establish trends in, population and population change over time. Potentially. Through 1997, NRI estimates are generated from approximately 800,000 sample sites throughout the country. The 2002 annual NRI is based on 150,000 sample sites, as a smaller sample was needed to allow for more timely reporting of results. Reliability levels for the annual NRIs (national and state level data) are not expected to approach those of the 1997 Five-Year NRI until 2005. State and regional level reports are not currently available for 2002. Again, land use data for federal lands are not available. Land use data are not reported for Alaska and the District of Columbia. http://www.nrcs.usda.gov/technical/land/nri02/)

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Census data are the most comprehensive data set on population available, and an excellent source for producing an indicator on population and population change over time. While measurement and sampling errors do exist, especially when calculating population estimates or projections, gaps or limitations in the data set should not mislead users on fundamental trends in the indicator over space or time.

Indicator: Fertilizer Applied For Agricultural Purposes – (063)

Commercial fertilizers are applied to agricultural crops to increase crop yields. Prior to the 1950s, most farming occurred on small family farms with limited use of chemicals. The shift since then to larger corporate farms has coincided with the use of chemical fertilizers in modern agricultural practices. The three major types of commercial fertilizer used in the United States include nitrogen, phosphate, and potash. Nitrogen (N) is primarily found in soil as nitrate, and is both extremely soluble and mobile: it can lead to nuisance algal growths, mostly in downstream estuaries, and can cause contamination of drinking water. Phosphorous (P) is primarily found as phosphate, and while less soluble, is still easily transportable with soil in runoff; it can lead to nuisance algae and plant growth, often in freshwater streams, lakes, and estuaries. Potash is the oxide form of potassium (K) and its principal forms as fertilizer are potassium chloride, potassium sulfate, and potassium nitrate. When used at recommended application rates, there are little to no adverse effects from potassium, but it is a common component of mixed fertilizers used for high crop yields and is tracked in the fertilizer use surveys conducted..

This indicator shows total commercial fertilizer use of the three major fertilizers in tons per year (expressed as N, P, or K) from 1960 to 2003, based on an annual survey for agricultural crops conducted by the United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS). NASS produces an annual *Agricultural Chemical Usage* report of 4-5 targeted field crops that is based on data compiled from the Agricultural Resources Management Survey (ARMS), which surveys farmers in major agriculture producing states that together account for 80-99 percent of total U.S. acreage planted. The indicator also shows total use of commercial fertilizer for key crops – corn, soybeans, and cotton – by EPA region for the year 2000.

What the Data Show

Based on fertilizer sales data, NASS estimates show that total use of the three major commercial fertilizers has steadily increased, from 7.5 million nutrient tons per year (MT/yr) in 1960 to 21.3 MT/yr in 2003 (Fig 063-1). Following a large decrease in 1983 to 18.1 MT/yr primarily due to federal land conservation programs that removed cropland from production and decreasing acreage harvested by 16%, aggregate use has fluctuated between 19-23 MT/yr over the last twenty. Nitrogen accounted for the steepest increase in use, from 2.7 MT/yr in 1960 to 12.0 MT/yr in 2003, and now accounts for over 55% of total fertilizer use, up from nearly 37% in 1960. In that same period, phosphate and potash use grew more slowly and remained steady between 4 and 5 MT/yr each. Both phosphate and potash declined by approximately 1 MT/yr since reaching their peak usage in the late 1970s, and now account for approximately 20% and 24% of total fertilizer usage, as compared to 34% and 29% in 1960.

Estimates from annual NASS *Acreage* reports show that similar amounts of land have been planted with corn each year since 1995. The acreage planted in corn has totaled between 77–80 million acres, an increase from 66 million acres planted in 1970. While grown in most states, corn production is concentrated in the middle of the country (EPA Regions 5 and 7). The acreage of land planted in cotton was 15.5 million acres in 2000 and has averaged between 12-14 million acres since 1990. Major cotton-producing states include 17 southern states located in EPA Regions 4, 6, and 9. Soybean acreage represents the fastest growing crop in total acreage, increasing from 57.8 million acres in 1990 to 74.3 million acres in 2000. The majority of soybean acreage (80%) is concentrated in the upper Midwest in EPA Regions 5 and 7.

Overall, the ARMS states for these three crops used slightly more than 10.8 MT/yr of fertilizer in 2000, or about one half of the 21.6 MT/yr estimated by USDA's Economic Research Service for the entire United States. Of this amount, slightly less than half (5.25 MT/yr) was in applied in EPA Region 5, of which 4.6

MT/yr was used for corn (Fig 063-2). An additional 3.2 MT/yr was applied in EPA Region 7 in corn or soybeans. Most of the remainder was used in EPA regions 4 and 6, primarily on cotton.

Indicator Limitations

- USDA national estimates of fertilizer use are based on sales data provided by states, and not on actual fertilizer usage, and are susceptible to differing reporting procedures or accuracy from state to state.
- Within the ARMS, not all states report fertilizer data every year for each crop type, so it is hard to establish year to year trends (a decrease in fertilizer use for a specific crop might be attributed to failure of a state to report, rather than an actual decrease of use).
- ARMS sampling is limited to program states, which represent only 65-99% of crops, depending on crop types
- The NASS *Acreage* report has estimates for the entire nation by crop, while fertilizer data are based on USDA program states. Even though they represent the majority of U.S. planted acreage, often over 90%, the ability to generalize the data to the country as a whole is unknown, as non-program states, while representing a small percentage of a crop, might have much different application rates due to climate, weather, etc.
- Fertilizer applied to trees that are considered agricultural-type crops (e.g., nut producing trees) are included in field crop summaries; but fertilizer applied in silviculture (e.g., southern pine plantations) are not covered by the NASS data collection system.

Data Sources

National Agricultural Fertilizer Use Estimates

Agricultural Resources and Environmental Indicators Report, USDA, Economic Research Service, 2003. http://www.ers.usda.gov/publications/arei/ah722/

U.S. Fertilizer Use, The Fertilizer Institute, 2004. http://www.tfi.org/Statistics/USfertuse2.asp

Email Correspondence (10/29/04), Wen Huang, USDA Economic Research Service

Fertilizer Estimates for ARMS Crop Program States

Agricultural Chemical Usage, Field Crop Summary 2000, USDA National Agricultural Statistics Service (NASS), May 2001. http://usda.mannlib.cornell.edu/reports/nassr/other/pcu-bb/agcs0501.pdf.

Acreages of Crop Production Estimates

Acreage, USDA, National Agricultural Statistics Service, 2004. http://usda.mannlib.cornell.edu/reports/nassr/field/pcp-bba/

Agricultural Statistics 2004, USDA, National Agricultural Statistics Service, 2004. http://www.usda.gov/nass/pubs/agr04/acro04.htm

USDA Briefing Rooms – Corn, Cotton, and Soybeans and Oil Crops, Economic Research Service http://www.ers.usda.gov/briefing/

Graphics

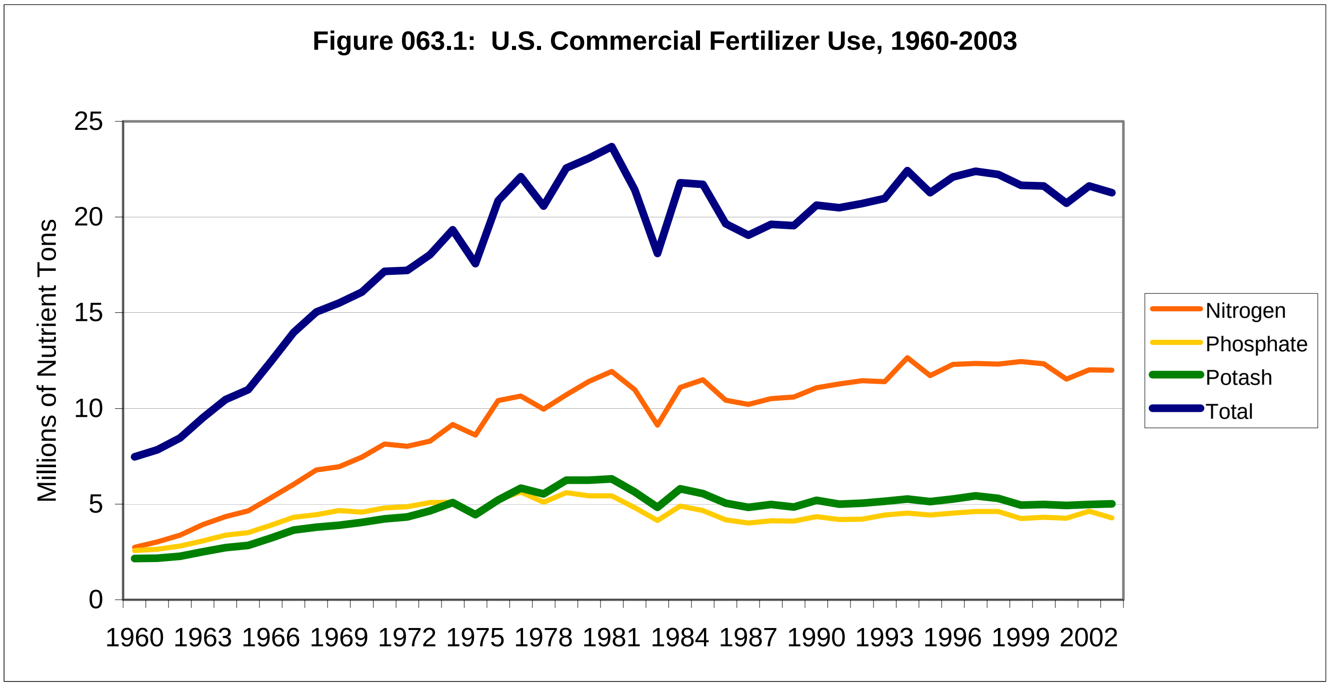
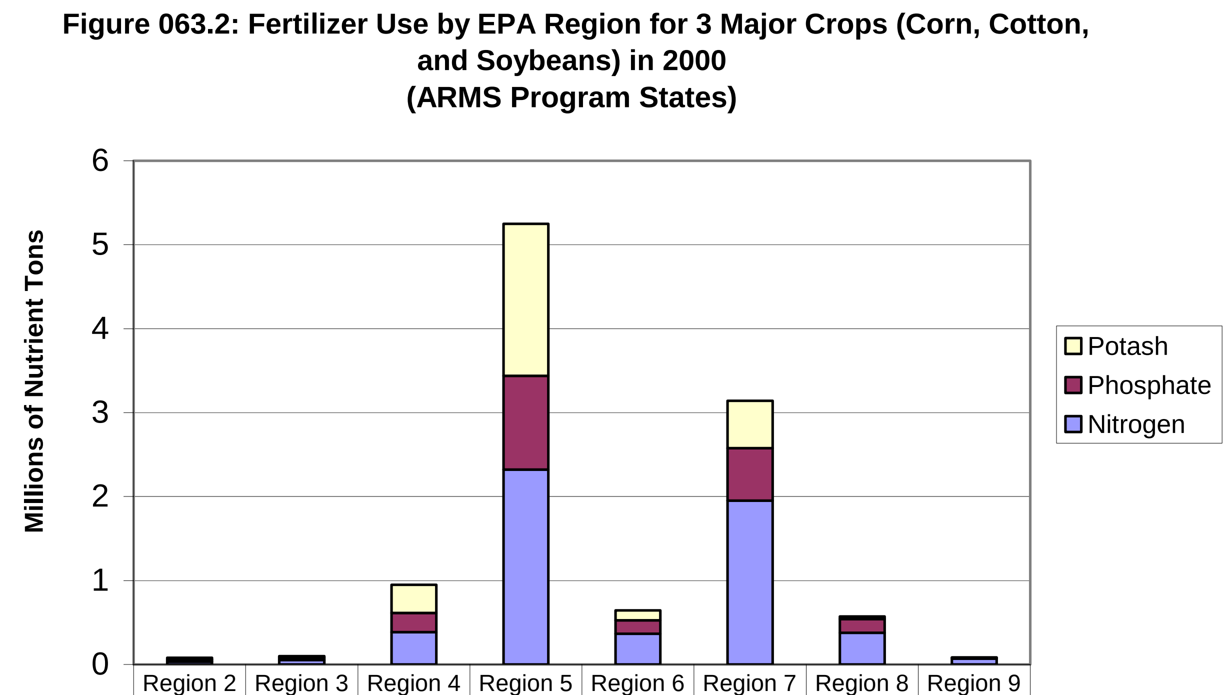


Figure 063.1: U.S. Commercial Fertilizer Use, 1960-2003
Millions of Nutrient Tons
25
20
15
10
5
0
1960 1963 1966 1969 1972 1975 1978 1981 1984 1987 1990 1993 1996 1999 2002
Nitrogen
Phosphate
Potash
Total



	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9
Potash	0.0209	0.01795	0.3376	1.8086	0.11735	0.56525	0.0322	0.0031
Phosphate	0.0228	0.02995	0.2289	1.1192	0.15925	0.62675	0.16295	0.00865
Nitrogen	0.0356	0.0519	0.384	2.3199	0.3674	1.9507	0.378	0.0705

064 - Figure 2

R.O.E. Indicator QA/QC

Data Set Name: FERTILIZER APPLIED FOR AGRICULTURAL PURPOSES
Indicator Number: 063 (89343)
Data Set Source: NASS
Data Collection Date: Ongoing: 1991-present, Ongoing:1975-present
Data Collection Frequency: 1 Year, 1 Year
Data Set Description: Amount of Fertilizer Applied for Agricultural Purposes by Type of Fertilizer, Crop, and Geographic Region
Primary ROE Question: What are the trends in chemicals used on the land and their effects on human health and the environment?(Chemicals to include toxic substances, pesticides, fertilizers, etc.)

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The data provide a variety of analyses relevant to determining status and trends in agricultural fertilizer use and agricultural acreage in the United States, and is based on estimates of on-farm fertilizer use which can be broken down by region or crop type. Fertilizer use is reported in either nutrient pounds or nutrient tons, as well as by the percentage of acreage to which fertilizer is applied for a specific crop. The National Agricultural Statistics Service (NASS) generates estimates, in million of acres, of the amount of estimated acreage of farmland in the United States. Data are collected from a list of farmers complied by NASS that produce or sell a certain amount of agricultural products annually.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. USDA conducts surveys in major-producing states for individual crops, most notably corn and soybeans. Collected via the Agricultural Resources Management Survey (ARMS), USDA estimates fertilizer use by state and crop based on a random sampling of farms, calculating the percentage of acreage treated with fertilizer, the average number of applications, the average amount per application, and the total amount of fertilizer applied. By calculating the total planted acreage in the ARMS program states versus the total national planted acreage, USDA calculates the percentage of total U.S. planted acreage program states account for, which can range between 65% and 97%, but is generally about 80%. From this, it can generalize national estimates, and compare them with the estimates based on fertilizer sales. For acreage reports, NASS conducts surveys for agricultural census data by mailing all members of the census mail list (CML) in Alaska and Rhode Island, and a sample of records in all other states. Records are selected based on several criteria, including size or volume of products sold, location in areas with fewer than 100 farms in 1997, or have other special characteristics that stand out. NASS has an extensive monitoring program that includes the use of scanned bar codes, computer assisted telephone interview software, and computer editing.
(http://www.ers.usda.gov/publications/arei/ah722/arei4_4/DBGen.htm.)

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. Although issues on the ability to generalize the survey results to the national level might exist, the survey questions produce estimates that allow for analysis of trends in fertilizer use based on region and crop type.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The question asks about trends and status in the use of chemicals on the land. Focusing on ARMS survey states, which are the major producing states for targeted crops such as corn, cotton, and soybeans, covers all types of farms and accounts for approximately 82% of all farmland in the U.S., with all farms on the list having an equal chance to be selected in any given year. Results are dependent on the number of surveys that are returned for each crop type in each state each year. For example, in 2003, 3,013 reports were collected for corn from 18 major producing states, which accounted for 92% of total U.S. planted corn acreage. For soybeans in 2002, 2,526 reports were collected in 20 major producing states, which accounted for 97% of total U.S. planted soybeans acreage. The datasets are typically published in May of the next calendar year. NASS conducts its acreage surveys the first two weeks in June. Surveys are based on a probability area frame survey with a certain number of segments or parcels of land and a certain number of farm operators. All farmers with operations within the sampled segments are contacted via telephone, mail, or personal interview.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Not applicable for either dataset.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

USDA does not publish specific thresholds or reference points beyond which fertilizer use is thought to affect people or ecosystems.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

NASS produces an annual publication entitled Agricultural Chemical Usage, which includes targeted crops for that year as well as the sampling and analytical procedures. This encompasses the last 10-15 pages of each report, and also includes terms and definitions. Documentation for the 2003 survey can be found at http://usda.mannlib.cornell.edu/reports/nassr/other/pcu-bb/agcs0504.pdf, p. 148-149. The 2002 Census of Agriculture, which includes detailed information on the statistical methodology is available on the USDA web site at http://www.nass.usda.gov/census/census02/.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The complete dataset is not available to protect the interests of the farmers that participate in the surveys; the reports included summary data of the surveys broken down by crop and location. There is a description of methodology and reliability estimates.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The study requires knowledge of, and access to, data from several other USDA programs and reports. The study provides adequate definitions and descriptions of the relevant terms and methodology, as well as the survey instrument. Reproduction of the survey would be possible, assuming one had access to the farms included in the NASS sampling frame.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The estimation procedures and reliability are well documented in the annual reports, the link to which is located in T3Q1. Survey results are reviewed by USDA personnel, which also work with respondents that have questions. Ultimately, as the data are reported directly from farms, quality assurance and quality control is determined by the volume of responses.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

ARMS program states for targeted crops typically account for 80-99% of total U.S. planted acreage, especially for corn and soybeans, which are listed as examples in the indicator text. Because of this, generalization to the national level can be done with confidence. NASS conducted a Farm Identification Survey in 2002 to screen potential farms before placing them on the census mail list.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Uncertainty measurements are available for acreage reports, but not for fertilizer applications.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

The large screening sample frame from which the surveys were selected, coupled with the large number (> 1000) of reports and a sampling design which insured that all farms on the sampling frame had an equal chance to be selected, provides excellent data quality and improves the utility of the indicator.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Figures on fertilizer use from the ARMS are generated from surveys of major producing (program) states for each crop, but the total U.S. planted acreage for which the program states account varies by year, depending on the number of reports and program states represented in a particular year for a particular targeted crop. As discussed in the indicator text, the fertilizer application rates and the percentage of total U.S. soybean acreage accounted for by ARMS states was rather consistent with the exception of 2001. In 2001, figures on the percentage of land treated with all three major types of fertilizer were much lower than in any other year between 1999 and 2002, and ARMS acreage accounted for only 71% of total U.S. planted acreage of soybeans, as compared to 92-97% in other years. This suggests that when fewer program states report their results (only 8 states reported in 2001, as opposed to 18-20 states in other years), the results can be affected. As fertilizer application rates can vary from state to state, omission of program states can result in significant differences in results, and the inability to accurately and confidently generalize results to the national level.

Indicator: Pesticide Poisonings (276)

Even though pesticides play an important role in protecting human health, food, and crops, they pose a risk of poisoning when not used and stored properly. The American Association of Poison Control Centers (AAPCC) collects statistics on poisonings and represents the single largest source of information on acute health effects of pesticides resulting in symptoms and requiring health care (Calvert et al. 2001). The data include exposures to individual pesticides and to mixtures of products (about 8% of reports) where the primary cause (between two pesticides or between a pesticide and another product or products) could not be determined. The data also include intentional exposures (suicide attempts and malicious use) that account for less than 3% of reports. The AAPCC uses the Toxic Exposure Surveillance System (TESS) to collect information on all reported poison exposures.

This indicator is based on data from TESS published reports for the years 1986 through 2003 from (http://www.aapcc.org/poison1.htm). During this period at least 50% of the U.S. population was covered by Poison Control Centers (PCCs) reporting to the national database, and data were collected using the same definitions from one year to the next. Statistics are presented as known outcomes, meaning that the poison specialist followed up until an exposure could be classified as none (no symptoms reported), minor, moderate, major, or fatal. Poisonings were counted as cases with minor, moderate, major, or fatal outcomes. Annual observed figures were divided by the percent of U.S. population served to estimate the total poisonings nationwide, and divided by the total U.S. population to develop the incidence rate. Data are grouped into 3- year time periods and presented as average annual rates to facilitate looking for trends.

Counting only known outcome data may introduce some bias because the percent of all pesticide exposures with a known outcome declined from 71% in 1986-1988 to just 42% in 2001-2003. In order to determine whether the overall decline reported for all pesticides and functional subgroups is likely due to a real decline or due to an artifact of reporting, the indicator data are also presented for all exposures, whether symptomatic or not, and whether with known outcome or not.

What the Data Show

Between the periods1986-1988 and 2001-2003, there was an overall 24% decline in estimated exposures to pesticides and a 40% decline in poisonings reported in the United States (Figure 276-1, 276-2). The single largest decline occurred for organophosphate insecticides with a decline of 71% in poisonings and 64% in exposures. Organophosphate insecticides accounted for 24% of all poisonings from 1986 to 1988, but decreased to 11% of all poisonings from 2001 to 2003, a decline of 51%. Given that all poisonings have shown little change in trend, this decline is likely real and not an artifact of reporting bias.

As safer insecticides have been substituted for the organophosphates, there has not been a corresponding increase in poisoning among the replacements, which also declined in terms of poisonings (23%) and exposures (15%) over the period. Substantial declines in poisonings and exposures also occurred for fungicides (55% poisonings; 46% exposures) and disinfectants (51% poisoning; 42% exposures). Exposures have increased only for herbicides (10%), and rodenticides (1%), and poisonings have only increased for “other” pesticides, such as fumigants and repellents.

Indicator Limitations

- Misclassification may occur when symptoms are reported over the phone and are not confirmed by a physician or laboratory tests. About 13% of calls to PCCs arise from health care professionals, but the majority are calls made by victims or their relatives or caretakers. The PCC poison specialists must rely on their experience and judgment to determine which cases have symptoms consistent with the toxicology, dose, and timing of the exposure. Although some misclassification can be expected to occur, it is assumed to be non-differential among the different types of pesticides. Declining follow-up of cases does effect the calculated decline in poisonings (which require follow-up to determine medical outcome), but this is not the case for exposures.

- Under-reporting of poisonings by doctors and hospitals to Poison Control Centers (PCCs) is a serious shortcoming. The range of referrals of poisonings from all substances from inpatient and outpatient cases to Poison Control Centers varies from 24 to 33%. (Chafee-Bahamon et al., 1983), (Harchelroad et al., 1990) (Veltri et al., 1987).

Data Sources

Poison Control Center Data, 1986-2003
http://www.aapcc.org/poison1.htm

References

Calvert GM, Barnett M, Blondell JM, Mehler LN, Sanderson WT. 2001. Surveillance of pesticide-related illness and injury in humans. Chapter in Handbook of Pesticide Toxicology, Second Edition, edited by R. Krieger, Academic Press, San Diego. p. 603-641

Chafee-Bahamon C, Caplan DL, Lovejoy FH. 1983. Patterns in hospital=s use of a regional Poison Information Center. American Journal of Public Health 73:396-400.

Harchelroad F, Clark RF, Dean B, Krenzelok EP. 1990. Treated vs. Reported toxic exposures: discrepancies between a Poison Control Center and a member hospital. Veterinary and Human Toxicology 32:156-159.

Veltri JC, McElwee NE, Schumacher MC. 1987. Interpretation and uses of data collected in Poison Control Centers in the United States. Medical Toxicology 2:389-397.

Graphics

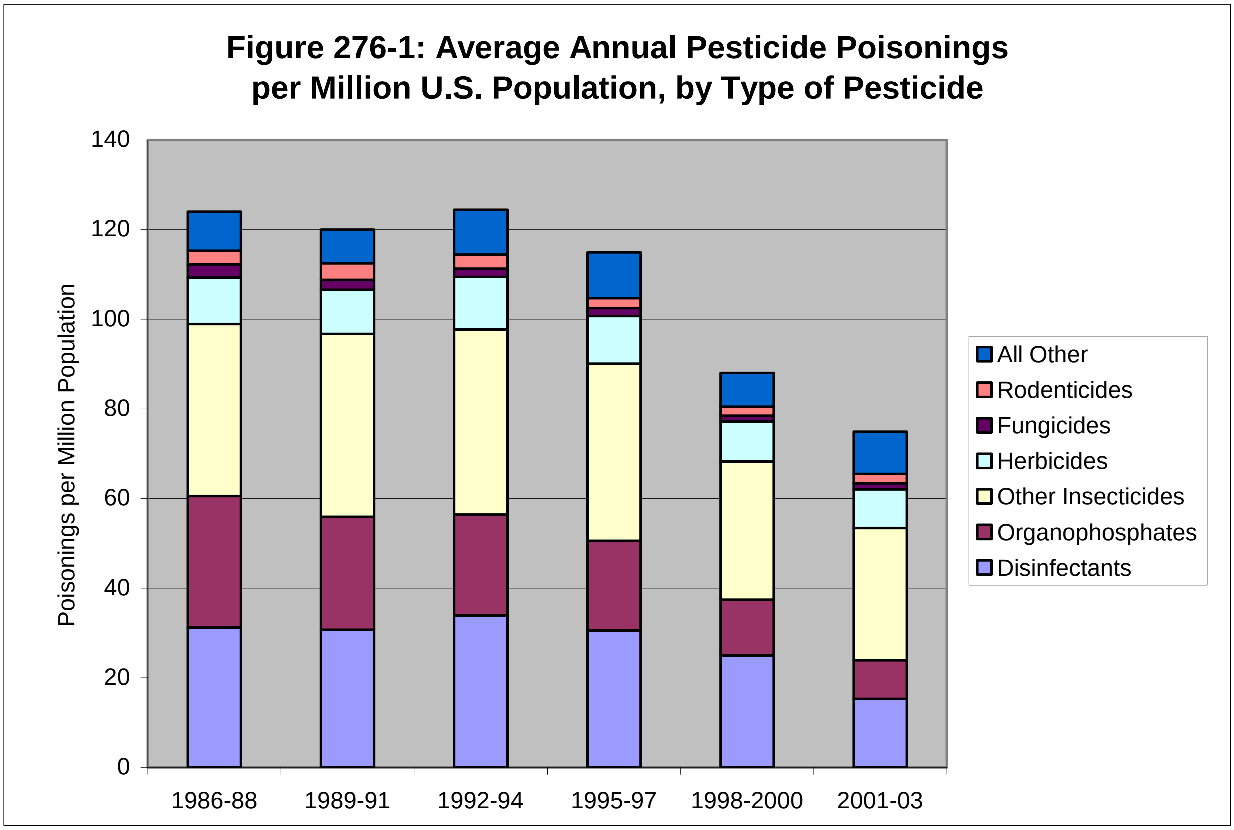


Figure 276-1: Average Annual Pesticide Poisonings per Million U.S. Population, by Type of Pesticide
Poisonings per Million Population
140
120
100
80
60
40
20
0
1986-88
1989-91
1992-94
1995-97
1998-2000
2001-03
All Other
Rodenticides
Fungicides
Herbicides
Other Insecticides
Organophosphates
Disinfectants

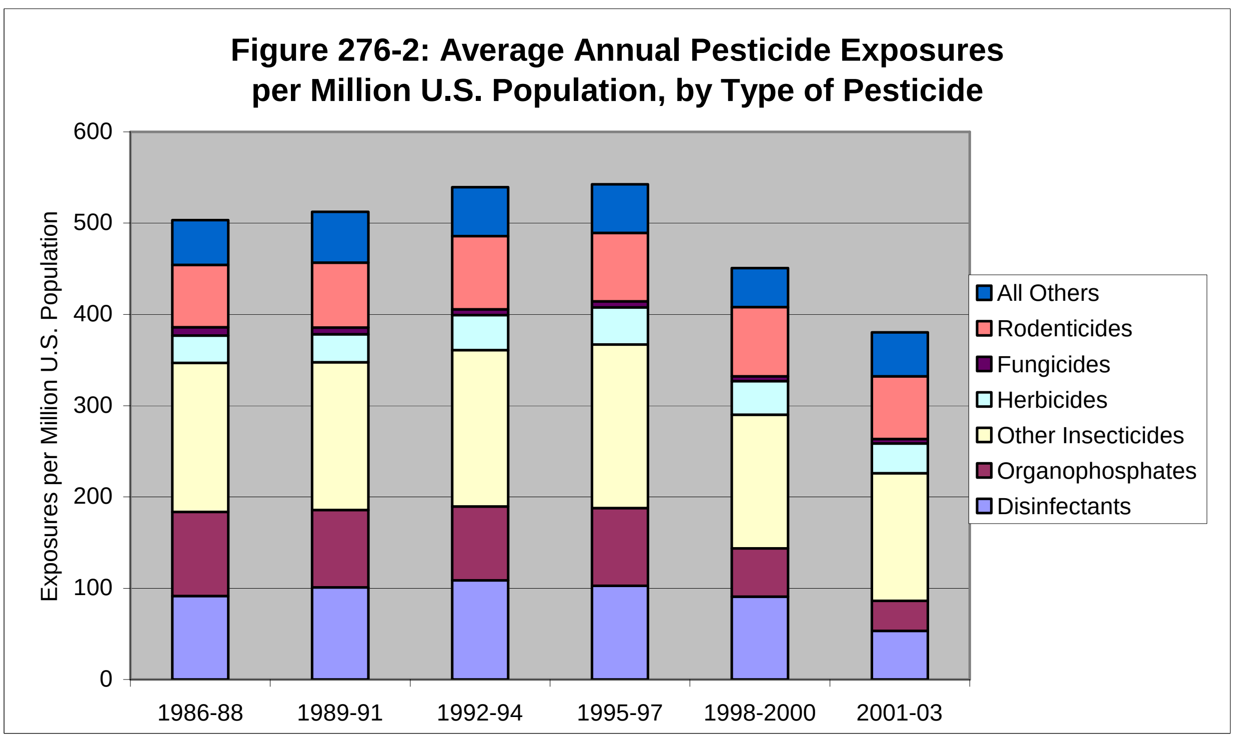


Figure 276-2: Average Annual Pesticide Exposures per Million U.S. Population, by Type of Pesticide
Exposures per Million U.S. Population
600
500
400
300
200
100
0
1986-88
1989-91
1992-94
1995-97
1998-2000
2001-03
All Others
Rodenticides
Fungicides
Herbicides
Other Insecticides
Organophosphates
Disinfectants

R.O.E. Indicator QA/QC

Data Set Name: PESTICIDE POISONINGS
Indicator Number: 276 (89085)
Data Set Source:
Data Collection Date: 1986-2003
Data Collection Frequency: 1 yr
Data Set Description: Pesticide Poisonings
Primary ROE Question: What are the trends in chemicals used on the land and their effects on human health and the environment?(Chemicals to include toxic substances, pesticides, fertilizers, etc.)

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

There are no physical, chemical, or biological measurements for this indicator. It is based on incidence data reported by poison control centers.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

There is no sampling plan or monitoring plan similar to that used in laboratory studies. Poison Control Centers collect information on each call according to standardized definitions for each data element collected. Some 60-65 Centers staffed by six or more personnel each are responsible for collection of the information on each case, properly coding the information and submitting it to the AAPCC that maintains the national database. Reporting by individual PCCs is dependent on how well their service is known and advertised. The standardized form or computer record that is used must contain all data elements filled out and sufficient narrative to permit peer review and medical or legal audit. The data must be submitted to the AAPCC's Toxic Exposure Surveillance System within deadlines and meet quality requirements as specified in guidance of the AAPCC.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The observations collected are presented along with the denominator population served and the total population of the United States. This permits calculating the incident rate which is the number of illnesses (poisonings) in a given year per million population in the United States. The incident rate is the primary measure of hazard used in epidemiology and surveillance studies.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The indicator in this case collects all observations (a census) rather than employing a sampling strategy. Given the widespread coverage of the US population, the data are appropriate for national estimates, but not regional ones. One limitation is that fewer states are covered in earlier years. An average of 62% of the US population was covered from 1986-90, 80% for 1991-96, and 97% for 1997-2003.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The indicator collects reports from all of the population served, but does not actively seek out reports from sensitive populations. Nevertheless, it is possible to examine the data for differences due to age, sex and pregnancy status that can identify particular susceptibilities in subgroups of interest.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Reference points, thresholds and range of values do not apply to this indicator in the same manner it would for laboratory-type measurements.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The use of a standard format by different Poison Centers with standard definitions for each data element means that studies can be done using two or more centers (Veltri et al. 1987). Each Center follows a coding manual that documents the procedures for documenting each call and the definitions of all the data elements. Instructions for the American Association of Poison Control Centers Toxic Exposure Surveillance System, 2001. unpublished, but may be available to APCC members at http://www.aapcc.org.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The data set is proprietary because it is sold by a non-governmental organization to the EPA under the condition that only summaries of the data may be shared outside of EPA. The summaries are not confidential but the raw data on individual cases is considered confidential. Medical confidentiality would apply for individual cases that could be traced back to a particular health care provider and but summary information for several cases has no such concern.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Descriptions of the procedures followed by each participating Poison Control Centers are written and include: " Have a board certified physician on-call at all times with expertise in medical toxicology. " Have poison specialists available to handle all calls. These specialists are required to complete a training program and are certified by the AAPCC. " Maintain a comprehensive file of toxicology information sources and have ready access to a major medical library. " Maintain operational guidelines which provide a consistent approach to evaluation and management of toxic exposures. " Have an ongoing quality assurance program including regularly scheduled conferences, case reviews and audits. " Keep records on all cases handled by the Center with data elements and sufficient narrative to allow for peer review. " Submit all case data to the Toxic Exposure Surveillance System, meet deadlines and quality requirements and include all required data elements. Taken together all these criteria help assure the quality of the data.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Not all procedures for quality assurance have been provided in detail, but there has been an audit at EPA s request. The AAPCC conducted an audit of 588 randomly-selected pesticide charts based on records submitted to the TESS in 1996. Thirty-four cases were excluded from a Center that was over-represented in the data set and another 24 cases were excluded because of three Centers that had closed since 1996. After these exclusions, requests for 530 cases were sent to the PCCs and 512 records were located and returned to the AAPCC for a response rate of 96.6%. Thirteen records could not be located, one Center did not send the three requested records, and the wrong record was sent in two cases. Cases were reviewed to determine how accurately the information coded in TESS matched the information in the original medical record. Five fields important to this analysis were selected for the audit: reason for exposure, route of exposure, management site of case, medical outcome, and accuracy of specific and generic substance category. Results from the audit found the majority of cases were coded correctly (AAPCC Audit of 1996 AAPCC TESS Human Exposures to Pesticides for EPA. American Association of Poison Control Centers, Washington, DC 1998). Of those cases that did contain errors, the most common error was insufficient follow-up to accurately code the flow of patient care or medical outcome. Reason for exposure was coded correctly 90.4% of the time, incorrectly coded in 4.5%, and insufficient information to determine coding in 5.1%. Route of exposure was coded correctly in 95.9% of cases and incorrectly coded in 3.7% (1.7% incorrect route and 2.0% route(s) omitted). Health care facility use and referral was correctly coded for 93.5%, incorrect in 1.8%, and unable to determine correct coding in 4.7%. Outcome was correctly coded in 82.8%, coded incorrectly in 5.1%, and unable to determine correct coding in 12.1% (due to inadequate follow-up or missing information). Substance was correctly coded 93.3% of the time, incorrectly coded 6.5%, and unable to determine if correct 0.2%. Generic code was coded correctly 98.1% of the time and incorrectly coded 1.7% of the time.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Data collected are a census of all calls received by participating Poison Control Centers. Appropriate methods are used to determine catchment areas served by Poison Centers so that the population served can be determined. Based on the proportion population served compared to the US population, national estimates may be generated.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

The analyses performed involve the calculation of rates based on total US population and simply comparing the earlier and later time period for trends. These calculations are not subject to variability or uncertainty in the usual statistical sense.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Counts rather than measurements are the primary data collected, therefore uncertainty and variability are not an important concern, except as described above.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

There are important limitations that can lead to misinterpretation of trends. Nearly half of the reported exposures received successful follow-up to determine medical outcome. These are the reports that can be classified as adverse effects or poisonings if signs or symptoms occur. The percentage of cases with outcome determined has declined from 71% during the early years (1986-88) to 42% in the later years (2001-3). One method of determining whether the decline is an artifact of decreased follow-up is to determine whether all exposures have declined. Misclassification may occur when symptoms are reported over the phone and are not confirmed by a physician or laboratory tests. About 13% of calls to PCCs arise from health care professionals, but the majority are calls made by victims or their relatives or caretakers. The PCC poison specialists must rely on their experience and judgment to determine which cases have symptoms consistent with the toxicology, dose, and timing of the exposure. Although some misclassification can be expected to occur, it is assumed to be non-differential among the different types of pesticides. Under-reporting of poisonings by doctors and hospitals to Poison Control Centers (PCCs) is a serious shortcoming. The range of referrals of poisonings from all substances from inpatient and outpatient cases to Poison Control Centers varies from 24 to 33%. A study by Chafee-Bahamon et al. (1983) found that of 19,544 inpatient or outpatient cases seen in Massachusetts in 1979, 24% were referred to the State s Poison Control Center. A one-year retrospective study in an urban hospital in Pennsylvania identified 470 toxic exposures of which 123 (26%) were referred to the local Poison Control Center in 1988 (Harchelroad et al. 1990). A much earlier report (Veltri et al. 1981) looking at inpatient and outpatient cases in Utah found that Poison Centers captured about a third of these cases.

Indicator: Pesticide Residues in Food (064)

More than one billion pounds of pesticides and herbicides are used in the United States each year to control weeds, insects, and other organisms that threaten or undermine human activities (Aspelin, 2003). Some of these compounds can be harmful to humans if ingested, inhaled, or otherwise contacted in sufficient quantities (see Indicator "Urinary Pesticide/Herbicide Level"). Potential health effects vary by chemical. The primary routes of exposure for the general population are ingestion of a treated food source and contact with applications in or near residential sites. Pesticides may also be harmful in the environment when non-target organisms are exposed (U.S. EPA, 2003).

This indicator represents data from the U.S. Department of Agriculture's Pesticide Data Program (PDP) which measures pesticide residue levels for more than 290 pesticides and their metabolites in fruits, vegetables, grains, meat, and dairy products from across the country, sampling different combinations of commodities each year. PDP data collection began in 1991 and includes both domestic and foreign-produced commodities. Results are published in annual reports, which include statistics on the number of pesticide residues detected, the number of residues exceeding the tolerance established by EPA for a given pesticide-commodity pair (Code of Federal Regulations, Title 40, Part 180), and the number of residues detected for which no tolerance has been established. This indicator depicts data from 1994 to 2003; data prior to 1994 are considered less reliable. Between 1994 and 2003, the number of food samples analyzed per year ranged from 5,771 to 12,899.

What the Data Show

Overall, the percent of samples with no detectable pesticide residues increased during the period from 1994 to 2002 (Figure 064-1). Samples with no detects accounted for 38.5% of samples analyzed in 1994 and rose to 57.9% of samples in 2002. Data for 2003 cannot be compared directly to the previous years' data due to a change in the way that detects are counted. During the same period, each of the other categories (i.e., samples with one or more detected residues) remained steady or declined slightly. For example, in 1994, 9.8% of samples were found to contain four or more pesticide residues; this figure dropped to 8.2% in 2002. The stable or slightly declining trend in number of detects occurred at the same time that analytical limits of detection for these compounds have been decreasing, allowing the instruments to pick up ever smaller concentrations.

The amount of residue detected for pesticides with established tolerance limits is examined in Figure 064-2. This figure illustrates the percentage of samples in which at least one residue was detected at a concentration exceeding the tolerance established by EPA for a given pesticide-commodity pair. The percentage of samples exceeding EPA tolerance values increased from 0.05% in 1994 to 0.31% in 2003 (Figure 064-2). In addition, the bars in figure 064-2 show that the number of samples analyzed each year increased nearly 50 percent between 1994 and 2003.

Figure 064-3 shows the percentage of samples containing at least one residue without an established EPA tolerance for the commodity on which it was detected. This number represents pesticides detected on crops for which they are not registered to be used and may be the result of spray drift, crop rotation, or other environmental contamination as well as unregistered use. Between 1999 and 2003, the percentage of samples in this category decreased overall from 3.7 to 1.5 percent and showed an irregular trend.

Indicator Limitations

- Among the data for number of residues detected (Figure 064-1), in 2003, measurement of a parent compound and/or any of its metabolites was counted as a single detect whereas in previous years, parent compounds and each of their metabolites were counted as separate detects. Therefore numbers from 2002 and earlier cannot be compared directly with the data from 2003.

- The PDP does not sample all commodities over all years, so some gaps in coverage exist. Differences in the percent of detections for any given class of pesticides might not be due to an increase (or decrease) in the predominance of detectable residues, but might simply reflect the changing nature and identity of the commodities selected for inclusion in any given time frame.
- The PDP has the ability to detect pesticide residues at concentrations that are orders of magnitude lower than those determined to have human health effects. The presence of detectable pesticide residues in foods is not necessarily indicative of a potential health concern (USDA, AMS, 2002).

Data Sources

U.S. Department of Agriculture (USDA), Pesticide Data Program. Annual summary reports available at http://www.ams.usda.gov/science/pdp.

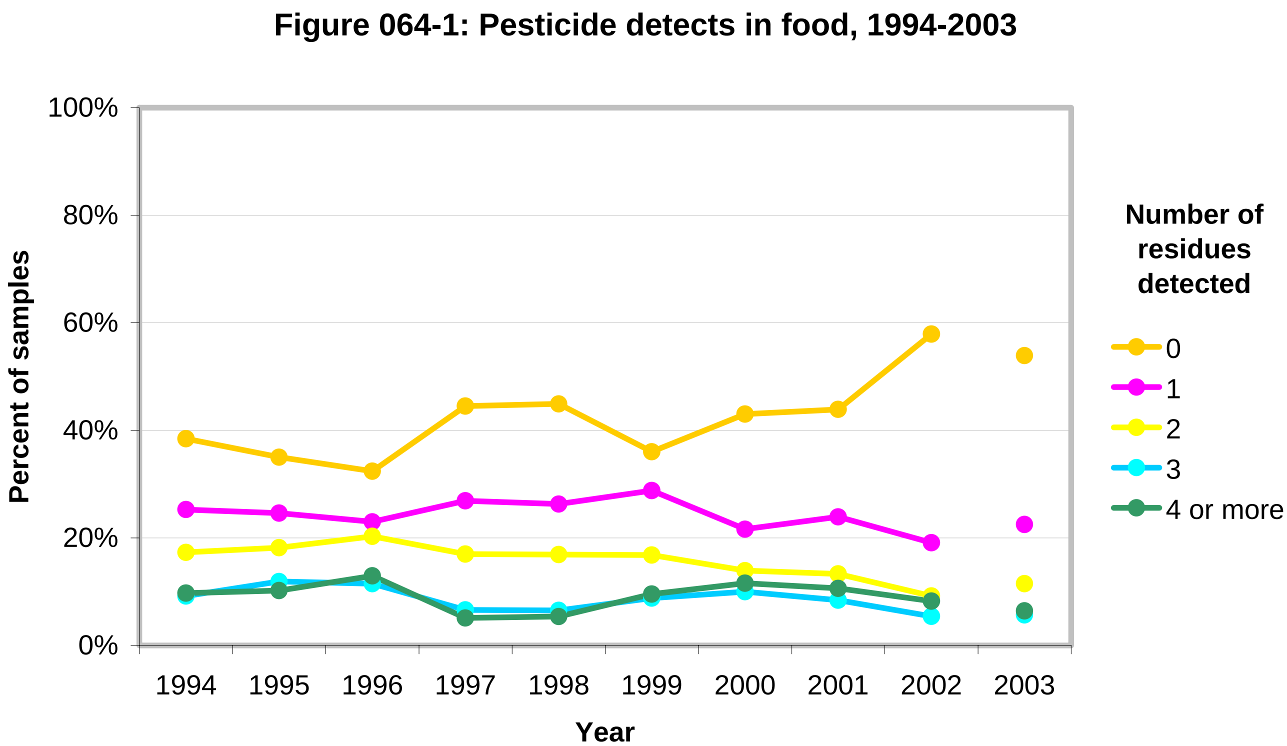
References

Aspelin AL. 2003. Pesticide Usage in the United States: Trends During the 20th Century. Raleigh, NC: Center for Integrated Pest Management, North Carolina State University. February 2003. http://www.pestmanagement.info/pesticide_history/index.pdf.

Food and Drug Administration. 2004. FDA Pesticide Program Residue Monitoring 1993-2002. http://vm.cfsan.fda.gov/~dms/pesrpts.html.

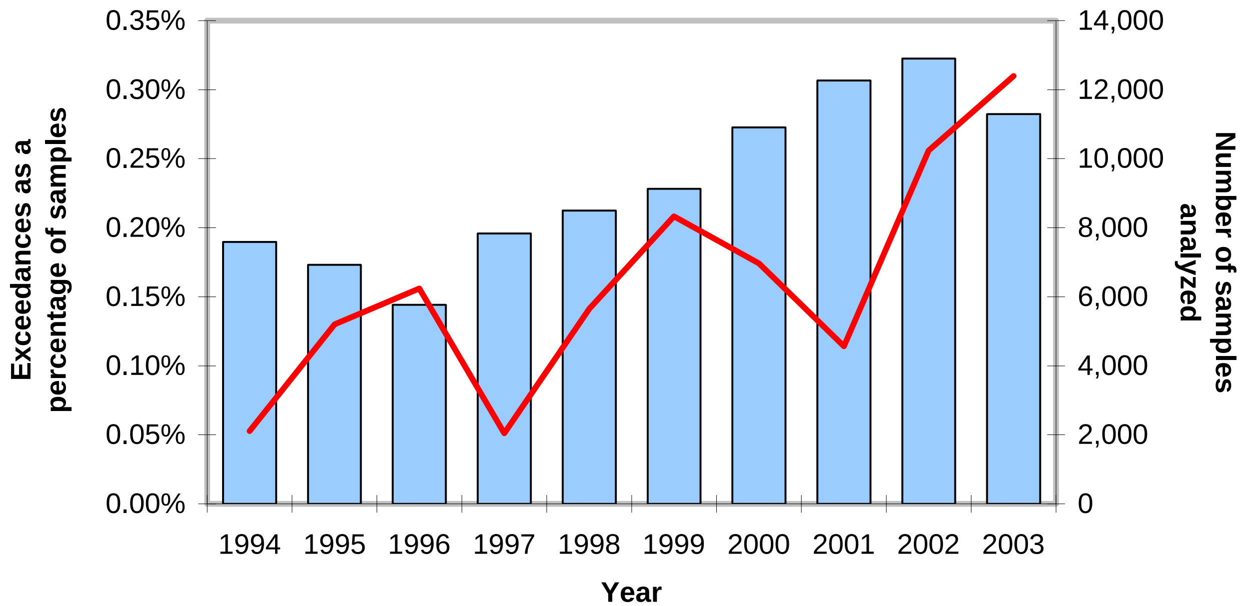
U.S. Environmental Protection Agency. 2003. Pesticides: Regulating Pesticides: Data Requirements. http://www.epa.gov/pesticides/regulating/data.htm

Graphics



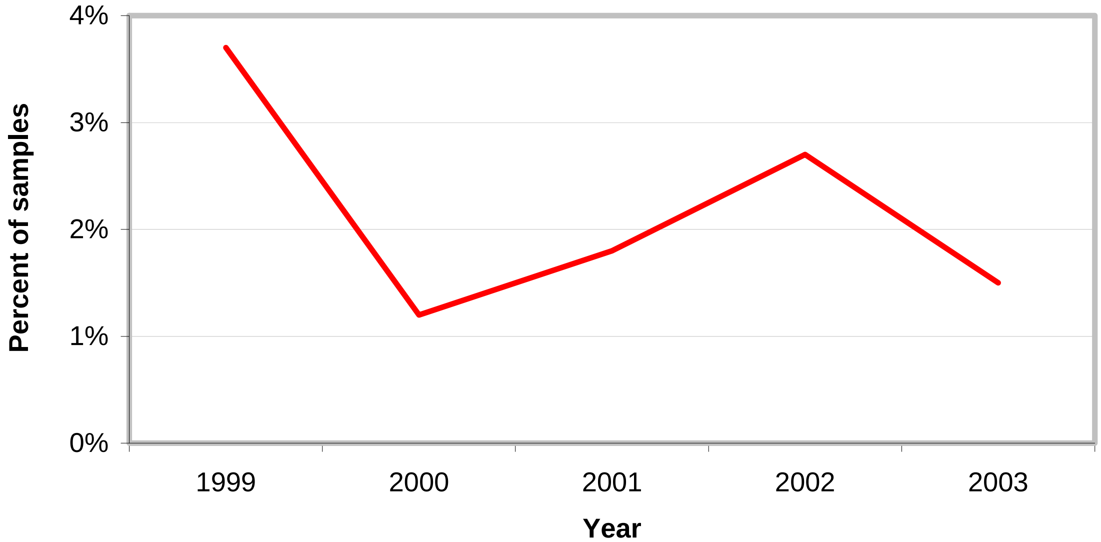
Data Source: United States Department of Agriculture (USDA), Pesticide Data Program. Annual summary reports available at <http://www.ams.usda.gov/science/pdp/download.htm#reports> Graphical interpretation by USEPA.
Data for 2003 parent compounds and their metabolites are combined to report the number of "pesticides" rather than the number of "residues", as was reported in previous years' summaries. For example, a sample with positive detections for Endosulfan I, II, and sulfate would have been counted as three residues detected in the 2002 Appendix L. That same sample would be counted as just one pesticide detected in the PDP summary 2003 Appendix M

Figure 064-2: Pesticide tolerance exceedances, 1994-2003



Data Source: United States Department of Agriculture (USDA), Pesticide Data Program. Annual summary reports available at http://www.ams.usda.gov/science/pdp/download.htm#reports
Graphical interpretation by USEPA.
The number of samples analyzd represented by the blue bars are the total number of samplesfor each year and represent a variety of different commodities that are rotated in and out of the program over time.

Figure 064-3: Detected residues of pesticides with no established tolerance, 1994-2003



Data Source: United States Department of Agriculture (USDA), Pesticide Data Program. Annual summary reports available at http://www.ams.usda.gov/science/pdp/download.htm#reports
Graphical interpretation by USEPA.

R.O.E. Indicator QA/QC

Data Set Name: PESTICIDE RESIDUES IN FOOD
Indicator Number: 064 (89303)
Data Set Source: USDA PDP Monitoring Database
Data Collection Date: 1993-2003
Data Collection Frequency: Daily
Data Set Description: Pesticide Residues in Food
Primary ROE Question: What are the trends in chemicals used on the land and their effects on human health and the environment?(Chemicals to include toxic substances, pesticides, fertilizers, etc.)

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The measurements upon which this indicator is based are widely accepted as scientifically and technically valid. PDPs monitoring data are considered the gold standard by those in the field of pesticide residues in/on food. Data quality is excellent and follows written Standard Operating and QA/QC procedures based on EPA Good Laboratory Practices. In the most recent sampling year, eleven laboratories across the U.S. (8 State and 3 Federal) performed these analyses consistently by using these written SOPs. Laboratory staff receive and maintain intensive training programs and must demonstrate analytical proficiency on an ongoing basis. State-of-the-art instrumentation is used and detection limits are very sensitive (low ppb levels). The analytical methodologies detect multiple pesticides and detects are verified by a second confirmatory method. Many of the SOPs are located at the following web site address: http://www.ams.usda.gov/science/pdp/SOPs.htm

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

The sampling design is nationally based and represents the annual market of commodities purchased in the United States. (see T3Q3 for details).

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. These are real data that are used directly in risk assessments.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

PDP concentrates its efforts in providing better pesticide residue data on foods most consumed by children. This PDP policy is guided by the requirements of the 1996 Food Quality Protection Act and by recommendations made in 1993 by the National Academy of Sciences (NAS) in "Pesticides in the Diets of Infants and Children." <http://www.nas.edu/> . For any goal related to pesticides exposure or safe food, the PDP data provide continuing, extensive information on pesticide residues in fruits, vegetables, grains, dairy products, and meats. Thousands of samples have been analyzed for over a hundred pesticides and their metabolites on dozens of commodities. This program has been in continual operation since 1992 and has produced valuable data on pesticide residues on food commodities at markets and warehouses. Samples are collected by USDA immediately before commodities are shipped to grocery stores and supermarkets, and prepared by the laboratory as they typically would be for consumption (i.e., they are washed, peeled, cored, etc.). PDP data thus are more likely to reflect actual exposures than other data based, for example, on farm-gate sampling. The PDP data provide an excellent measure of pesticide residues in produce and other food commodities at a point very close to consumption by the general public.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

PDP concentrates its efforts in providing better pesticide residue data on foods most consumed by children, who may be more sensitive to pesticides than adults because of their body size and metabolism. This indicator is based on data from the USDA Pesticide Data Program (PDP). PDP s data on pesticides in selected commodities are collected and analyzed to strengthen the government s ability to respond to food safety and marketing concerns, to protect public health, and to provide EPA with data needed to implement the Food Quality Protection Act. PDP operations are guided by recommendations presented to the U.S. Congress by the National Academy of Sciences report Pesticides in the Diets of Infants and Children, (1993). In this report, the NAS examined a variety of scientific and policy issues that need to be addressed when regulating pesticides in foods. The report recommended new ways and approaches for assessing pesticide risks to infants and children, which required better information on food consumption patterns of infants and children and pesticide residue data on foods most consumed by infants and children. OPP has identified a list of commodities that are considered major items of consumption by children using data collected from the USDA s Continuing Surveys of Food Intakes by Individuals. The PDP program and sample collection effort was initiated and sustained to address the issue of providing better pesticide residue data on foods most consumed by children.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Yes, a tolerance is a legal reference point with regards to commodities in channels of trade but this should not be related to a threshold for environmental quality.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Data quality is excellent and follows written Standard Operating and QA/QC procedures based on EPA Good Laboratory Practices. In the most recent sampling year, eleven laboratories across the U.S. (8 State and 3 Federal) performed these analyses consistently by using these written SOP s http://www.ams.usda.gov/science/pdp/SOPs.htm Laboratory staff receive and maintains intensive training programs and must demonstrate analytical proficiency on an ongoing basis. State-of-the-art instrumentation is used and detection limits are very sensitive (low ppb levels). The analytical methodologies detect multiple pesticides and detects are verified by a second confirmatory method. Many of the SOPs are located at the following web site address: http://www.ams.usda.gov/science/pdp/SOPs.htm

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes, the data are available to the public in its entirety. http://www.ams.usda.gov/science/pdp
Deputy Director Diana Haynes 703.3330.2300 ext. 34

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. Sampling Operations: PDP samples are collected by 10 participating States, which represent about 50 percent of the Nation's population and all regions of the country. Samples are collected close to the point of consumption. Collection at terminal markets and large chain store distribution centers allows the capture of sample identity data, takes into account pesticide degradation during transit and storage, and provides data on residues from post-harvest applications of fungicides and growth regulators. Sample sizes for all fresh fruit and vegetables are 3 to 5 pounds; processed products are 1 to 3 pounds; milk, corn syrup, and juices are 1 quart; and grains, poultry, and beef are 1 pound. For some commodities (such as grains, poultry, and beef), Federal personnel perform sample collection because of access and expertise in product collection, packaging, and shipping. The number of samples to be collected is apportioned according to State population or commodity production figures. Samples are randomly chosen without regard for commodity origin or variety. Samples reflect what is typically available to consumers throughout the year. PDP's statistically-reliable sampling protocol is designed to select random samples that best represent pesticide residues in the food supply to allow for realistic estimates of exposure to these chemicals. All participating States, except California, ship samples to a single laboratory for dedicated commodity analysis. All California samples are tested at the California lab. PDP maintains Standard Operating Procedures (SOPs) designed to provide criteria to State samplers for site selection and specific instructions for sample selection, shipping, and handling. Support and oversight for all sampling operations is provided by USDA's National Agricultural Statistics Service (NASS). Detailed information about PDP sampling operations can be found in Section II of the PDP 2003 Annual Summary. http://www.ams.usda.gov/science/pdp/Download.htm#reports Laboratory Operations Analytical services are provided by nine State and two Federal laboratories. Participation as a contributing laboratory is voluntary and is funded through a Cooperative Agreement between the laboratory and USDA. Upon receipt, samples are visually examined for acceptability and are discarded if determined to be inedible (decayed, extensively bruised, or spoiled). Accepted samples are prepared (washed with inedibles removed) emulating consumer practices. All sample preparations are controlled by program-wide Standard Operating Procedures (SOPs) that ensure consistency between laboratories. Samples are mixed or homogenized into one representative composite sample. Residues are isolated from composite samples using various extraction and clean-up procedures. Extracts are then ready for instrumental analysis. PDP also conducts special surveys on single-serving food items to support acute dietary risk exposure studies. PDP Laboratories continuously evaluate and utilize state-of-the-art instrumental systems when conducting initial identification and quantification of pesticides. All extraction methods and instrumental systems are independently validated by the laboratory performing the analysis. PDP requires continuous quality assurance (QA) controls and on-site monitoring by independent QA officers to ensure the reliability of PDP data. Performance equivalency of the participating laboratories is monitored by a program-wide check sample program. All residues initially identified are verified using various forms of mass spectrometry, atomic emission detectors, or alternate detection systems. PDP laboratories also report non-detects for all pesticides screened, with corresponding reference Limits of Detection (LOD). Detailed information about PDP laboratory operations can be found in Section III of the PDP 2003 Annual Summary.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

USDA started PDP in May 1991 to test commodities in the U.S. food supply for pesticide residues. PDP has tested over 50 different commodities: fresh/frozen/canned fruit and vegetables, fruit juices, whole milk, grains, corn syrup, poultry, beef, and drinking water. PDP has tested for more than 290 different pesticides: insecticides, fungicides, herbicides, and growth regulators. PDP samples are collected by 10 participating States, which represent about 50 percent of the Nation's population and all regions of the country. All California samples are tested at the California lab. PDP maintains Standard Operating Procedures (SOPs) designed to provide criteria to State samplers for site selection and specific instructions for sample selection, shipping, and handling. Support and oversight for all sampling operations is provided by USDA's National Agricultural Statistics Service (NASS). Detailed information about PDP sampling operations can be found in Section II of the PDP 2003 Annual Summary. Analytical services are provided by 9 State and 2 Federal laboratories. All extraction methods and instrumental systems are independently validated by the laboratory performing the analysis. PDP requires continuous quality assurance (QA) controls and on-site monitoring by independent QA officers to ensure the reliability of PDP data. Performance equivalency of the participating laboratories is monitored by a program-wide check sample program. Detailed information about PDP laboratory operations can be found in Section III of the PDP 2003 Annual Summary. Database Management & Reporting PDP maintains an electronic database which serves as a central repository for its residue monitoring data. The data captured and stored in the PDP database include product information, residue findings, and process control recoveries for each sample collected and analyzed, plus fortification results for each set of samples. Data for each calendar year are stored in a separate database structure, allowing for easier administration and reporting of data. PDP utilizes a customized Web-based software application package that provides participating laboratories with the ability to enter the PDP data into interactive data entry screens using just a Web browser and Internet access. The data are stored directly into a central database that resides in Washington, D.C. Ad hoc queries and customized reports are generated in response to data requests from government agencies and the public sector. PDP calendar year databases are available for download on the Download Data/Reports page. PDP has published Annual Summary reports to present program findings for calendar years 1991 through 2003. Detailed information about PDP database management and reporting activities can be found in Section IV of the PDP 2003 Annual Summary. http://www.ams.usda.gov/science/pdp/SOPs.htm

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. Database Management & Reporting PDP maintains an electronic database which serves as a central repository for its residue monitoring data. The data captured and stored in the PDP database include product information, residue findings, and process control recoveries for each sample collected and analyzed, plus fortification results for each set of samples. Data for each calendar year are stored in a separate database structure, allowing for easier administration and reporting of data. PDP utilizes a customized Web-based software application package that provides participating laboratories with the ability to enter the PDP data into interactive data entry screens using just a Web browser and Internet access. The data are stored directly into a central database that resides in Washington, D.C. Ad hoc queries and customized reports are generated in response to data requests from government agencies and the public sector. PDP calendar year databases are available for download on the Download Data/Reports page. PDP has published Annual Summary reports to present program findings for calendar years 1991 through 2003. Detailed information about PDP database management and reporting activities can be found in Section IV of the PDP 2003 Annual Summary.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No. The only the limit is that of the detection and quantifications during analysis.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

There are no limits or gaps in the data that would substantially mislead a user about fundamental trends in pesticide residues. The data are collected in such a manner to be representative of the U.S. food supply. While all foods are not sampled by the PDP program, the foods that are sampled are major items of consumption. The PDP program analyzes for several hundred pesticides and their metabolites and thus this represents a broad cross-section of insecticides, herbicides, and fungicides. There are no plans at this point to stop the data from continuing being generated.

Indicator: Pesticide Resistant Arthropod Species (225)

The World Health Organization defines pesticide resistance as “the development of an ability in a strain of insects to tolerate doses of toxicants which would prove lethal to the majority of individuals in a normal population (WHO 2002).” A case of arthropod pesticide resistance is defined as “an arthropod species with documented resistance to a unique pesticide formulation, mixtures or compound in one or more location in the world (Mota-Sanchez, Bills and Whalen).” The occurrence of pesticide resistence in crop pests means that additional types of pesticides or other integrated pest management (IPM) strategies must be applied, with the potential for additional harm to ecological systems.

This indicator is based on data collected by the Center for Integrated Plant Systems & Department of Entomology at Michigan State University, which summarizes reports of pesticide resistance cases from 1914 to the present on the internet. The database reports when the resistance was first discovered for a specific time and place. The arthropod resistance database developed at Michigan State University has tracked peer reviewed cases of resistance where the resistance ratio is 10 or higher. A resistance ratio is a ratio of the dose-mortality of the tested strain to the dose-mortality of a known susceptible strain. LD50 or LC50 values are commonly used. For the time dimension of resistance, the year of the research was used, if included, otherwise the year of submission or the year publication was a surrogate value.

What the Data Show

Between 1950 and 2000, the incidence of new cases of arthropod pesticide resistance in the United States increased from an average of 12 new cases per year in the 1950s to an average of 49 new cases per year in the 1960s and 46 new cases per year in the 1970s (Figure 225-1). The peak years of incidence increase were 166 new cases in 1965 and 146 new cases in 1974 (Mota-Sanchez, 2004). The incidence of new resistance cases decreased to 30 cases per year in the 1980s and increased slightly to 38 new cases per year in the 1990s. The incidence of arthropod pesticide resistance is strongly correlated with the cumulative number of active pesticide ingredients registered by the U.S. Environmental Protection Agency. The Pearson’s correlation coefficient between reported resistance cases and the cumulative number of active pesticide ingredients registered by the EPA is 0.97.

Indicator Limitations

- Pesticide resistance is a dynamic, evolutionary phenomena and a record in this database may or may not be indicative of a given region. Similarly, the absence of a record in this database does not indicate absence of resistance in a region.
- Not all submissions in the database clearly document the time of the first appearance of a resistance population in a region, but detect it only after a resistant population has been established.

Data Sources

The database is a compilation of arthropod species (insects, spiders and mites), the pesticides that they are resistant to, when and where in the world the resistance was documented, and a citation of the research paper that documents this resistance. The database of resistance reports cases from 1914 to the present and notes when resistance is first discovered for a specific time and place. The data is based upon continuing review of all available peer reviewed literature as well as a previously published review by G. Gheorghe (UN FAO, 1991). The database can be found at http://www.cips.msu.edu/resistance/rmdb/.

References

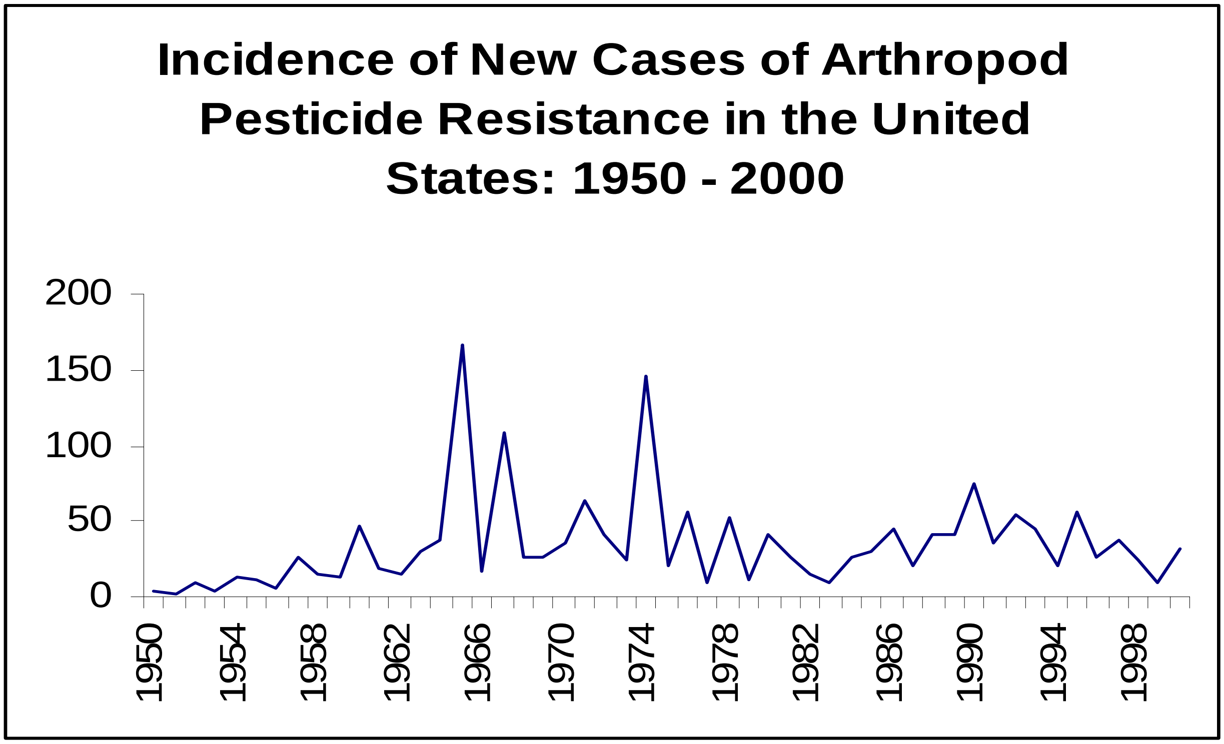
David Mota-Sanchez, PhD, Michigan State University, Center for Integrated Plant Systems, Department of Entomology, 2004

David Mota-Sanchez, Patrick S. Bills, and Mark Whalon, A Database of Arthropods Reported to be Pesticide Resistant- Poster

World Health Organization, Expert Committee on Malaria. 7th Report, WHO Tech. Rep. Ser. 125, 1957 as cited in David Mota-Sanchez, Patrick S. Bills, and Mark Whalon, "Chapter 8 Arthropod Resistance to Pesticides: Status and Overview," Pesticides in Agriculture and the Environment, ed. Willis B. Wheeler, (2002), p 243.

Graphics

Figure 225-1



R.O.E. Indicator QA/QC

Data Set Name: PESTICIDE RESISTANT ARTHROPOD SPECIES
Indicator Number: 225 (89363)
Data Set Source: Michigan State University, Center for Intregrated Plant Systems, Department of Entomology
Data Collection Date: 1914 to present
Data Collection Frequency:
Data Set Description: Pesticide Resistant Arthropod Species
Primary ROE Question: What are the trends in chemicals used on the land and their effects on human health and the environment? (Chemicals to include toxic substances, pesticides, fertilizers, etc.)

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The underlying data are peer reviewed journals documenting cases of arthropod pesticide resistance. The criterion for inclusion is the resistance ratio, a dose-mortality ratio of the tested species to known susceptible species. The ratio is usually in LD50 or LC50.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

The database relies on new reported cases of resistance in peer reviewed journal rather than statistical field collection. For more about the methodlogy of the database's development, see http://www.cips.msu.edu/resistance/rmdb/

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

In reference 1, the authors and managers of the MSU resistance database indicate that, although there are standardized methods documenting resistance detection, authors frequently report and interpret the data differently. The MSU authors relied upon well established measures of LD50, LC50, median lethal time, median knockdown (KD50) and discriminating doses. They used a widely accepted measurement of documenting resistance, the resistance ratio, which compares LD50 values for the resistant population with LD50 values for the susceptible population. The authors define a case of resistance as a documents resistance ratio of 10 or greater in general. Lower resistance ratios are included when there is other evidence to suggest significant resistance. For more about the methodology of the database's development, see http://www.cips.msu.edu/resistance/rmdb.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

This indicator is based on reported cases rather than a statistical sampling design.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The database compiles reported published peer reviewed new cases of pesticide resistance rather field sampling.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

The resistance ratios used as the basis for inclusion in the database are a comparison of dose to mortality of tested strains of pests in comparison to dose to mortality of susceptible strains. A resistance ratio of 10 is generally the cutoff and LC50 or LD50 is usually the dose to mortality measure used in calculating the resistance ratio.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

This indicator is based on reported cases rather than a statistical sampling design.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The complete data set are available online. http://www.cips.msu.edu/resistance/rmdb/

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

NA. This indicator is based on reported cases rather than a statistical sampling design.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

There is no formal QA protocol for existing entries in the data base. For prospective entries, there will be an electronic survey that requires more substantiation.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

This indicator is based on reported cases rather than a statistical sampling design.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No. For more about the methodlogy of the database's development, see http://www.cips.msu.edu/resistance/rmdb/

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Since pesticide resistance does not have standardized reporting methodologies and because interpretation of the same data and measure (e.g. resistance ratios)vary among researchers, it is difficult to quantify or characterize uncertainty and variability impact. In this database, the resistance ratio (LC50 resistant population/ LC50 susceptable population) of 10 is used to screen cases for inclusion in the database. Sometimes cases with lower resistance ratios are used if there is other strong evidence of resistance.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Since the data in the database are reported new cases rather than a randomly obtained sample of resistant arthropods, it's unlikely a user would mistake the data for national incidence. Just as the numbers of new snakeheads found in the Potomac or the number of new SARS cases don't tell us what the prevalence of these cases are for the whole population.

Indicator: Toxic Chemicals in Production-Related Wastes Released, Treated, Recycled, or Recovered for Energy Use (338)

Toxic chemicals are contained in waste materials produced by a wide variety of industrial activities, in both public (e.g., sewage treatment plants) and private facilities. These chemical "wastes" are really a composite matrix of various chemicals- some of which may be "hazardous" or "toxic", and therefore subject to reporting under the Toxic Release Inventory (TRI) program. Some of these chemicals are released on-site or off-site to air, water, or land (including ponds and deep water injection wells). The rest are treated, recycled, or burned to produce energy. Reductions in the quantities of TRI chemicals are desirable from both environmental and economic perspectives. TRI chemicals have known toxic properties rendering them potentially hazardous to workers in both production and waste management as well as to ecosystems systems and human health. As elements of overall business strategies, companies target waste reduction in ways that reduce costs and increase profits.

This indicator tracks trends in the amounts of "production-related wastes" that contain reported TRI chemicals which are either released to the environment, or are treated, recycled, or used for energy recovery. "Non-production related waste", such as might be associated with catastrophic events and remedial actions (clean-up) are not included in this indicator, because they are not directly related to routine production practices.

The TRI contains information on more than 650 chemicals and chemical categories from nine industry sectors, including manufacturing operations, certain service businesses, and federal facilities. Facilities are required to report to TRI if they employ 10 or more employees, have a TRI covered code (using the North American Industrial Classification System code), and manufacture or process more than 25,000 pounds or otherwise use more than 10,000 pounds of the 650 listed chemicals during a calendar year. Facilities that manufacture, process, or otherwise use Persistent Bioaccumulative and Toxic (PBT) chemicals have lower reporting thresholds, which were established in 2000 and 2001, making the comparison with earlier data sets difficult.

TRI is national in coverage, including all U.S territories. Because the reporting requirements for TRI have varied somewhat between 1998 and 2002 (the most recent year for which annual data reports are available in TRI), only chemicals that were reported consistently from year to year are included in this indicator. A key categories of chemicals in wastes omitted in this analysis include PBT chemicals (due to the above-noted changes in PBT chemicals' reporting thresholds). Metal mining sector land releases are analyzed separately due to a 2003 court decision that significantly altered the scope of TRI reporting of these quantities.

What the Data Show (these data will be updated prior to the publication of the ROE)

In 2002 the quantities of TRI chemicals associated with production-related wastes tracked in this indicator totaled 23.8 billion pounds, a decrease of more than 1 billion pounds (4.5%) since 1998 (Figure 338.1). The decrease was gradual over time with the exception of the year 2000, which saw an increase of 4.9 billion pounds from the previous year, followed by a return to prior levels and reduction trends in 2001. The 2000 increase maybe attributed to a few facilities that reported significant amounts of on-site treatment and on-site recycling (see http://www.epa.gov/tri/tridata/tri00/index.htm).

Of the 23.8 billion pounds of TRI chemicals in production-related wasted reported for 2002, 3.38 billion pounds (14.2%) were disposed of on land (on- or off-site) or were released on-site to air, land or water. The remaining 20.44 billion pounds (85.7%) were managed (on- or off-site) through treatment, recycling and energy recovery processes (Figure 338-1).

The 3.38 billion pounds of environmental releases and off-site transfers in 2002 were 10.1% less than the amount reported in 1998, despite a 180 million pound increase in 2002 from 2001. The 20.44 billion pounds otherwise managed in 2002, however, represent only a 3.4% decline from 1998. The ratio of environmental releases to other waste management amounts remained relatively constant from 1988 through 2002, except in 2000 when total production wastes increased by 19.8%.

There were distinct environmental media-specific trends, as well as an off-site transfer trends. Air releases declined steadily over the five years by 21.9% (460 million pounds) from 1998 to 2002. Releases to surface waters dropped 9.5% (20 million pounds) since 1998, after increasing in 1999 by 15 million pounds (the 39 million pound reduction since 1999 is 14.5%). Land releases actually increased by 20 million pounds (1.6%), if metal mining land releases are excluded (Figure 338-2) but showed significant year to year variability (ranging from -18.8% to +23.8% over the four-year period). Off-site transfers, which can't be apportioned by media in TRI, rose steadily by 22.9% (90 million pounds) over the period.

Virtually all of the amounts of production-related wastes released to the environment reported by the metal mining sectors were releases to land. As figure 338.2 illustrates, total production-related wastes released was approximately 11.7 billion pounds over a five year period, compared to 17.8 billion pounds reported by all other industry sectors. The metal mining industry accounted for 65% of the total production-related wastes released to the environment, with the majority of production-related wastes managed by metal mining facilities impacting land. As the graph shows, there is a substantial downward trend for the quantities of total releases reported by the metal mining sector from 2001 to 2002. In 2001, the metal mining industry reported approximately 2 billion pounds in total releases and in 2002, only 1 billion was reported. This overall decrease may be attributed to the court decision of Barrick Goldstrike Mines v EPA.

There are less dramatic trends among treatment, energy recovery, and recycling over the period. The amount of TRI chemicals reported as treated in 2002 declined by 480 million pounds (5.8%) from 1998, but were also the source of much of the large increase observed in 2000, when treatment quantities increased by 3.8 billion pounds (42.2%). That increase was more than offset by a 4.4 billion pound decrease 2001 and another 565 million pound decrease in 2002. Recycling quantities also declined from 1998 to 2002, though by smaller amounts in absolute and relative terms (300 million pounds; 3.3%). Recycling quantities also experienced a significant increase in 2000 (960 million pounds; 11.2%), but that increase was not fully offset by the 720 million pound decrease in 2001, which was followed by a 110 million pound increase in 2002. Quantities managed through energy recovery processes fluctuated by approximately 200 million pounds from year to year, with a net change of only a 1.5% increase over the five year period. Some of the year to year fluctuations may reflect changes in aggregate production levels in the national economy.

There was a substantial downward trend for total releases reported by the metal mining sector from 2001 to 2002 (figure 338.2). This overall decrease may be attributed to the court decision of Barrick Goldstrike Mines v EPA. Virtually all of the production-related wastes released to the environment reported by the metal mining sectors were releases to land.

Indicator Limitations

- Wastes from facilities and industries within industrial categories that are not required to report to TRI, and small facilities with fewer than ten employees or that manufactured or processed less than the threshold amounts of chemicals are not included in this indicator.

- TRI chemicals vary widely in toxicity, so some low-volume releases of highly toxic chemicals might actually pose higher risks than high-volume releases of less toxic chemicals. The release or disposal of chemicals also does not necessarily result in the exposure of people or ecosystems.

- Lead compounds are not included in the indicator because of a significant change in the reporting threshold in 2001. Vanadium releases were measured beginning in 2001; because the overall amounts were small relative to the other wastes, they are included in the 2001 and 2002 data.

- EPA has published two rules that lowered the TRI reporting thresholds for certain persistent bioaccumulative toxic (PBT) chemicals and added certain other PBT chemicals to the TRI list of toxic chemicals. These PBT chemicals are of particular concern not only because they are toxic but also because they remain in the environment for long periods of time, are not readily destroyed, and build up or accumulate in body tissue. Because of these rules the reporting requirements for these chemicals listed at 40 CFR Section 372.28 have changed since 1998, and therefore, have not been included in the trends provided in this indicator.

- National trends in wastes released to the environment are frequently heavily influenced by a dozen or so large facilities in any particular reporting category, and may not reflect the broader trends in the 2500 smaller facilities that report to TRI each year.

Data Sources

2002 Toxic Release Inventory, Public Data Release Report. EPA 260-R-04-003. Environmental Protection Agency, Toxics Release Inventory Program Division, Office of Information Analysis and Access. Released June 2004. http://www.epa.gov/tri/tridata/tri02/pdr/index.htm

2002 Toxic Release Inventory, TRI Press Materials Data Charts and Tables. Environmental Protection Agency, Toxics Release Inventory Program Division, Office of Information Analysis and Access. http://www.epa.gov/tri/tridata/tri02/press/press.htm

2002 Toxic Release Inventory, The Toxics Release Inventory (TRI) and Factors to Consider When Using TRI Data. Environmental Protection Agency, Toxics Release Inventory Program Division, Office of Information Analysis and Access. http://www.epa.gov/tri/FactorsToConPDF.pdf

http://www.epa.gov/triexplorer/, accessed August 2, 2004.

Graphics

Figure 338.1 Wastes Quantities of All Chemicals Except PBT Chemicals Reported by All Industry Sectors from 1998-2002

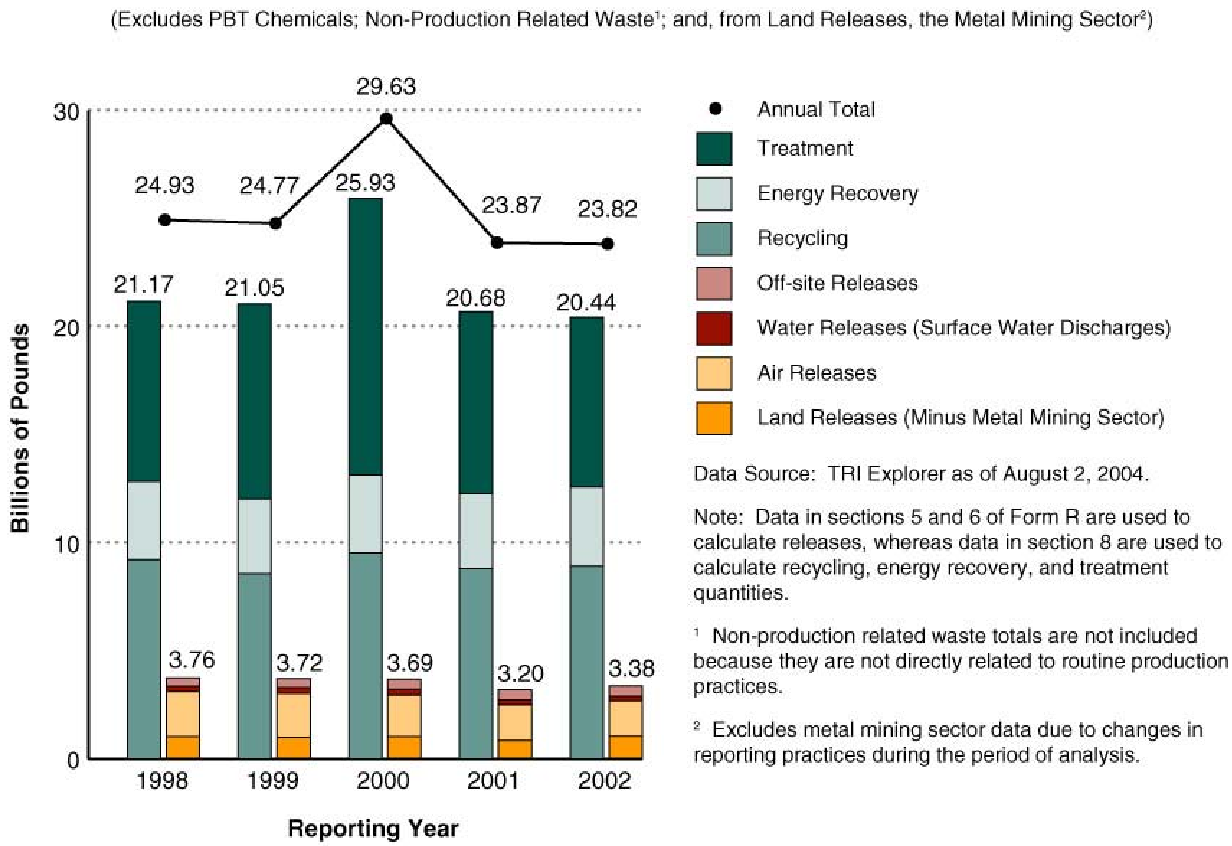
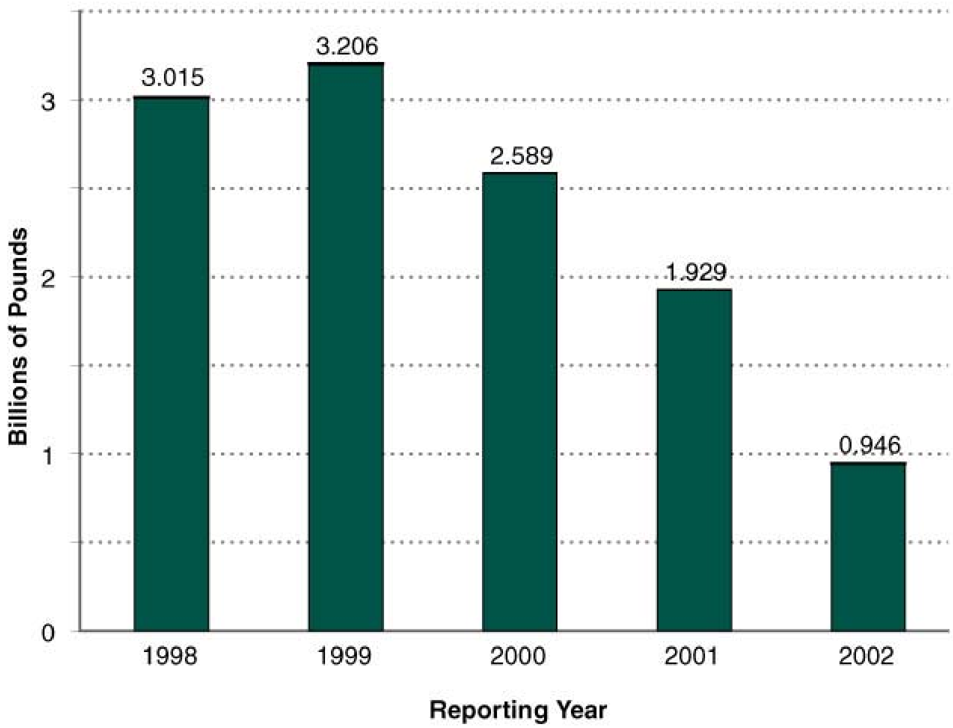


Figure 338.2 Waste Release Quantities for all Chemicals Except PBT Chemicals Reported by the Metal Mining Sector from 1998-2002

Data Source:
TRI Explorer as of August 2, 2004.

Notes:

- Some waste quantities may be double counted when waste has been transferred from one TRI facility (which has counted waste as off-site disposal or other releases) to another TRI facility (which has counted transferred waste as on-site disposal or releases to air, land, or water).
- Data in sections 5 and 6 of Form R are used to calculate releases.
- Excludes PBT chemicals.



	1998	1999	2000	2001	2002
Off-Site Release	0.001	0.002	0.001	0.001	0.001
Water Releases (Surface Water Discharges)	0.001	0.000	0.000	0.000	0.000
Air Releases	0.005	0.004	0.003	0.003	0.002
Land Releases	3.009	3.199	2.585	1.925	0.943
Total	3.015	3.206	2.589	1.929	0.946

R.O.E. Indicator QA/QC

Data Set Name: REPORTED TOXIC CHEMICALS IN WASTES RELEASED, TREATED, RECYCLED, OR RECOVERED FOR ENERGY USE
Indicator Number: 338 (89183)
Data Set Source: U.S.TRI
Data Collection Date: 1998-2002
Data Collection Frequency: 1 Year
Data Set Description: Reported Toxic Chemicals in Wastes Released, Treated, Recycled, or Recovered for Energy Use
Primary ROE Question: What are the trends in chemicals used on the land and their effects on human health and the environment? (Chemicals to include toxic substances, pesticides, fertilizers, etc.)

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

EPCRA does not allow EPA to prescribe a specific release estimation method that facilities must use to calculate release and other waste management quantities of toxic chemicals for TRI reporting purposes. Instead, a facility may use readily available data (including monitoring data) collected pursuant to other provisions of law, or, where such data are not readily available, reasonable estimates of the amounts involved. EPA recommends that facilities use one or more of four techniques: direct monitoring; emission factors; mass balance; and engineering calculations. Facilities have the flexibility to decide if engineering calculations or some other estimation technique would more accurately represent facility activities. In addition, to assist facilities in understanding the TRI reporting requirements and calculating accurate release and other waste management information, EPA provides more than 20 guidance documents (industry-specific, chemical-specific, and general) http://www.epa.gov/tri/guide_docs/index.htm

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Annual TRI reporting is required by law for all facilities meeting the reporting criteria, so the data represent a census of all covered facilities. The monitoring plan varies among plants, depending on whether they use direct monitoring; emission factors; mass balance; and engineering calculations. EPA guidance documents are provided to ensure that the resulting data are as technically sound as feasible.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The conceptual model is simple. The total waste from all facilities required to report are summed to provide annual totals by pollutant and release and other waste management categories.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The TRI program covers the entire United States, including Alaska, Hawaii, Puerto Rico and the Virgin Islands. Almost 25,000 facilities located across the entire United States report their annual release and other waste management activities on more than 650 toxic chemicals and chemical categories to the TRI program. The data cover the entire calendar year. The TRI does not cover releases and other waste management from facilities not required to report. The types (SIC codes) of facilities that must report and the reporting thresholds for some toxic chemicals have changed over time, so it is important that the indicator include only trends that are comparable over time.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Reporting is required for all facilities that meet the reporting criteria, without regard to the sensitivity of receptor populations.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

The nature of the release, and the form, transport, and transformation of pollutants in the environment all affect the impact of the releases on ambient concentrations, exposures, and effects of the pollutants.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The procedures can be found at: http://www.epa.gov/tri

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Complete data from all parts of the reporting are available on Envirofacts http://www.epa.gov/enviro, and data on on-site releases and off-site waste management are available using TRI Explorer http://www.epa.gov/triexplorer. Reporting forms and an Instruction manual that explains each data element on the forms can be found at http://www.epa.gov/tri/guide_docs/index.htm. Confidentiality issues do not seriously affect data availability - the TRI Program receives less than 5 trade secret claims each year for all of 95,000 reporting forms submitted by almost 25,000 facilities each year. Trade secret claims made under the TRI Program do not relieve facilities of their obligation to submit release and other waste management data. Instead, trade secret claims merely allow the submitter to mask the specific toxic chemical identity with a generic name that must be structurally descriptive of the chemical claimed a trade secret.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes, all of the compliance assistance materials (guidance documents, etc.), are available at http://www.epa.gov/tri/guide_docs/index.htm.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The TRI Program has implemented a number of data collection and validation protocols, including sound collection methodologies, data management systems, and quality assurance procedures to help ensure that the TRI reporting requirements are correctly applied on a consistent basis. Specifically, EPA provides the following assistance and data quality checks: - over 20 guidance documents (industry-specific, chemical-specific, and general); - over 50 annual workshops, including Web-based sessions; - an interactive, intelligent, and user-friendly software, known as the Toxics Release Inventory Made Easy (TRI-ME) software that walks reporters through the compliance determinations and assists in completing the reporting forms, and runs a series of validation checks on the data before allowing submission to the Agency on paper, diskette, or over the Internet via the Agency s Central Data Exchange (CDX); - Facility Data Profiles that allow facilities to review the data submitted to the TRI Program; - the identification of data outliers through an analysis of the data, - data quality calls that alert facilities with potential data quality issues to check their data; - periodic site visits and the inspection of facilities for data quality and reporting violations; and - a formal data withdrawal and revision process to update the database with the best available information. See http://www.epa.gov/tri/guide_docs/index.htm. Facilities must certify that the data submitted is true and complete and that the amounts and values are accurate based on reasonable estimates using data available to the preparers of the report. Data quality reports are available for 1994, 1995, and 1996 data: http://www.epa.gov/tri/tridata/data_quality_reports/index.htm

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Because TRI collects actual data, there is no need to use statistics or generalizations to portray data beyond the time or spatial locations where measurements were made.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Variability in the facilities that report and the thresholds for reporting must be taken into account when looking at long-term trends. Facilities can also move into and out of SIC codes required to report due to inter-annual variability in their product streams. Because trend analysis is conducted over a number of years the Program has some insight into whether there is consistent application of the reporting requirements over time.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Potential gaps include the classes of facilities required to report, releases below the reporting thresholds, and toxic chemicals not included in the reporting requirements.

Indicator: Quantity of Municipal Solid Waste Generated and Managed (068, 071)

Municipal solid waste (also called trash or garbage) is defined at the national level as wastes consisting of everyday items such as product packaging, grass clippings, furniture, clothing, bottles and cans, food scraps, newspapers, appliances, consumer electronics, and batteries. These wastes come from homes, institutions such as prisons and schools, and commercial sources such as restaurants and small businesses. Municipal solid waste (MSW) does not include municipal wastewater treatment sludges, industrial process wastes, automobile bodies, combustion ash, or construction and demolition debris. Once generated, MSW must be collected and managed, including recovery for recycling (including composting), combustion, and landfill disposal. Facilities that manage MSW also generate residues, such as broken glass, wet papers, ash, that are usually sent to landfills.

Prior to the 1970s, municipal waste disposal usually meant dumping in open landfills where open burning to reduce volume was a common practice. Historically, landfills have been associated with environmental problems such as ground-water contamination, air emissions such as greenhouse gases, land contamination, and increases in vector populations (including rodents, flies, mosquitoes). Most wastes generated in the United States are still disposed of in landfills, but today, MSW landfills are subject to federal or state requirements to minimize environmental impacts. Municipal solid waste landfills are discrete areas of land or an excavation that receive trash or garbage. MSW landfills also receive various other types of wastes such as non-hazardous sludges, hazardous wastes from small quantity generators, household hazardous wastes, non-hazardous industrial wastes, municipal wastewater treatment sludges, and construction and demolition debris.

This indicator shows trends in the national generation and management of MSW on an annual basis starting from 1960, using a materials flow methodology, based on data for source reduction, recycling, land disposal, and combustion practices EPA 2003). The data for MSW are estimates compiled annually by a national journal through a survey to all state officials. No federal agency specifically compiles information nationally on MSW landfills. Landfills that pose threats to human health and the environment are considered to be contaminated lands subject to federal or state cleanup efforts and are not included in this indicator. MSWs also do not land application units, surface impoundments, injection wells, or waste piles.

What the Data Show

The quantity of municipal solid waste generated grew steadily from 88 million tons (MT) in 1960 to over 225 MT in 2001, an increase of 256% (Figure 068-1). During this time, the U.S. population grew by 58%. Therefore, on a per capita basis, MSW generation increased from 2.7 pound per person per day in 1960 to 4.5 pounds per person per day in 1990, where it has thus far stabilized to about 4.4 pounds per person per day in 2001.

In the 1960s and early 1970s a large percentage of MSW was burned, with little recovery for recycling (Figure 068-2). Of the 88 MT of MSW generated, 6% was recovered through recycling and composting, 31% was combusted, and 63% was landfilled. Landfill disposal at that time typically consisted of open dumping, where open burning often occurred to reduce the volume of waste. Through the mid-1980s, quantities sent to incinerators declined and landfills became difficult to site, while waste generation continued to increase. With material recovery rates increasing very slowly during this time period, the burden on the nation’s landfills grew dramatically.

MSW quantities sent to landfills or other disposal apparently peaked in the mid-1980s and then began to decline as recycling and combustion increased. Since 1999, the percent going to landfills has declined slightly and recycling has risen slightly. After rising to about 132 MT in 1999, the quantity of MSW sent to landfills declined to 128 MT in 2001, which is close to 1998 levels. Much of this is attributed to a temporary decline in production of paper and paperboard (a large component of MSW) between 2000 and 2001. In 2001, of the 229 MT generated, 30% was recycled, 15% was combusted, and 56% was landfilled. Over the last several years, the quantity sent to combustion has held steady at roughly 15% of generation.

The number of MSW landfills has decreased substantially in recent years, from nearly 8,000 in 1988 to 1,858 in 2001 (Fig 068-3), while the average landfill size has increased, so more waste-hauling vehicles go to fewer locations and more site maintenance vehicles are required per location. The Southeast has the largest number of landfills with 738; the West and Midwest have 536 and 441, respectively; and the Northeast has the fewest at 143. Alaska has 275 and Hawaii has 9.

At the national level, MSW capacity is not a problem, although regional dislocation sometimes occurs. Compared to 2 years ago, more states have less than a decade of capacity left. Twenty-nine states have more than 10 years of capacity left, down from 1997, when 42 states had more than 10 years of capacity left**.** Six states have 5 to 10 years of capacity remaining. Only three states reported having less than 5 years of capacity remaining. Ten states do not have capacity data available.

Indicator Limitations

- MSW data do not include construction and demolition debris, municipal wastewater treatment sludge, automobile bodies, combustion ash, and non-hazardous industrial wastes that may go to a municipal waste landfill (data are available for construction and demolition debris and some other areas, but year-by-year data are not available)
- Residues associated with other items in MSW (usually containers) are not accounted for in the data.
- The data (including generation, recycling, and recovery data) are generated using the materials flow method, based on national data sources such as trade associations and the Department of Commerce; they are believed to be accurate at a national level, but cannot readily be used at the state and local level.
- Landfill data do not indicate the capacity or volume of landfills, so the fact that there are fewer landfills does not mean that less land is used for managing MSW. Land used for recycling facilities and waste transfer stations also are not included in this indicator.
- The data also do not indicate the status or effectiveness of landfill management or the extent to which contamination of nearby lands does or does not occur.

Data Sources

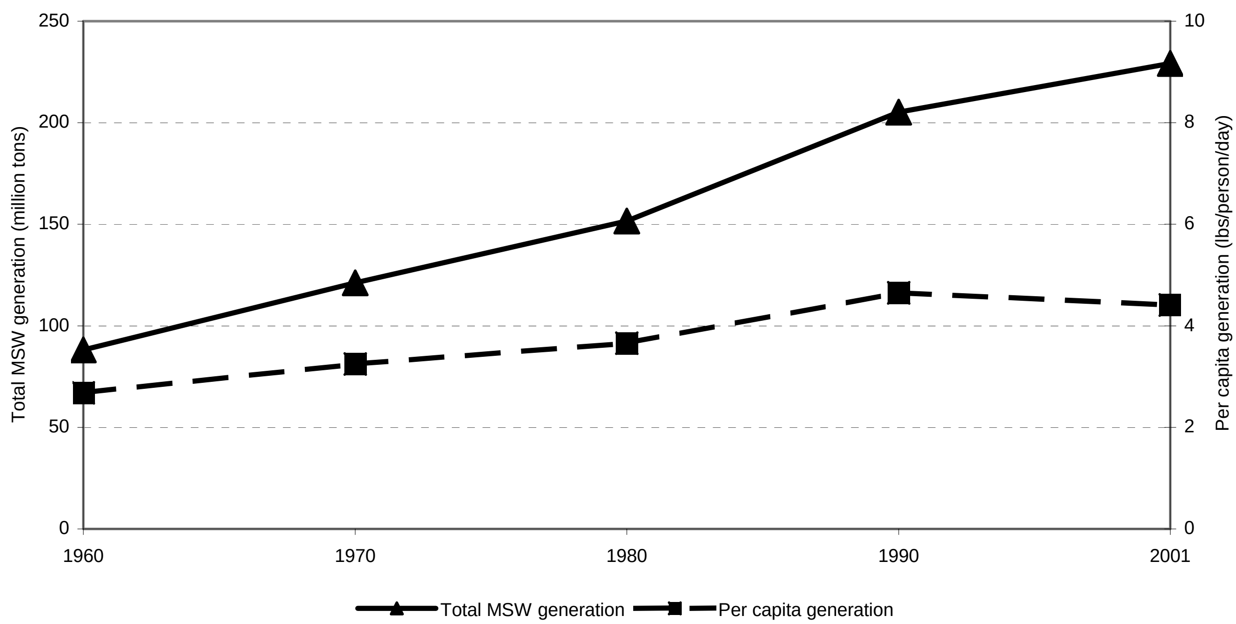
U.S. Environmental Protection Agency. *Municipal Solid Waste in the United States: 2001 Facts and Figures*, EPA530-R-03-011. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, October 2003. (http://www.epa.gov/epaoswer/non-hw/muncpl/msw99.htm).

References

U.S. Environmental Protection Agency. *Municipal Solid Waste in the United States: 2001 Facts and Figures*, EPA530-R-03-011. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, October 2003.

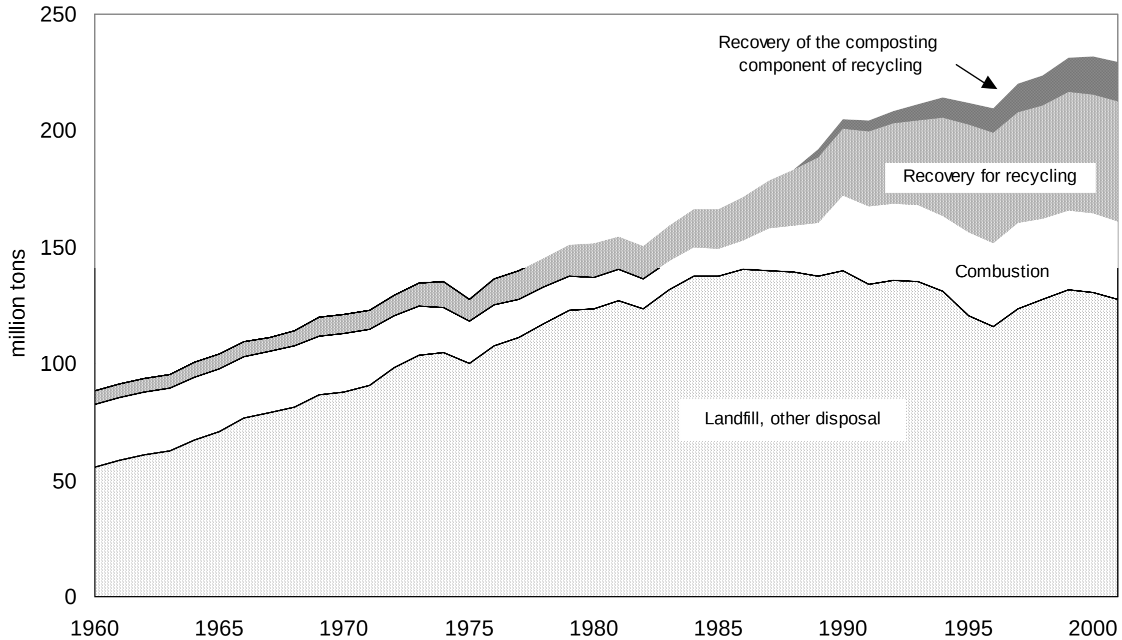
Graphics

Figure 068-1: MSW Generation Rates from 1960 to 2001



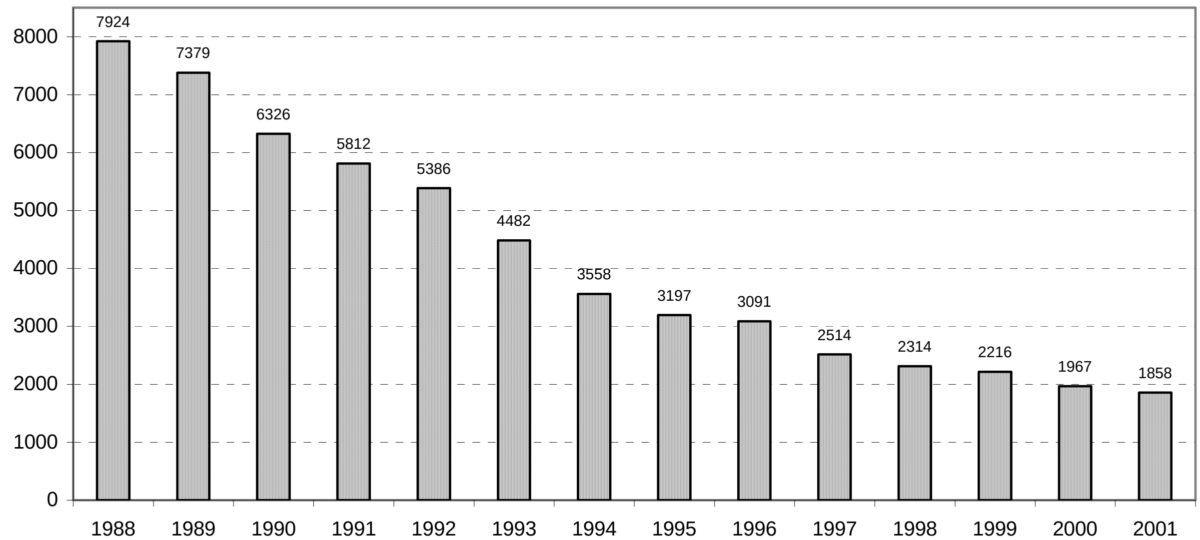
Source: Municipal Solid Waste in the United States: 2001 Facts and Figures, EPA530-R-03-011.
U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, October 2003.

Figure 068-2. Municipal solid waste management, 1960 to 2001



Source: Municipal Solid Waste in the United States: 2001 Facts and Figures, EPA530-R-03-011. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, October 2003.

Figure 068-3: Number of Landfills in the U.S.



Source: Municipal Solid Waste in the United States: 2001 Facts and Figures, EPA530-R-03-011.
U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, October 2003.

R.O.E. Indicator QA/QC

Data Set Name: QUANTITY OF MUNICIPAL SOLID WASTE GENERATED AND MANAGED
Indicator Number: 068 (89132)
Data Set Source: Municipal Solid Waste in the United States: 2001 Facts and Figures
Data Collection Date: regular: 1960 - 2001
Data Collection Frequency: 1 yr.
Data Set Description: Quantity of Municipal Solid Waste Generated and Managed (combine indicators 068, 071, 222)
Primary ROE Question: What are the trends in wastes and their effects on human health and the environment?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

The materials flow methodology is based on production data (by weight) for the materials and products in the waste stream. To estimate generation data, specific adjustments are made to the production data by each material and product category. Adjustments are made for imports and exports and for diversions from MSW (e.g., for building materials made of plastic and paperboard that become construction and demolition debris.) Adjustments are also made for the lifetimes of products. Finally, food wastes and yard trimmings and a small amount of miscellaneous inorganic wastes are accounted for by compiling data from a variety of waste sampling studies. More detail can be found in Municipal Solid Waste in the United States: 2001 Facts and Figures, pp22-26. http://www.epa.gov/epaoswer/non-hw/muncpl/msw99.htm

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes, Landfill data are collected by Chartwell through an annual survey to state officials. Chartwell Directory and Atlas of Solid Waste Disposal Facilities 2003, available at http://www.wasteinfo.com. Secondary source is BioCycle Journal of Composting and Organics Recycling 42 (12), December 2001 as reprinted in the U.S. Environmental Protection Agency s Municipal Solid Waste in the United States: 2001 Facts and Figures, EPA530-R-03-011. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, October 2003. (http://www.epa.gov/epaoswer/non-hw/muncpl/msw99.htm).

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The materials flow methodology first step is to estimate the generation of the materials and products in MSS. Data on domestic production of materials and products were compiled using published data series. U.S. Department of Commerce sources were used where available, but in several instances more detailed information on production of goods by end use is available from trade associations. Domestic production numbers are adjusted for converting or fabrication scrap generation in the production processes. Examples of these kinds of scraps would be clippings from plants that make boxes from paperboard, glass scrap generated in a glass bottle plant etc. This scrap typically has high value because it is clean and readily identifiable, and it is almost always recovered and recycled within the industry that generated it. Thus, converting/fabrication scrap is not counted as part of the postconsumer recovery of waste. In some instances, imports and exports of products are a significant part of MSW, and adjustments are made to account for this. Various adjustments are made to account for diversions from MSW. Some consumer products are permanently diverted from MSW because of the way they are used. For example, some paperboard is used in building materials, which are not counted as MSW. Another example is toilet tissue, which is disposed in sewer systems rather than becoming MSW. In other instances, products are temporarily diverted from MSW. For example, textiles reused as rags are assumed to enter MSW the same year the textiles are initially discarded. Some products (e.g., newspapers and packaging) normally have a very short lifetime; these products are assumed to be discarded in the same year they are produced. In other instances (e.g., furniture and appliances), products have relatively long lifetimes. Data on average product lifetimes are used to adjust the data series to account for this. Data on recovery of materials and products for recycling are compiled using industry data adjusted, where appropriate, with U.S. Dept. of Commerce import/export data. Recovery estimates of yard trimmings for composting are developed from data provided by state officials. Mathematically, discards equal that portion of generation remaining after recovery for recycling and composting. More detail can be found in Municipal Solid Waste in the United States: 2001 Facts and Figures, Appendix A. http://www.epa.gov/epaoswer/non-hw/muncpl/msw99.htm

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Landfill data cover approximately 80% of the states.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Not applicable.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Not applicable.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

See Municipal Solid Waste in the United States: 2001 Facts and Figures, Appendix A. http://www.epa.gov/epaoswer/non-hw/muncpl/msw99.htm.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

A single data source does not exist. Data used have come from numerous sources that are available to the public. These sources are cited in the references sections of the MSW report. See Municipal Solid Waste in the United States: 2001 Facts and Figures. http://www.epa.gov/epaoswer/non-hw/muncpl/msw99.htm

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The description of the study is clear and complete. The study method is highly consistent over time. The data base and resulting facts and figures are developed from a wide variety of publicly available sources, such as trade associations and Department of Commerce data, and best professional judgement. Because of the complexity, the study would not be readily reproducible by a third party. See Municipal Solid Waste in the United States: 2001 Facts and Figures, Appendix A. http://www.epa.gov/epaoswer/non-hw/muncpl/msw99.htm

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Data are considered to be of good quality. However, most of the data are from public sources for which the quality assurance and controls processes are not under the direct control of EPA.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Quantity data are aggregated from key data sources such as trade associations, although government sources such as the Department of Commerce are used where possible. In some instances, data are supplemented with calculations using certain assumptions.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

No.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The data do not include non-hazardous industrial wastes, construction and demolition debris, municipal waste water treatment sludge, automobile bodies, and combustion ash that may be sent to municipal solid waste landfills. Some of those wastes (in particular construction and demolition debris) are counted by some states as MSW. In many states, some of these materials, such as construction and demolition debris are disposed along to municipal landfills with MSW. The landfill data do not indicate the capacity or volume of landfills, or in general, a means to estimate extent of lands used for MSW management. For example, the fact that there are fewer landfills does not mean that less land is used for managing wastes because newer landfills are typically larger than their predecessors. The information is also limited by the fact that other lands are also used for waste management, such as for recycling facilities and waste transfer stations, but are not included in the indicator data. The data also do not reflect upon the status or effectiveness of landfill management or the extent to which contamination of nearby lands does or does not occur.

Indicator: Quantity of RCRA Hazardous Waste Generated and Managed (069, 072)

Historically, uncontrolled dumping of wastes, including hazardous industrial wastes, was commonplace, with numerous entities handling and disposing of these materials. Landfills and surface impoundments containing these materials were unlined and uncovered, resulting in contaminated groundwater, surface water, air, and soil. Even with tight control of hazardous wastes from generation to disposal, the potential exists for accidents that could result in the release of hazardous wastes and their hazardous constituents into the environment.

Through the Resource Conservation and Recovery Act (RCRA) and the subsequent 1984 Hazardous and Solid Waste Amendments (HSWA), Congress sought to better control waste management and disposal and to conserve valuable materials and energy resources. The term "RCRA hazardous waste" applies to wastes that are ignitable, corrosive, reactive, or contain certain constituents at toxic levels.

Facilities that treat, store, or dispose of wastes are termed RCRA treatment, storage and disposal facilities (TSDFs). Some hazardous waste generators treat, store, and dispose of their hazardous waste on-site, while others ship their waste to TSDFs (if a generator stores waste longer than a brief time period, then the generator is considered to be a TSDF). Most hazardous waste eventually is disposed of in a land-based unit (a landfill, surface impoundment, land farming facility, or a site using deep well injection). All hazardous wastes disposed of in land-based units must be treated prior to disposal.

EPA, in partnership with states, collects extensive data only on the waste generation, management and disposal practices of "large quantity generators" (businesses that generate more than 2,200 pounds per month of RCRA hazardous waste as part of their regular activities) and TSDFs. These data are collected every two years. This indicator tracks trends in wastes generated and managed under the national RCRA hazardous waste program for two years: 1999 and 2001.

What the Data Show ***[2003 RCRA hazardous waste data were not available in time for this review, but will be for the final report]***

In 1999, 38.2 million tons (MT) of RCRA hazardous wastes were generated and managed (Figure 069-1). To avoid potential double-counting, this does not include amounts for storage, bulking, and/or transfer. Seven percent (2.6 MT) of these wastes were sent to material recovery activities such as metal or solvent recovery, and 4% (1.6 MT) were sent for energy recovery. Twelve percent (4.7 MT) were treated, of which 32% (1.5 MT) were incinerated and 30% (1.4 MT) were stabilized or encapsulated (usually metal-bearing wastes). In 2001, the amount of RCRA hazardous waste generated dropped to 30.9 MT, a 19% reduction compared to 1999. Wastes sent for materials recovery decreased by 12% (2.3 MT), while wastes sent for energy recovery increased by 6% to 1.7 MT. There was a 36% decrease in the amount of RCRA hazardous wastes being treated, with 3 MT sent through treatment processes, but 1.6 MT were incinerated, a 6% increase over quantities incinerated in 1999. Quantities stabilized or encapsulated dropped from 1.4 MT in 1999 to 1.2 MT in 2001, a 14% decrease.

In 1999, 76% of hazardous wastes disposed of (29.2 MT) were disposed of on land: 26.9 MT were deep-well injected and 2.3 MT were placed in landfills or surface impoundments that became landfills (Figure 069-2). Disposal by deep well-injection accounted for 70% of the total amount RCRA hazardous waste generated and managed. In addition to the 38.2 MT, another 0.7 MT sat in storage for some time prior to final disposition (when they would be included in wastes recovered, treated, or disposed). In 2002, quantities of RCRA hazardous waste disposed on land showed an 18% decrease to 23.8 MT. Quantities deep-well injected decreased by 20% to 21.6 MT, but this remained the primary management choice, accounting for 70% of the wastes generated and managed. Landfills or surface impoundments that become landfills received 2.2 MT in 2001, a 4% decrease from 1999. The amount of RCRA hazardous wastes sitting in storage prior to recovery, treatment, or disposal showed over a three-fold increased to 2.4 MT.

Indicator Limitations

- Data are not collected on wastes from all generators that generate less than 2200 pounds per month. However, wastes coming from these sources *are* included in the waste management data from treatment, storage, and disposal facilities that receive the wastes.
- RCRA is a state implemented program and states have the authority to designate additional wastes as hazardous, i.e., go beyond the national program. State-designated hazardous wastes are not tracked by EPA or reflected in the aggregated information presented
- Although RCRA regulations set controls to minimize threat to human health and the environment for wastes disposed of in a land disposal unit, the issue about whether managing treated hazardous wastes by land disposal is a permanently safe practice still exists.
- Most hazardous waste generated in this country is in the form of wastewater. The majority of these wastewaters are: 1) sent untreated to publicly-owned treatment works (POTW); 2) treated and sent to a POTW; or 3) discharged directly to surface waters through a National Pollutant Discharge Elimination System (NPDES) permit.
- Hazardous wastewaters generated and subsequently sent to POTWs or discharged through a NPDES permit are not included in this indicator.

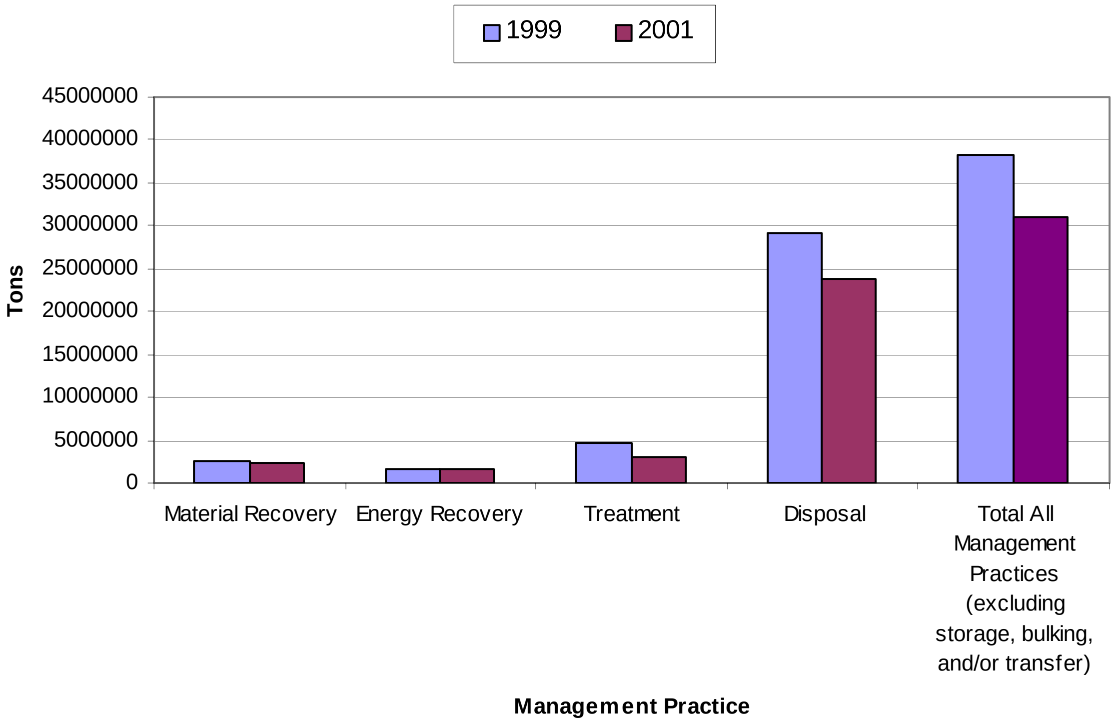
Data Sources

RCRAInfo National Database. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. RCRAInfo. Data as of November 12, 2004.
http://www.epa.gov/epaoswer/hazwaste/data/index.htm#rcra-info

RCRAInfo acontains a comprehensive web-enabled help module (RCRAInfo_Flat_File_WebHelp.zip) that supports direct queries of the Hazardous Waste Report Data Files. The help module explains the flat file specifications and data element values. (See ftp://ftp.epa.gov/rcrainfodata/rcra_flatfiles/). The flat files are provided to Envirofacts and the Right to Know Network and can be downloaded free of charge from EPA's publicly accessible FTP server (ftp://ftp.epa.gov/rcrainfodata/brfiles/).

Graphics

Figure 069-1. Management Trends for RCRA Hazardous Waste



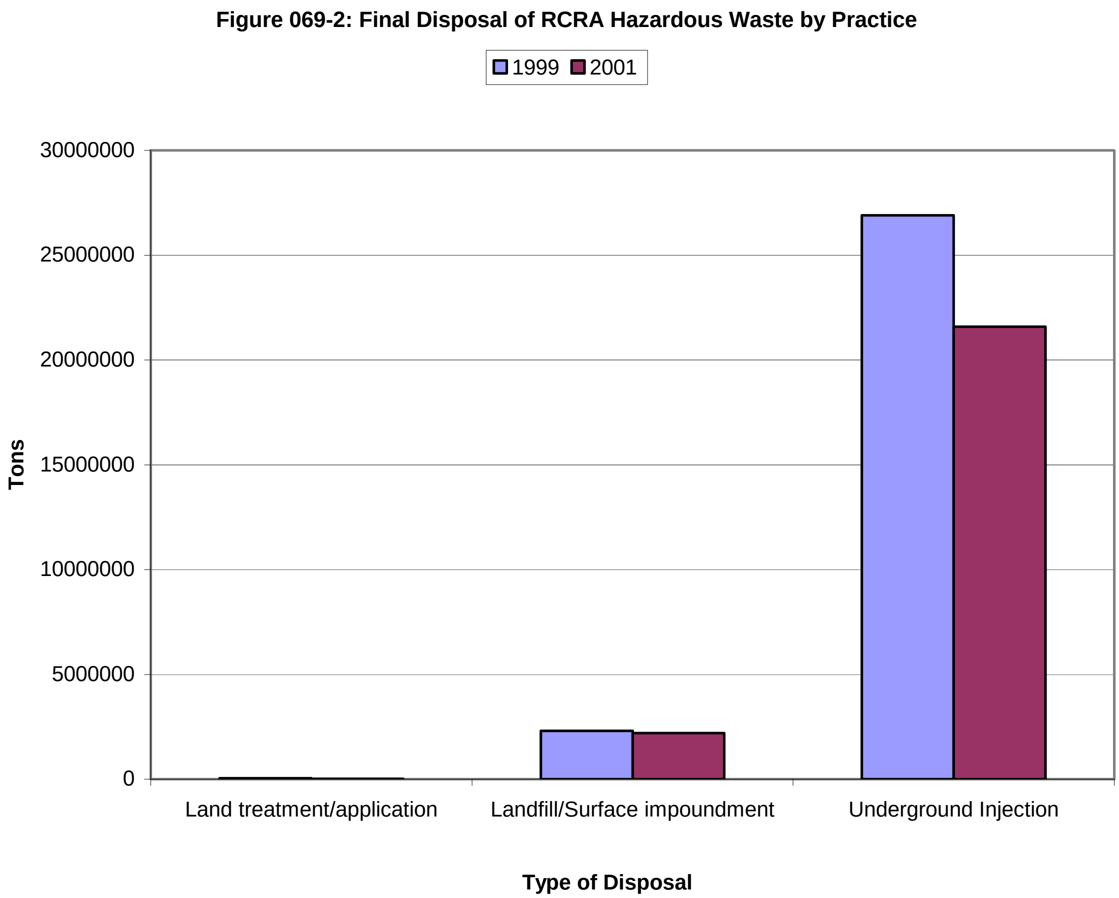


Figure 069-2: Final Disposal of RCRA Hazardous Waste by Practice
1999
2001
30000000
25000000
20000000
15000000
10000000
5000000
0
Tons
Land treatment/application
Landfill/Surface impoundment
Underground Injection
Type of Disposal

R.O.E. Indicator QA/QC

Data Set Name: QUANTITY OF RCRA HAZARDOUS WASTE GENERATED AND MANAGED
Indicator Number: 069 (89130)
Data Set Source: RCRAInfo.
Data Collection Date: regular: 1989 - 2001
Data Collection Frequency: 2 yrs
Data Set Description: RCRA Hazardous Waste Generated by Large Quantity Generators and Managed (combines indicators 069, 223, 072, 074)
Primary ROE Question: What are the trends in wastes and their effects on human health and the environment?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

The RCRA hazardous waste program is a cradle to grave program and the level of regulation with which a facility must comply is based on the quantity of hazardous waste generated. Facilities are required to keep records of their wastes. Information submitted on hazardous waste comes from facility records such as:· Hazardous waste manifest forms;· Hazardous Waste Report forms submitted in previous years;· Records of quantities of hazardous waste generated or accumulated on site;· Results of laboratory analyses of your wastes;· Contracts or agreements with off-site facilities managing your wastes; and· Copies of permits for on-site waste management systems.A facility must specifically report the amount of waste, the unit of measurement (pounds, short tons, kilograms, metric tons, gallons, liters, or cubic yards) and the density.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. All RCRA Large Quantity Generators and RCRA Treatment, Storage and Disposal facilities are required to submit a Hazardous Waste Report every two years (for odd number years). The reporters complete the forms provided in the Hazardous Waste Report Instructions and Forms Booklet (EPA Form 8700-13 A/B) for the specific reporting year. Some states require reporting on their equivalent forms. RCRA hazardous wastes that must be reported are specifically listed in 40 CFR Part 261. Generally, regulations lay out two steps for determining if a facility is generating a hazardous waste. The first step is to check whether the waste being generated is on the list of wastes determined to be hazardous. The second step is to determine if the waste exhibits certain characteristics, i.e., ignitability, corrosivity, reactivity, or toxicity. The regulations state how to make these determinations. Since 1989, the RCRA hazardous waste program has collected information on RCRA hazardous wastes generated in this country. This is actually a statutory mandate. During the 1990 s, the RCRA hazardous waste program undertook several large efforts to identify additional wastes that should be added to the list of hazardous wastes. Also, the program sought to be more selective in the information it collected on RCRA hazardous waste. These efforts make information collected throughout the 1990 s somewhat inconsistent for examining trends. By 1999, program activities that could cause these types of trending difficulties stabilized. Therefore, this indicator uses 1999 as the baseline year for beginning a trend analysis. Data are not collected on the area of land used in the management of hazardous wastes.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The submitted data are directly aggregated for indicators

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

All RCRA Large Quantity Generators and RCRA Treatment, Storage and Disposal facilities are required to submit a Hazardous Waste Report (Biennial Report) every two years (for odd number years). The reported data provides information on the identity and location of hazardous waste generators and TSDFs. The reports describe and quantify the hazardous wastes that were generated and managed during the specific year. RCRA Sections 3002 and 3004. http://www.epa.gov/epaoswer/hazwaste/data/br03/forms.htm

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Not applicable.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

No.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Reporting requirements are for the submitted data are specified in the Hazardous Waste Report Instructions and Forms Booklet (EPA Form 8700-13 A/B) for the specific reporting year. Some states require reporting on their equivalent forms. The booklets are available at - http://www.epa.gov/epaoswer/hazwaste/data/biennialreport/index.htm

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes. Hazardous Waste Report Data Files can be downloaded from the Internet. http://www.epa.gov/epaoswer/hazwaste/data/index.htm RCRAInfo also contains a comprehensive web-enabled help module (RCRAInfo_Flat_File_WebHelp.zip) for those interested in directly querying the Hazardous Waste Report Data Files. This help module explains the flat file specifications and data element values. (See ftp://ftp.epa.gov/rcrainfodata/rcra_flatfiles/). In addition, these flat files are provided to Envirofacts and the Right to Know Network making them free for downloading from EPA s publicly accessible FTP server (ftp://ftp.epa.gov/rcrainfodata/brfiles/). Other related documents are at - http://www.epa.gov/epaoswer/hazwaste/data/biennialreport/index.htm

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The Biennial Report for each specific year must be reviewed and approved by the Office of Management and Budget. EPA submits an Information Collection Request which describes the reporting universe, what data will be collected, the data collection instrument and process, the management of the data, and how the will be used. This process includes public review and comment through notices in the Federal Register.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

For RCRA hazardous waste information, EPA coordinates a national review process with states and EPA regions when the initial data are compiled. EPA Headquarters, regions and states all perform data quality assurance. This includes follow-up with non-respondents, the detection and correction of unacceptable responses (e.g., where the respondent misunderstood the instructions), and the verification of exceptional data (e.g., data reported by a respondent differ significantly from data reported by the rest of the respondent universe) and significant response changes between reporting years. They identify cases where the state or region may want to confirm that data were entered correctly, and/or contact a regulated entity to confirm what they reported and provide them with the opportunity to submit an updated report it the original contained errors. The quality assurance and quality control plan documents are available from the Office of Solid Waste.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Not applicable. The submitted data are aggregated.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Not applicable.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not applicable.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

All RCRA Large Quantity Generators and RCRA Treatment, Storage and Disposal facilities are required to submit a Hazardous Waste Report (Biennial Report) every two years (for odd number years). The reported data provides information on the identity and location of hazardous waste generators and TSDFs. The reports describe and quantify the hazardous wastes that were generated and managed during the specific year. The data do not include information on the area of land used by these facilities. Businesses that generate a substantial amount (i.e., more than 2,200 pounds per month) of RCRA hazardous waste as part of their regular activities are called large quantity generators (LQGs). National data on businesses that do not generate a substantial amount (called small quantity generators or conditionally-exempt small quantity generators depending on the amount) are not directly collected, although their quantities can be calculated through information submitted by TSDFs. There are a large number of these smaller generators and their contributions to the overall quantities of hazardous waste generated have not been adequately assessed.

Indicator: Contaminated Groundwater Under Control on Contaminated Lands (221)

Contaminated lands include sites contaminated as a result of improper disposal of toxic and hazardous wastes in the past, as well as improper handling or accidents occurring at active hazardous waste management facilities. People and ecosystems can be harmed if they come into contact with these toxic and hazardous materials, either on-site or as a result of migration offsite through air, water, and groundwater. Trends in addressing the area covered by contaminated lands are all difficult to document on a nationwide basis, because efforts have focused on characterization of contamination and remedial responses at specific sites and their local surroundings, and because federal and state governments use a variety of laws and regulations to initiate, implement, and enforce cleanup. Restoration at the nation's most contaminated lands, however, is managed primarily by EPA's Superfund Program or its RCRA Corrective Action Program.

The Superfund Program investigates and collects data on potentially contaminated sites to determine whether they are contaminated and require cleanup. When a potentially hazardous waste site is reported to EPA, trained inspectors determine whether the site presents a hazard to human health and the environment. Sites that pose the greatest threat are placed on the National Priority List (NPL). Sites are considered for deletion from the NPL when all cleanup goals are met and there is no further need for federal action. Approximately 40 million people, 13% of the US population, live within 2.5 miles of an NPL site. A site that has been proposed to the NPL is termed "final" once it has been formally added to the NPL.

The RCRA Corrective Action Program addresses the clean-up of contamination at active hazardous waste management facilities arising from current or past solid and hazardous waste management activities. Approximately 6,000 hazardous waste management facilities fall within the domain of the RCRA Corrective Action Program. Approximately 3,800 of these facilities have corrective action already underway or will need to implement corrective action as part of the process to obtain a permit to treat, store, or dispose of hazardous waste. A cleanup baseline of 1,714 of these were designated high-priority sites targeted for immediate action by federal, state, and local agencies and are used as the baseline against which the cumulative number of corrective action sites with human exposure under control are measured.

One of the priorities for these sites is controlling any migration of contaminated groundwater away from the site. EPA and state officials determine contaminated groundwater migration is under control when on-going monitoring shows that the contaminant plume is not expanding or impacting surface waters. This may occur due to an action taken, such as installation of a "pump and treat" or subsurface barrier system, or because of natural attenuation of the waste. This determination is based on monitoring data (usually hundreds of analytical samples) collected from groundwater wells that surround the site. This indicator is based on the percentage of sites that have been designated "contaminated groundwater under control" at the 1,714 high-priority RCRA Corrective Actions sites and a baseline of 1,275-1,328 NPL sites. Sites that are not designated as under control are designated either "not under control" or as having "insufficient data" (EPA 2004).

What the Data Show

Control of migration of contaminated groundwater increased from 32% of the 1,714 high-priority RCRA Corrective Actions sites in 2000 to 70% of the sites in 2004, increasing 10% each year on average (Figure 221-1).

Control of migration of contaminated groundwater increased from 60% of 1,272 final and deleted NPL sites with contaminated ground water in 2002 (the first year this indicator was calculated for NPL sites) to 67% of 1,328 final and deleted with contaminated groundwater NPL sites in 2004 (Figure 221-2).

Indicator Limitations

- The NPL does not represent all of the contaminated or potentially contaminated sites listed in the CERCLIS database, the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) database that contains information on hazardous waste sites, potential hazardous waste sites, and remedial activities across the nation.
- The indicator covers the 1,714 high-priority RCRA corrective action sites, and not the entire group of 6000 hazardous waste management sites that fall under the RCRA Corrective Acton Program.
- Concentrations of toxic and hazardous waste that must not be exceeded to designate a site as under control vary from state to state.
- The indicator is based on the certification by a responsible official that the criteria necessary to designate a site as under control have been met. To the extent that the certification lags the actual year in which migration of contaminated groundwater away from the site actually came under control , or was the result of having insufficient information in previous years, the actual trend in the percentage of sites in which the migration of contaminated groundwater was under control may be underestimated**.**
- Regarding NPL sites, 3 years (2002-2004) may not be enough time to assess a trend of groundwater migration under control.

Data Sources

National Priority List/Superfund Sites: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. CERCLIS. http://www.epa.gov/enviro/html/cerclis/

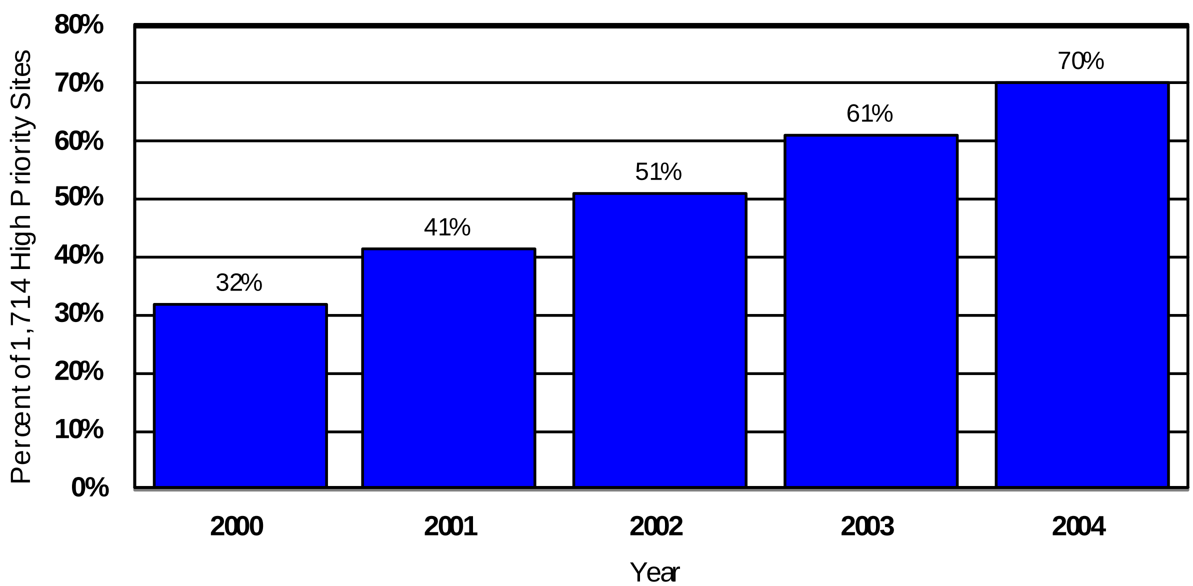
RCRA Corrective Action Sites: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. RCRA Corrective Action. http://www.epa.gov/epaoswer/hazwaste/ca
http://www.epa.gov/epaoswer/hazwaste/data/index.htm#rcra-info

References

U.S. Environmental Protection Agency, RCRA Corrective Action, Environmental Indicators. Office of Solid Waste and Emergency Response (2004). http://www.epa.gov/epaoswer/hazwaste/ca/eis.htm

Graphics

Figure 221-1: Percent of the 1,714 High-Priority RCRA Corrective Action Sites With Migration of Contaminated Groundwater Under Control 2000 to 2004



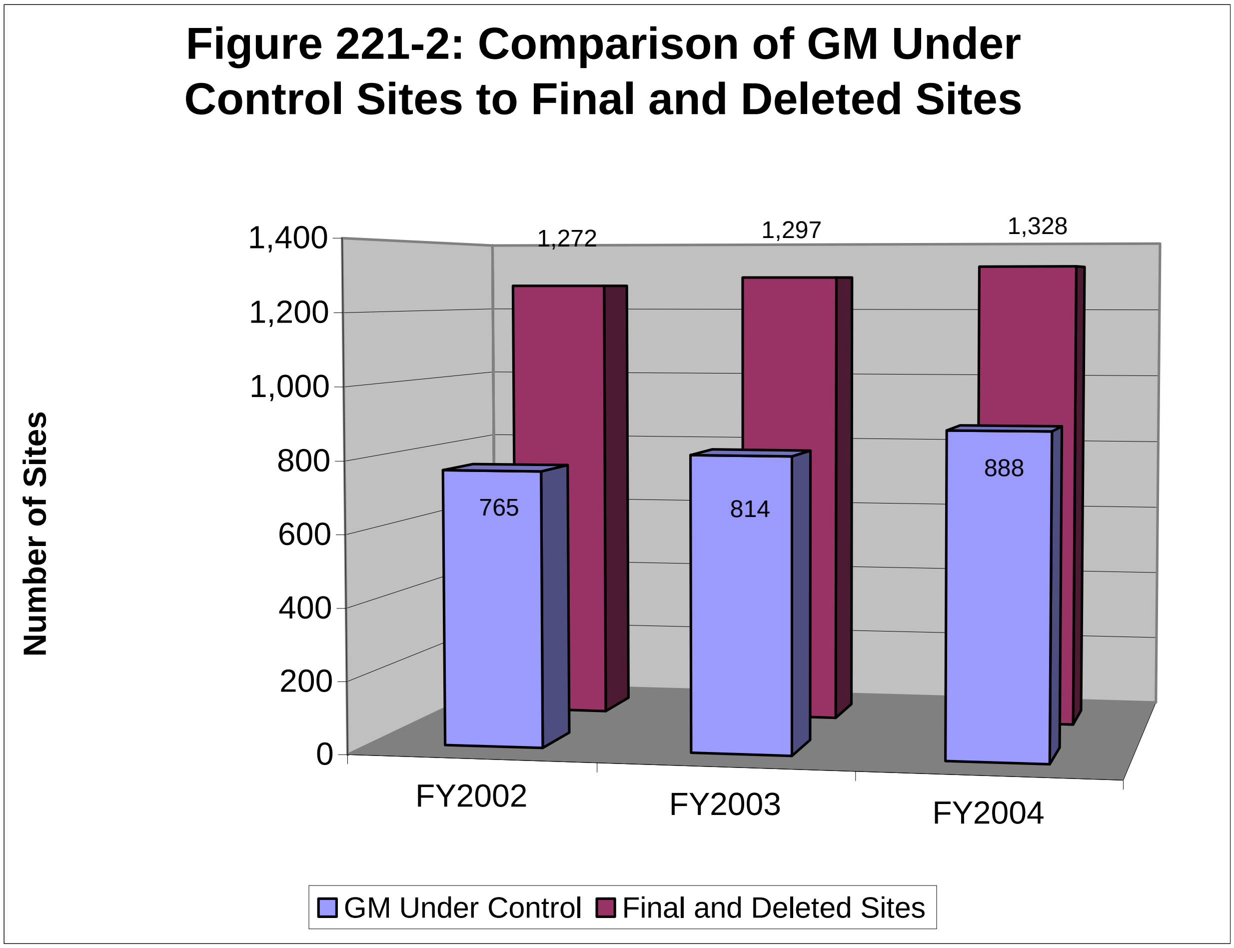


Figure 221-2: Comparison of GM Under Control Sites to Final and Deleted Sites
Number of Sites
1,400
1,200
1,000
800
600
400
200
0
1,272
1,297
1,328
765
814
888
FY2002
FY2003
FY2004
GM Under Control
Final and Deleted Sites

R.O.E. Indicator QA/QC

Data Set Name: CONTAMINATED GROUNDWATER UNDER CONTROL ON CONTAMINATED LANDS
Indicator Number: 221 (116287)
Data Set Source: CERCLIS; RCRA Info
Data Collection Date: Ongoing: 2001 - Present
Data Collection Frequency: 1 year
Data Set Description: At Superfund and high priority RCRA Corrective Action sites with contaminated ground water, indicates whether contamination is below protective, risk-based levels or, if not, whether the migration of contaminated ground water is stabilized and there is no unacceptable discharge to surface water and monitoring will be conducted to confirm that affected ground water remains in the original area of contamination.
Primary ROE Question: What are the trends in contaminated land and their effects on human health and the environment?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The indicator relies on three types of information: 1) ground water monitoring data (contaminant concentrations; 2) hydraulic data and ground water modeling data; and, in cases where there is ground water-to-surface water discharge, 3) findings from examinations of potential ecological effects (e.g., via bio-assays/benthicsurveys or site-specific ecological Risk Assessments). Contaminant data are collected using standard sampling and analytical methods that result in data of known quality. Ground water hydraulic and modeling data are collected using standard methods relied upon for risk management decisions at Superfund sites. Ecological risk assessment practices are well defined and widely accepted as a valid basis for ecological risk characterization at Superfund sites. Determinations at high priority RCRA Corrective Action sites with groundwater discharges to surface waters also permit the use of bioassays, benthic surveys, and other well-established tools for assessing potential effects on ecological receptors.
http://www.epa.gov/epaoswer/hazwaste/ca/eis.htm
http://www.epa.gov/superfund/accomp/ei/ei.htm

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. Regional and state (for RCRA Corrective Action) personnel respond to a survey based on data collected and conclusions derived (e.g., through capture zone analysis) from sampling designs, monitoring plans, and other field observations that were established as the basis for risk management decisions at Superfund and high priority RCRA Corrective Action sites and are based on sound scientific principles. http://www.epa.gov/epaoswer/hazwaste/ca/eis.htm
http://www.epa.gov/superfund/accomp/ei/ei.htm

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The conceptual model relies on straightforward questions that relate monitoring and/or modeling data to the question of whether contamination in ground water is migrating. Modeling data are used as a line of evidence for capture zone analysis and to evaluate ground water-to-

surface water discharge. http://www.epa.gov/epaoswer/hazwaste/ca/eis.htm
http://www.epa.gov/superfund/accomp/ei/ei.htm

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The indicator measures the effect of EPA actions at Superfund and high priority RCRA Corrective Action sites on stressors to ground water resources. The indicator does not measure ambient ground water quality but, rather, pressures (contaminants) on ground water quality.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The indicator is a measure of pressure on ground water resources, rather than a direct indicator of human health exposure. It does not distinguish among populations.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

The extent of the contaminated plume is defined based on risk-based contaminant levels. Plume migration is measured based on hydraulic and contaminant monitoring data.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The FY-04/05 Superfund/Oil Implementation Manual (SPIM) outlines indicator definitions and reporting requirements. http://www.epa.gov/superfund/action/process/spim04.htm (See Appendix B, Part IV). The Superfund Environmental Indicators Guidance Manual includes a discussion of indicator background, reporting requirements, detailed instructions for making the Migration of Contaminated Ground Water Under Control determination, frequently asked questions, and CERCLIS data entry instructions. The RCRA Corrective Action website provides detailed instructions for making the Migration of Contaminated Groundwater Under Control determination, frequently asked questions, and training slides. See http://www.epa.gov/epaoswer/hazwaste/ca/eis.htm Further guidance is provided in the Data Quality Objectives Process for Hazardous Waste Site Investigations (EPA/600/R-00/007), see http://www.epa.gov/QUALITY/qs-docs/g4hw-final.pdf; Guidance for the Data Quality Objective Process (EPA/600/R-96/055), see http://www.epa.gov/QUALITY/qs-docs/g4-final.pdf; and SW-846: Test Methods for Evaluating Solid Waste Physical/Chemical Methods, see http://www.epa.gov/epaoswer/hazwaste/test/main.htm#Table

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Migration of Contaminated Ground Water Under Control determinations at NPL sites (this indicator is limited to NPL sites) can be viewed via the CERCLIS Public Access database. http://cfpub.epa.gov/supercpad/cursites/srchsites.cfm Further information on the Migration of Contaminated Ground Water Under Control indicator including definition and quarterly data can be viewed via the Superfund Environmental Indicators Website. http://www.epa.gov/superfund/accomp/ei/gw.htm Information on the Migration of Contaminated Groundwater Under Control indicator determinations for priority RCRA Corrective Action sites can be found at http://www.epa.gov/epaoswer/hazwaste/ca/eis.htm, with links to each EPA Region's Corrective Action website where details about each facility accessed can be observed.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The Migration of Contaminated Ground Water Under Control survey is available in Portable Document Format (PDF) on the Superfund Environmental Indicators Website. http://www.epa.gov/superfund/accomp/ei/gwsurvey.pdf Information on the Migration of Contaminated Groundwater Under Control indicator determinations for priority RCRA Corrective Action sites can be found at http://www.epa.gov/epaoswer/hazwaste/ca/eis.htm, with links to each EPA Region s Corrective Action website where details about each facility accessed can be observed.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Migration of Contaminated Ground Water Under Control data quality objectives are thoroughly outlined in the Human Exposure/Migration of Contaminated Ground Water Under Control CERCLIS Data Quality Objectives (DQO) document. The DQO includes a discussion of data completeness, accuracy, timeliness, and consistency. The DQO is available to EPA Headquarters and the Regions via EPA's CERCLIS3 Document Database. The RCRA Corrective Action website provides detailed instructions for making the Migration of Contaminated Groundwater Under Control determination, frequently asked questions, and training slides. See http://www.epa.gov/epaoswer/hazwaste/ca/eis.htm Further guidance is provided in the Data Quality Objectives Process for Hazardous Waste Site Investigations (EPA/600/R-00/007), see http://www.epa.gov/QUALITY/qs-docs/g4hw-final.pdf; Guidance for the Data Quality Objective Process (EPA/600/R-96/055), see http://www.epa.gov/QUALITY/qs-docs/g4-final.pdf; and SW-846: Test Methods for Evaluating Solid Waste Physical/Chemical Methods, see http://www.epa.gov/epaoswer/hazwaste/test/main.htm#Table

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

The unit of measure for the indicator is the site. This is a population measure not requiring inferential statistics. Due to lack of adequate data, the indicator does not measure the extent to which migration of contaminated ground water associated with non-NPL or lower-priority RCRA Corrective Action waste sites has have been mitigated, and does not attempt to generalize beyond ground water resources impacted by NPL and high priority RCRA Corrective Action sites. Currently, EPA believes that there are over 6,500 facilities subject to RCRA corrective action statutory authorities. Of these, approximately 3,800 facilities have corrective action already underway or will need to implement corrective action as part of the process to obtain a permit to treat, store, or dispose of hazardous waste. EPA refers to these 3,800 facilities as the "corrective action workload." To help prioritize resources further, EPA established specific short-term goals for 1,714 high priority facilities referred to as the RCRA Cleanup Baseline. The RCRA Corrective Action program ranked sites low, medium, or high priority, based on a site's environmental releases and potential for impacting people and the environment. If a facility ranked high before 1997, it was automatically included on the baseline. The states and EPA also added some sites to the RCRA Cleanup Baseline, which posed a potentially significant environmental risk or were of particular concern to communities, despite being ranked medium or low. The facilities on the RCRA Cleanup Baseline comprise the basis of the Corrective Action Program's 2005 goals under the Government Performance and Results Act (GPRA).

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Uncertainties in the ground water data used to support this indicator are evaluated on a site-specific basis but are not rolled-up for a measure of cross-indicator uncertainty. No formal study has been conducted regarding the reproducibility of survey responses.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

The uncertainty and variability could impact the conclusions that can be inferred from the data. However, unless there are systematic biases introduced to the process (e.g., systematic differences in interpretation of questions), the impacts of these factors on the aggregated data and overall conclusions should be minimal. The Superfund and RCRA Corrective Action programs has have implemented guidance and training to minimize the effects of variability and systematic bias.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

In some instances, there may be underlying factors (e.g., changes in MCLs (EPA periodically re-evaluates MCLs) used to identify contaminated ground water) that could cause a data shift, the cause of which would not be evident to the user. The indicator instrument documents reasons for changes in the indicator determination that could be monitored to identify and communicate to the user the effect of exogenous factors on indicator trends. Superfund NPL and RCRA Corrective Action sites are a subset of contaminated lands in the U.S.

Indicator: Human Exposure Under Control on Contaminated Lands (219)

Contaminated lands include sites contaminated as a result of improper disposal of toxic and hazardous wastes in the past, as well as improper handling or accidents occurring at active hazardous waste management facilities. People and ecosystems can be harmed if they come into contact with these toxic and hazardous materials, either on-site or as a result of migration offsite through air, water, and groundwater. Trends in addressing the area covered by contaminated lands are all difficult to document on a nationwide basis, because efforts have focused on characterization of contamination and remedial responses at specific sites and their local surroundings, and because federal and state governments use a variety of laws and regulations to initiate, implement, and enforce cleanup. Restoration at the nation's most contaminated lands, however, is managed primarily by EPA's Superfund Program or its RCRA Corrective Action Program.

The Superfund Program investigates and collects data on potentially contaminated sites to determine whether they are contaminated and require cleanup. When a potentially hazardous waste site is reported to EPA, trained inspectors determine whether the site presents a hazard to human health and the environment. Sites that pose the greatest threat are placed on the National Priority List (NPL). Sites are considered for deletion from the NPL when all cleanup goals are met and there is no further need for federal action. Approximately 40 million people, 13% of the US population, live within 2.5 miles of an NPL site. A site that has been proposed to the NPL is termed "final" once it has been formally added to the NPL.

The RCRA Corrective Action Program addresses the clean-up of contamination at active hazardous waste management facilities arising from current or past solid and hazardous waste management activities. Approximately 6,000 hazardous waste management facilities fall within the domain of the RCRA Corrective Action Program. Approximately 3,800 of these facilities have corrective action already underway or will need to implement corrective action as part of the process to obtain a permit to treat, store, or dispose of hazardous waste. A cleanup baseline of 1,714 of these were designated high-priority sites targeted for immediate action by federal, state, and local agencies and are used as the baseline against which the cumulative number of corrective action sites with human exposure under control are measured.

One of the priorities for these sites is controlling current human exposures to site contamination. EPA and state officials determine if current human exposures are under control, if current exposure levels to hazardous substances at potential points of contact are below appropriate risk-based screening levels, or if actions were taken to reduce or eliminate all current exposures - such as removing contaminated media, providing alternative water supplies, and restricting access and other land use controls. This determination is based on site-specific characterization information and monitoring data (usually hundreds of analytical samples) pertaining to relevant environmental media (e.g., soil, indoor air, outdoor air, groundwater and surface), current human activity patterns, and actions taken to prevent exposure. All potential exposure routes are assessed, including inhalation, direct contact, or ingestion of the contaminated media or food impacted by contaminated media. Sites that are not designated as under control are designated either "not under control" or as having "insufficient data" (EPA 2004).

What the Data Show

Control of human exposure to site contamination increased from 38% of the 1,714 high-priority RCRA Corrective Actions sites in 2000 to 84% of the sites in 2004, increasing 11.5% each year on average (Figure 219-1).

Control of human exposure to site contamination increased from 79% of the 1,498 final and deleted NPL sites in 2002 (the first year this indicator was calculated for NPL sites) to 82% of the 1,529 final and deleted NPL sites in 2004 (Figure 219-2).

Indicator Limitations

- The NPL does not represent all of the contaminated or potentially contaminated sites listed in the CERCLIS database, the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) database that contains information on hazardous waste sites, potential hazardous waste sites, and remedial activities across the nation.
- The indicator covers the 1,714 high-priority RCRA corrective action sites, and not the entire group of 6000 hazardous waste management sites that fall under the RCRA Corrective Action Program.
- The indicator does not typically make measurements of exposure biomarkers among potentially exposed individuals at the Superfund NPL or RCRA Corrective Action Sites.
- Concentrations of toxic and hazardous waste that must not be exceeded to designate a site as under control vary from state to state.
- The indicator is based on the certification by a responsible official that the criteria necessary to designate a site as under control have been met. To the extent that the certification lags the actual year in which human exposure actually came under control or was the result of having insufficient information in previous years, the actual trend in the percentage of sites in which human exposure is under control may be underestimated.
- Regarding NPL sites, 3 years (2002-2004) may not be enough time to assess a trend of human exposure under control.

Data Sources

National Priority List/Superfund Sites: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. CERCLIS.
http://www.epa.gov/enviro/html/cerclis/

RCRA Corrective Action Sites: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. RCRA Corrective Action. http://www.epa.gov/epaoswer/hazwaste/ca
http://www.epa.gov/epaoswer/hazwaste/data/index.htm#rcra-info

References

U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. RCRA Corrective Action, Environmental Indicators (2004). http://www.epa.gov/epaoswer/hazwaste/ca/eis.htm

Graphics

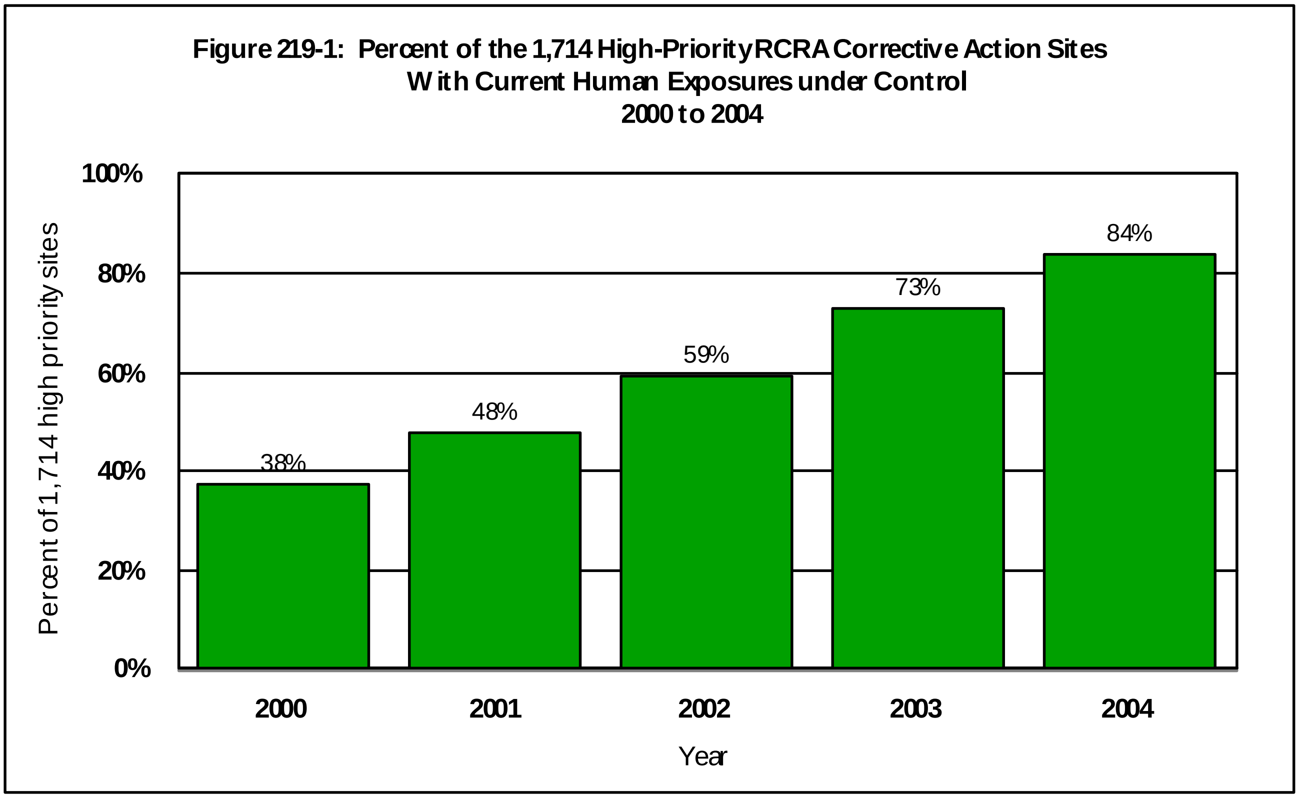


Figure 219-1: Percent of the 1,714 High-Priority RCRA Corrective Action Sites
With Current Human Exposures under Control
2000 to 2004
100%
80%
60%
40%
20%
0%
Percent of 1,714 high priority sites
38%
48%
59%
73%
84%
2000
2001
2002
2003
2004
Year

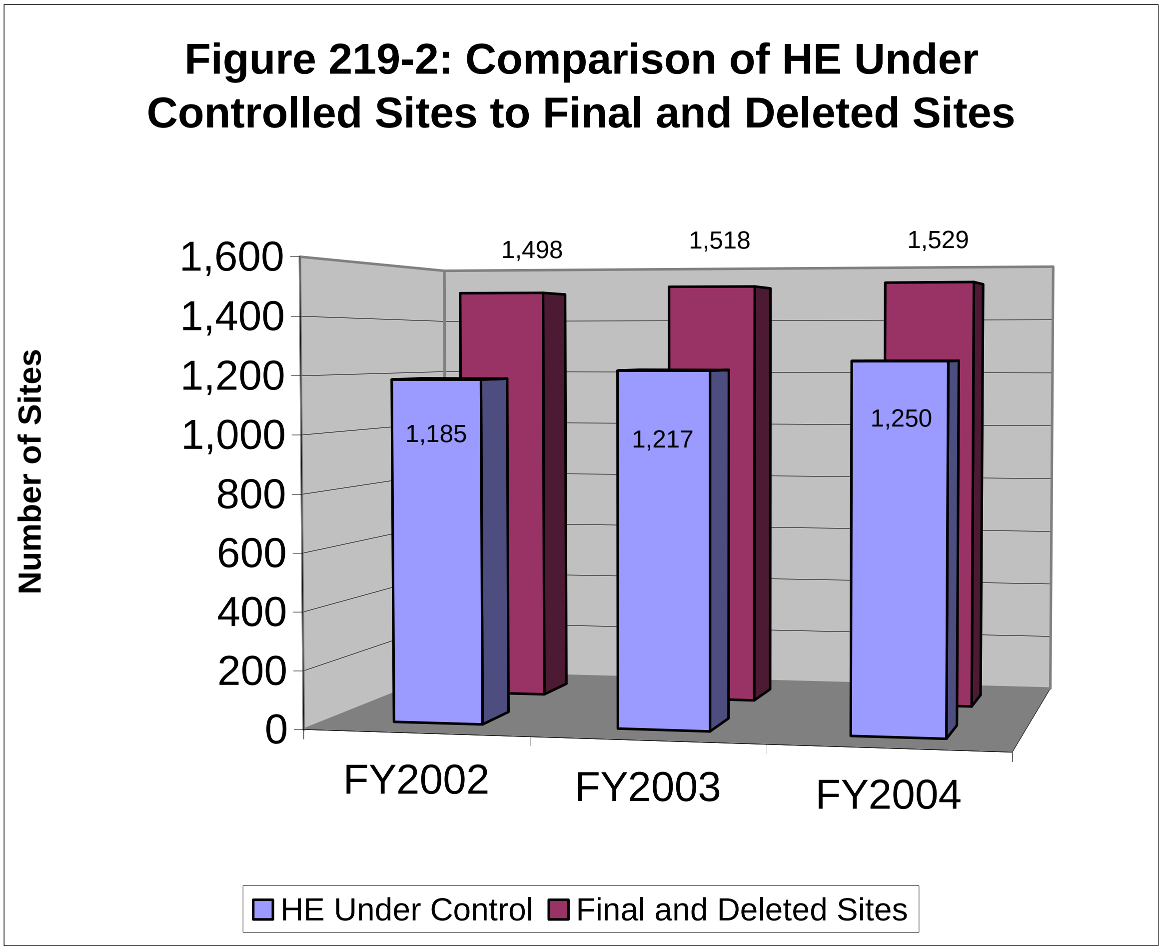


Figure 219-2: Comparison of HE Under Controlled Sites to Final and Deleted Sites
Number of Sites
1,600
1,400
1,200
1,000
800
600
400
200
0
1,498
1,518
1,529
1,185
1,217
1,250
FY2002
FY2003
FY2004
HE Under Control
Final and Deleted Sites

R.O.E. Indicator QA/QC

Data Set Name: HUMAN EXPOSURE UNDER CONTROL ON CONTAMINATED LANDS
Indicator Number: 219 (116286)
Data Set Source: CERCLIS; RCRA Info
Data Collection Date: Ongoing: 2001 - Present
Data Collection Frequency: 1 year or as changes in site conditions warrant
Data Set Description: Indicates whether contamination is below protective, risk-based levels at NPL and high priority RCRA Corrective Action sites or if not, whether adequate controls are in place to prevent unacceptable human exposures under current land and ground water use conditions.
Primary ROE Question: What are the trends in contaminated land and their effects on human health and the environment?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The indicator relies on three types of information: 1) contaminant concentrations in media (e.g., air, water, land, sediment, biota); 2) site-specific observations regarding human contact at exposure points; and 3) findings from human health risk assessment. Contaminant data are collected using standard analytical methods that result in data of known quality. Observations regarding human contact at exposure point concentrations are a fundamental component of exposure assessment (current scenarios). Human exposure and human health risk assessment practices are well defined and widely accepted as a valid basis for exposure and risk characterization at Superfund and high priority RCRA Corrective Action sites.
http://www.epa.gov/epaoswer/hazwaste/ca/eis.htm
http://www.epa.gov/superfund/accomp/ei/ei.htm

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. Regional and state (for RCRA Corrective Action) personnel respond to a survey based on data collected and conclusions derived (e.g., through exposure assessment) from sampling designs, monitoring plans, and other field observations that were established as the basis for risk management decisions at Superfund and high priority RCRA Corrective Action sites and are based on sound scientific principles. http://www.epa.gov/epaoswer/hazwaste/ca/eis.htm
http://www.epa.gov/superfund/accomp/ei/ei.htm

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The conceptual model mirrors the standard human risk assessment model. The indicator asks whether there are complete exposure pathways between contaminated media and current human receptors (exposure assessment) and, if so, whether the complete exposure pathways represent unacceptable risk (risk characterization). http://www.epa.gov/epaoswer/hazwaste/ca/eis.htm
http://www.epa.gov/superfund/accomp/ei/ei.htm

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The indicator documents the outcomes of a variety of EPA actions, including enforcement, site assessment, and physical cleanup to address human health stressors (i.e., exposure to contaminants via complete exposure pathways) associated with Superfund and high priority RCRA Corrective Action sites. The indicator addresses all media and measures impacts on stressors to human health directly (not via impacts on stressors to ambient conditions).

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The indicator measures whether there are unacceptable human exposures via complete exposure pathways, and relying on standard risk assessment techniques. Risk assessment takes into account sensitive populations in the exposure assessment (RME individual) and toxicity assessment (factors for intraspecies variability). Advances in risk assessment practice to better address sensitive populations will be automatically incorporated into the indicator as they are incorporated into practice. The indicator does not address ecosystems.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Yes. The indicator measures whether there are complete pathways between contaminated media and human receptors that represent unacceptable risk to human health. "Contamination" is defined based on documented risk-based levels. "Unacceptable risk" is defined based on the cancer risk range (10-6 to 10-4 excess lifetime cancer risk) and a hazard index of 1

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The FY-04/05 Superfund/Oil Implementation Manual (SPIM) outlines indicator definitions and reporting requirements. http://www.epa.gov/superfund/action/process/spim04.htm (See Appendix B, Part IV). The Superfund Environmental Indicators Guidance Manual includes a discussion of indicator background, reporting requirements, detailed instructions for making the Human Exposure Under Control determination, frequently asked questions, and CERCLIS data entry instructions. The RCRA Corrective Action website provides detailed instructions for making the Human Exposure Under Control determination, frequently asked questions, and training slides. See http://www.epa.gov/epaoswer/hazwaste/ca/eis.htm Further guidance is provided in the Data Quality Objectives Process for Hazardous Waste Site Investigations (EPA/600/R-00/007), see http://www.epa.gov/QUALITY/qs-docs/g4hw-final.pdf; Guidance for the Data Quality Objective Process (EPA/600/R-96/055), see http://www.epa.gov/QUALITY/qs-docs/g4-final.pdf; and SW-846: Test Methods for Evaluating Solid Waste Physical/Chemical Methods, see http://www.epa.gov/epaoswer/hazwaste/test/main.htm#Table

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Human Exposure Under Control determination can be viewed via the CERCLIS Public Access database. http://cfpub.epa.gov/supercpad/cursites/srchsites.cfm Further information on the Human Exposure Under Control indicator including definition and quarterly data can be viewed via the Superfund Environmental Indicators Website. http://www.epa.gov/superfund/accomp/ei/exposure.htm Information on the Human Exposure Under Control indicator determinations for high priority RCRA Corrective Action sites can be found at http://www.epa.gov/epaoswer/hazwaste/ca/eis.htm, with links to each EPA Region's Corrective Action website where details about each facility accessed can be observed.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The Human Exposure Under Control survey is available in Portable Document Format (PDF) on the Superfund Environmental Indicators Website. http://www.epa.gov/superfund/accomp/ei/hesurvey.pdf Information on the Human Exposure Under Control indicator determinations for high priority RCRA Corrective Action sites can be found at http://www.epa.gov/epaoswer/hazwaste/ca/eis.htm, with links to each EPA Region's Corrective Action website where details about each facility accessed can be observed.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Human Exposure Under Control data quality objectives are thoroughly outlined in the Human Exposure/Migration of Contaminated Ground Water Under Control CERCLIS Data Quality Objectives (DQO) document. The DQO includes a discussion of data completeness, accuracy, timeliness, and consistency. The DQO is available to EPA Headquarters and the Regions via EPA's CERCLIS3 Document Database. The RCRA Corrective Action website provides detailed instructions for making the Human Exposure Under Control determination, frequently asked questions, and training slides. See http://www.epa.gov/epaoswer/hazwaste/ca/eis.htm Further guidance is provided in the Data Quality Objectives Process for Hazardous Waste Site Investigations (EPA/600/R-00/007), see http://www.epa.gov/QUALITY/qs-docs/g4hw-final.pdf; Guidance for the Data Quality Objective Process (EPA/600/R-96/055), see http://www.epa.gov/QUALITY/qs-docs/g4-final.pdf; and SW-846: Test Methods for Evaluating Solid Waste Physical/Chemical Methods, see http://www.epa.gov/epaoswer/hazwaste/test/main.htm#Table

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

The unit of measure for the indicator is the site. This is a population measure not requiring inferential statistics. Due to lack of adequate data, the indicator does not measure the extent to which human exposure to contaminants associated with non-NPL or lower-priority RCRA Corrective Actione sites has have been mitigated, and does not attempt to generalize beyond exposures relative to NPL and high priority RCRA Corrective Action sites. Currently, EPA believes that there are over 6,500 facilities subject to RCRA corrective action statutory authorities. Of these, approximately 3,800 facilities have corrective action already underway or will need to implement corrective action as part of the process to obtain a permit to treat, store, or dispose of hazardous waste. EPA refers to these 3,800 facilities as the "corrective action workload." To help prioritize resources further, EPA established specific short-term goals for 1,714 high priority facilities referred to as the RCRA Cleanup Baseline. The RCRA Corrective Action program ranked sites low, medium, or high priority, based on a site's environmental releases and potential for impacting people and the environment. If a facility ranked high before 1997, it was automatically included on the baseline. The states and EPA also added some sites to the RCRA Cleanup Baseline, which posed a potentially significant environmental risk or were of particular concern to communities, despite being ranked medium or low. The facilities on the RCRA Cleanup Baseline comprise the basis of the Corrective Action Program's 2005 goals under the Government Performance and Results Act (GPRA).

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Uncertainties in the exposure and risk assessment findings used to support this indicator are evaluated on a site-specific basis but are not rolled-up for a measure of cross-indicator uncertainty. No formal study has been conducted regarding the reproducibility of survey responses.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

The uncertainty and variability could impact the conclusions that can be inferred from the data. However, unless there are systematic biases introduced to the process (e.g., systematic differences in interpretation of questions), the impacts of these factors on the aggregated data and overall conclusions should be minimal. The Superfund and RCRA Corrective Action programs has have implemented guidance and training to minimize the effects of variability and systematic bias.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

In some instances, there may be underlying factors (e.g., the reassessment of the toxicity of a prevalent contaminant of concern at Superfund and high priority RCRA Corrective Action sites) that could cause a data shift, the cause of which would not be evident to the user. The indicator instrument documents reasons for changes in the indicator determination that could be monitored to identify and communicate to the user the effect of exogenous factors on indicator trends. Superfund NPL and RCRA Corrective Action sites are a subset of contaminated lands in the U.S.

Charge to the Peer Reviewers: Human Health and Other Relevant Indicators for the U.S. Environmental Protection Agency's 2007 *Report on the Environment* Technical Document May 20, 2005

The U.S. Environmental Protection Agency (EPA) has asked that independent peer reviewers critically review the indicators that the Agency proposes to use for its 2007 *Report on the Environment*—Technical Document (ROE07 TD). The purpose of this peer review is to ensure that the proposed indicators are appropriate, adequate, and useful for evaluating human health in general; useful for answering the questions posed in ROE07; meet technical requirements (including the indicator definition and criteria); are properly documented; and are scientifically sound. Separate peer reviews will be conducted for the indicators proposed for each of the five main chapters in the ROE07. This charge provides background and instructions for peer review of the *human health* indicators. It includes the following sections and attachments:

- Section 1: Background information on ROE07 TD
- Section 2: Indicator definition and criteria
- Section 3: Charge and materials for the individual pre-workshop review
- Section 4: The peer review meeting
- Attachment 1: Questions and Proposed Indicators for the ROE07 Technical Document
- Attachment 2: Comment Sheet for Group 1 Indicators
- Attachment 3: Comment Sheet for General Questions for Group 1 Indicators
- Attachment 4: Comment Sheet for Group 2 Indicators
- Attachment 5: List of and EPA Rationale for Withdrawn ROE03 Indicators (will be posted by 6/10/05)
- Attachment 6: Indicator Materials for Review (included as subsequent sections of this binder).

Section 1: Background

In 2003, EPA published its first draft *Report on the Environment* (ROE03). ROE03 is a set of two question-driven reports comprising:

- A Technical Document (TD), which provides the scientific foundation for the ROE.
- A shorter Public Document that distills information in the TD for a non-technical audience.

These two reports were intended to identify and present the best available national-level indicators to help answer broad questions about the state of the nation's environment in five topic areas (chapters): air, water, land, human health, and ecological condition. In addition to reporting what we know, the ROE03 was also intended to point out where current data and understanding fall short of fully answering the questions in terms of delivering national, consistent, comprehensive data about the state of the nation's air, water, land, human health, and ecological condition. The ROE03 also presented some contextual information from other scientific sources in order to provide background and explain indicator data gaps.

EPA's Administrator has requested that the generation of Reports on the Environment be continued into the future. Current plans are for future reports to be developed on an approximately 3-year reporting cycle. To support the next anticipated ROE release in 2007, EPA has compiled a set of proposed indicators to help answer the questions posed for the 2007 Technical Document. EPA proposes reporting on both national-level indicators, national-level indicators that are provided at the scale of EPA regions, as well as several region-level indicators. As with ROE03, the questions are organized into five topic areas: air, water, land, human health, and ecological condition. There will be a separate chapter in the ROE07 Technical Document for each topic area. Each chapter will describe the set of questions for the topic area and the indicators that answer those questions.

Many of the indicators proposed for ROE07 were presented in ROE03, but some are new and others have new data sources. In addition, after refining the indicator definition and criteria (see boxes on the following pages), and applying both more consistently to the proposed indicator list, EPA recommends that some indicators from ROE03 not be presented in 2007.

To ensure that the indicators presented in the ROE07 TD are supported by data that are technically sound, meet the established indicator definition and criteria, and help answer the questions posed in the ROE, EPA has contracted with ERG to organize an independent peer review of the proposed ROE07 indicators.

Reviewers for the human health indicators are charged with four tasks:

1) Assess whether the proposed human health indicators are appropriate, adequate, and useful for evaluating and establishing an overall picture of human health.

2) Evaluate the proposed indicators with respect to their importance in terms of their ability to respond to the question.

3) Evaluate the proposed human health and related indicators and their underlying data with respect to the ROE indicator definition and criteria presented below.

4) Identify any additional ***national-level*** human health indicators that currently exist which meet the ROE indicator definition and criteria, help to answer one of the ROE questions, and for which data are readily available such that text and graphics describing the indicator could be developed within a short time frame (approximately 6 weeks).

Section 2: Indicator Definition and Criteria

Each indicator in ROE07 should conform to the following definition.

Definition: Indicator

For purposes of the ROE, an “indicator” is ***a numerical value derived from actual measurements of a pressure, ambient condition, exposure, or human health or ecological condition*** *over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment*. Indicators and their underlying data must meet criteria (see box below) for data quality, comparability, representativeness, and adequate coverage in time and space. Note that indicators rely on an underlying database or set of databases, but the databases themselves are not indicators.

In the above definition, "derived from" means that trends in *actual environmental observations* (e.g., rather than estimates or projections) must serve as the principal driver for trends in the indicators.

EPA has defined six indicator levels, as follows. Note that levels 1 and 2 are administrative indicators that measure progress in implementing environmental programs, and compliance with or response to those programs. They are *not* the subject of ROE07. Levels 3 through 6 indicators reflect environmental results/condition and are the subject of ROE07.

Description of Indicator Levels

Level 1 (Administrative—not covered by ROE07): Government Regulations/Activities. Examples: policy leadership, statutes, regulations, guidance, information.

Level 2 (Administrative—not covered by ROE07): Actions/Responses by Regulated and Non-regulated Parties. Examples: Pollution prevention and control, recycling, changes in consumer behavior, best management practices.

Level 3 (Environmental): Changes in Pressure or Stressor Quantities. Examples: Pollutants entering media, habitats altered or destroyed, hydrologic alteration.

Level 4 (Environmental): Ambient Conditions. Examples: Pollutant concentrations in media, food and drinking water, solid wastes in landfills, radiation; temperature, habitat condition, hydrology.

Level 5 (Environmental): Exposure or Body Burden/Uptake. Examples: Biological markers of uptake in people, plants, animals, or microorganisms.

Level 6 (Environmental): Changes in Human Health or Ecological Condition. Examples: Morbidity, mortality, biotic structure, and ecological processes.

Each indicator in ROE07 should conform to the following criteria:

Indicator Criteria

1) The indicator makes an important contribution to answering a question for the ROE. (In this context, “important” means that the indicator answers a substantial portion of and/or a critical part of the question.)
2) The indicator is objective. It is developed and presented in an accurate, clear, complete, and unbiased manner.
3) The underlying data are characterized by sound collection methodologies, data management systems that protect their integrity, and quality assurance procedures.
4) Data are available to describe changes or trends, and the latest available data are timely.
5) The data are comparable across time and space, and representative of the target population. Trends depicted in this indicator accurately represent the underlying trends in the target population.
6) The indicator is transparent and reproducible. The specific data used and the specific assumptions, analytic methods, and statistical procedures employed are clearly stated.

Section 3: Charge and Materials for the Individual Pre-Workshop Review

Attachment 1 lists all the ***proposed questions*** and ***associated indicators*** for the 2007 ROE by topic area. Pages 10 to 11 list the indicators to be reviewed by human health reviewers. Note that, for review purposes, there are two groups of indicators:

- **Group 1: Proposed Human Health Indicators.** Indicators that are proposed to answer one of the three questions posed in the human health chapter *and* that will be *written up in that chapter*.

- **Group 2: Three Relevant Indicators from Other Chapters.** Each of these indicators is *proposed to answer a question in another chapter* and will be written up in that chapter, but peer-reviewed by human health reviewers since it is related to health.

The materials and instructions for reviewing each group of indicators are described below. Please conduct the review in the sequence indicated. Forms are provided as Attachments 2 through 4 to this charge to structure your review. Attachment 5 provides background for Step 2, below. The materials to be reviewed are provided in Attachment 6.

Step 1: Review Group 1 Indicators

For each indicator in Group 1, Attachment 6 provides:

- *Draft text* introducing the indicator, identifying the underlying data used to evaluate the indicator, and describing data interpretations. EPA proposes including this text in the ROE07 TD.

- *Draft graphic(s)/table(s)* to help readers visualize spatial and temporal trends in the indicator. EPA proposes including these graphics in the ROE07 TD. (Note that some of the indicators also have a brief text describing the method used to compile the EPA regional data.)

- *An information quality review form* that presents detailed background information on the indicator and its supporting data (e.g., data quality, coverage, processing). EPA documents this information for the overall project record and to facilitate peer review of the indicators.

Collectively, these three items should adequately present each indicator and thoroughly document the information that EPA considered when evaluating the indicators for ROE07. For each indicator in this category, you should thoroughly review the draft text, draft graphics/tables, and information quality review forms provided. Then, document your review comments by filling out the "Comment Sheet" in Attachment 2 *for each indicator*.

This sheet asks you a series of questions about each indicator. For questions 1 through 4, you are asked to provide a numerical response on a scale of 1 to 4 and then a written explanation of the rationale for your numerical response. Question 5 asks about graphical presentation and question 6 asks you to provide any other comments, concerns, or suggestions about the indicator that you did not already cover in your responses to Questions 1 through 5. Question 7 asks you to state whether you think the indicator merits inclusion in ROE07.

Step 2: Consider General Questions for Group 1 Indicators

After completing your reviews for the individual Group 1 indicators, as described above, please use Attachment 3 to answer the following two questions for these indicators:

- **General Question 1:** Considering the Group 1 indicators collectively, do any of these indicators clearly seem to be more appropriate, adequate, or useful for evaluating and/or establishing an overall picture human health than others? Do any seem to be more important than the others for answering the question they are intended to answer? Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators or if it covers an area of diminishing interest environmentally.

- **General Question 2:** Are there any additional *national-level* indicators that currently exist, but were not proposed for ROE07, that you would recommend for ROE07? Proposed indicators should meet the ROE indicator definition and criteria, be national in scale, make an important contribution to answering one of the ROE questions in your topic area, be of a quality that likely would pass this type of peer review, and have data that are readily available (e.g., could be compiled within 6 weeks or less). For any new indicators proposed, provide detailed justification for their inclusion and list references or citations for the associated underlying data sources. As you consider this question, please read Attachment 5, which provides the list of human health and other indicators presented in ROE03 that EPA does not intend to carry forward to ROE07, along with EPA's rationale for withdrawing them. If you disagree with EPA's rationale and feel any of these indicators should be included in ROE07, please so indicate in your response to this question, along with your rationale for why they should be included. Note: The full text and graphics for the ROE03 indicators can be viewed on-line at: http://www.epa.gov/indicators/roe/html/tsd/tsdHealth.htm

Step 3: Review Group 2 Indicators

Group 2 indicators are indicators that are *proposed to answer a question in another chapter* and will be written up in that chapter, but peer-reviewed by human health reviewers since they are related to human health. You are asked to review the three Group 2 indicators in the same way you reviewed Group 1 indicators under Step 1. For each Group 2 indicator, Attachment 6 provides:

- *Draft text* introducing the indicator, identifying the underlying data used to evaluate the indicator, and describing data interpretations.

- *Draft graphic(s)/table(s)* to help readers visualize spatial and temporal trends in the indicator.

- *An information quality review form* that presents detailed background information on the indicator and its supporting data (e.g., data quality, coverage, processing).

Collectively, these three items should adequately present the indicator and thoroughly document the information that EPA considered when evaluating the indicator for ROE07. For each indicator, you should thoroughly review the draft text, draft graphics/tables, and information quality review form provided in Attachment 6. Then, document your review comments by filling out the "Comment Sheet" in Attachment 4 *for each indicator*.

Preparing for the Peer Review Workshop

After receiving the reviewers' pre-meeting comments, ERG will compile these comments and distribute them to all peer reviewers. Please familiarize yourself with the pre-meeting comments of the other human health peer reviewers prior to the peer review workshop.

Note that the pre-meeting comments are preliminary in nature and are intended to help initiate discussion at the peer review meeting. Reviewers may change their comments based on discussion at the peer review meeting.

Section 4: The Peer Review Meeting

Most of the peer review meeting will take place with the peer reviewers split into breakout groups by topic area. Within each group, reviewers will consider the same questions they answered individually in their pre-meeting comments:

- Reviewers will discuss the merits of the individual Group 1 and Group 2 indicators based on responses provided on the "Comment Sheets" and, where possible, agree on a composite score for each indicator.

- Then, considering the Group 1 indicators collectively, reviewers will identify any indicators that clearly do not seem to be on the same level of importance as the other indicators.

- Finally, reviewers will discuss and, where possible, reach agreement on any possible other national-level indicators they believe EPA should consider for the ROE07 TD.

ERG will prepare a summary report of the discussions at the peer review workshop. This report will document the peer reviewers' final conclusions and recommendations regarding the indicators for ROE07 TD. You will have a chance to check ERG's draft report of the meeting for accuracy and completeness before it is finalized.

Attachment 1:

Questions and Proposed Indicators for the ROE07 Technical Document

Attachment 2: Comment Sheet for Group 1 Indicators

Please fill out a separate sheet for each Group 1 indicator.

Your Name: ______________________________
Topic Area: **Human Health**
Indicator Name: ______________________________

1) Please indicate the extent to which you think the proposed indicator is appropriate, adequate, and useful (AA&U) for evaluating human health and for contributing to an overall picture of human health.

1	2	3	4
Indicator is not AA&U	Indicator is of somewhat AA&U	Indicator is largely AA&U	Indicator is completely AA&U

Comments:

2) Please indicate the extent to which you think the proposed indicator makes an important contribution to answering the specific ROE question it is intended to answer (see Attachment 1 for list of questions). (Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators, or if it covers an area of less or diminishing importance environmentally.)

1	2	3	4
Indicator is not important	Indicator is of minor importance	Indicator is important	Indicator is critical

Comments:

3) To what extent do you think the indicator meets the following indicator definition:

An "indicator" is ***a numerical value derived from actual measurements of a pressure, ambient condition, exposure, or human health or ecological condition*** *over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment*.

1	2	3	4
Doesn't meet the definition	Only partly meets the definition	Largely meets the definition	Fully meets the definition

Please explain:

4) To what extent do you think the indicator meets each of the following indicator criteria:

a) The indicator makes an important contribution to answering a question for the ROE. (In this context, "important" means that the indicator answers a substantial portion of and/or a critical part of the question.)

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

b) The indicator is objective. It is developed and presented in an accurate, clear, complete, and unbiased manner.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

c) The underlying data are characterized by sound collection methodologies, data management systems that protect its integrity, and quality assurance procedures.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

d) Data are available to describe changes or trends, and the latest available data are timely.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

e) The data are comparable across time and space, and representative[1] of the target population. Trends depicted in this indicator accurately represent the underlying trends in the target population.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

f) The indicator is transparent and reproducible. The specific data used and the specific assumptions, analytic methods, and statistical procedures employed are clearly stated.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

Please explain:

[1] An indicator seeks to describe trends in an overall target "population" (e.g., land area, type of surface water, type of emissions, U.S. population), yet data often can only be sampled from a subset of this population. The validity of the trends described by the indicator will depend on the degree to which the sampled population is representative of the target population.

5) Do you have any suggestions for more effective graphic presentation of the data? If yes, please describe.

6) Please provide any additional comments, suggestions, or concerns regarding the indicator that you have not already noted in Questions 1 through 5. In particular, note any limitations to the indicator that you have not already described in your responses to the preceding questions.

7) Overall, this indicator:

_____ Should be included in ROE07 TD.

_____ Should be included in ROE07 TD with the modifications identified above.

_____ Should *not* be included in ROE07 TD.

Attachment 3: Comment Sheet for General Questions for Group 1 Indicators

Your Name: ________________________________
Topic Area: **Human Health**

1) Considering the Group 1 indicators *collectively*, do any of these indicators clearly seem to be more appropriate, adequate, or useful for evaluating human health and/or for contributing to an overall picture of human health than others? Do any seem to be more important than the others for answering the question(s) they are intended to answer? (Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators or if it covers an area of diminishing interest environmentally.)

2) Are there any additional *national-level* indicators that make an important contribution to answering one of the ROE questions in your topic area, but were not proposed for ROE07, that you would recommend? (Proposed indicators should meet the ROE indicator definition and criteria, be national in scale, be of a quality that likely would pass this type of peer review, and have data that are readily available. For any new indicators proposed, provide justification for their inclusion and list references or citations for the associated underlying data sources.)

   As you consider this question, ***please read Attachment 5***, which provides the list of human health and other indicators presented in ROE03 that EPA does not intend to carry forward to ROE07, along with EPA's rationale for withdrawing them. If you disagree with EPA's rationale and feel any of these indicators should be included in ROE07, please so indicate in your response to this question, along with your rationale for why they should be included. Note: The full text and graphics for the ROE03 indicators can be viewed on-line at: http://www.epa.gov/indicators/roe/html/tsd/tsdHealth.htm

Attachment 4: Comment Sheet for Group 2 Indicators

Please fill out a separate sheet for each Group 2 indicator.

Your Name: ______________________________
Topic Area (circle one): Air or Land
Indicator Name: ____

1) To what extent do you think the indicator meets the following <u>indicator definition</u>:

An "indicator" is ***a numerical value derived from actual measurements of a pressure, ambient condition, exposure, or human health or ecological condition*** *over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment*.

1	2	3	4
Doesn't meet the definition	Only partly meets the definition	Largely meets the definition	Fully meets the definition

Please explain:

2) To what extent do you think the indicator meets each of the following <u>indicator criteria</u>:

a) The indicator makes an important contribution to answering a question for the ROE. (In this context, "important" means that the indicator answers a substantial portion of and/or a critical part of the question.)

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

b) The indicator is objective. It is developed and presented in an accurate, clear, complete, and unbiased manner.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

c) The underlying data are characterized by sound collection methodologies, data management systems that protect its integrity, and quality assurance procedures.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

d) Data are available to describe changes or trends, and the latest available data are timely.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

e) The data are comparable across time and space, and representative[2] of the target population. Trends depicted in this indicator accurately represent the underlying trends in the target population.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

f) The indicator is transparent and reproducible. The specific data used and the specific assumptions, analytic methods, and statistical procedures employed are clearly stated.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

Please explain:

[2] An indicator seeks to describe trends in an overall target "population" (e.g., land area, type of surface water, type of emissions, U.S. population), yet data often can only be sampled from a subset of this population. The validity of the trends described by the indicator will depend on the degree to which the sampled population is representative of the target population.

3) Do you have any suggestions for more effective graphic presentation of the data?
If yes, please describe.

4) Please provide any additional comments, suggestions, or concerns regarding the indicator that you have not already noted in Questions 1 through 3. In particular, note any limitations to the indicator that you have not already described in your responses to the preceding questions.

5) Overall, this indicator:

_____ Should be included in ROE07 TD.

_____ Should be included in ROE07 TD with the modifications identified above.

_____ Should *not* be included in ROE07 TD.

Attachment 5: List of and EPA Rationale for Withdrawn ROE03 Indicators

Background:
A number of indicators were included in EPA's 2003 Draft Report on the Environment (DROE03) that are not proposed to be included in ROE07. The general reasons for these changes are described below, followed by indicator-specific explanations.

> EPA's Science Advisory Board Committee review of the DROE03 recommended EPA develop and utilize a more precise definition of "indicator" than was used for DROE03.
>
> EPA developed a set of specific indicator criteria to provide a more precise conformance to Office of Management and Budget (OMB) and EPA Information Quality Guidelines.
>
> The ROE07 introduced a Regional Pilot Project and developed and implemented a relevant process. Sub-national or regional indicators that were included in DROE03 but did not go through this pilot are not recommended to be included in ROE07.

When screened against these factors, the ROE07 development team identified a small number of the indicators in DROE03 that did not appear to conform to one or more of these requirements. A group decision was made that developing indicator write-ups, quality forms, and graphics for these indicators was not the best use of team resources. Broadly speaking, the rationales for withdrawal fall into four categories, coded as follows:

> **(D) Definition** – The indicator fails to meet the improved indicator definition for ROE07 (most often because the indicator was a level 1 or 2 indicator, rather than a level 3, 4, 5, or 6 indicator).
>
> **(C) Criteria** – The indicator fails to meet one of the six indicator criteria that were established to conform with EPA Information Quality Guidelines.
>
> **(N) New indicator** – The indicator is replaced by a "new" and superior indicator that was not available for the DROE03.
>
> **(R) Regional –** The indicator is not national in scope and is not part of the ROE07 EPA Regional Pilot Project.

The following information briefly explains the rationale for excluding specific indicators from development for the ROE07 Indicator Peer Review. Each indicator is categorized as D, C, N, or R. The indicators are organized by general peer review topic.

Air

Production of Ozone Depleting Substances - C

This DROE03 indicator presents estimates of the amount of ODSs produced worldwide in 1986 and 1999, and annual U.S. production from 1958 to 1993. This indicator is being withdrawn because of issues concerning data reliability and relevance. Global ODC production data are not reliable with respect to comparability among reporting countries. The US estimates are more reliable because of legal reporting requirements and the small number of sources. However, the data set fails to account for imports, and annual production is not a good surrogate for emissions of ODCs into the environment because of the time between production and eventual entry into the environment is highly variable among the various products and recovery systems.

Number of People Living in Counties with Ambient Air Concentrations Above the NAAQS - C

This DROE03 indicator conveyed how many people (based on census) lived in counties where air pollutant levels at times were above the level of the NAAQS during the year stated. It was intended to give the reader some indication of the number of people potentially exposed to unhealthy air. Because of changing populations and air quality standards, however, this indicator masks actual trends in the levels of air pollutants. It is not a valid exposure indicator because it is not based on measurement of an actual marker of exposure measured on individuals.

Percent of Population Living in Homes Where Someone Smokes Regularly Inside the Home - D

This DROE indicator portrayed the percentage of homes in the U.S. in which young children were exposed to tobacco smoke in 1998 versus 1957. The survey is based on a questionnaire (do children live in the home, and does someone who smokes regularly live in the home), rather than on actual measurements of the amount of smoke actually present or the degree to which children are exposed to the resulting smoke. This indicator violates the ROE indicator definition, requiring that indicators be based on actual measurements, and blood cotenine (Indicator 102) provides a better indicator of children’s exposure to smoke.

Water

Altered Fresh Water Ecosystems – C
Percent Urban Land Cover in Riparian Areas – C
Agricultural Lands in Riparian Areas - C

These DROE03 indicators are based on the percentage of land within 30 m of the edge of a stream or lake that is classified as urban or agriculture based on 1991 satellite data (NLCD). Baseline data are incomplete, and there are no reference points for the appropriate percentage of such cover, and it is not clear that the indicators could be reproduced with newer satellite data. There are no data for other alterations such as damming, channelization, etc.

Number of Watersheds Exceeding Criteria for Mercury, PCBs, & Dioxin – C

This DROE03 indicator is based on voluntary reporting of Hg contamination using data that has not undergone formal QA/QC review. It is not representative of the nation, or suitable for trend monitoring.

Lake Trophic State Index – R, C

This DROE03 indicator is based on phosphorous data collected in a one-time a statistical sample of lakes in the Northeast US during 1991-94. It is not included in the ROE07 Regional Pilot Project.

Sedimentation Index – R, C

This DROE03 indicator is based on data collected on freshwater streams in the Mid Atlantic Highlands Region during a one-time 1993-94 statistical survey. It is not included in the ROE07 Regional Pilot Project.

Contaminants in Fresh Water Fish (NAWQA) – C

This DROE03 indicator is based on reported concentrations of contaminants in fish collected by the US Geological Survey NAWQA program. While the data are collected from a large number of streams and are of high and consistent quality, the sample is not statistically representative of the nation, there are no national guidelines to serve as reference values for tissue concentrations, and Cycle II of NAWQA will not include comparable routine monitoring of trace organics and trace elements in fish tissues at sampling sites across the Nation.

Fish Index of Biotic Integrity – R, C

This DROE03 indicator is based on fish community data collected on freshwater fish in the Mid Atlantic Highlands Region during a one-time1993-96 statistical survey. Condition cannot be assessed in streams where no fish were caught, because data were insufficient to indicate whether the stream had poor quality or simply no fish. It is not included in the ROE07 Regional Pilot Project.

Macroinvertebrate IBI (MAIA) – R, C

This DROE03 indicator is based on benthic macroinvertebrate community data collected in freshwater streams in the Mid Atlantic Highlands Region during a one-time 1993-96 statistical survey. It is not included in the ROE07 Regional Pilot Project.

Beach Days Open – D

Waters with Fish Consumption Advisories - D

These DROE03 indicators are based on the frequency of beach closures or fish consumption advisories as reported to EPA voluntarilyby states and local government organizations. The data are not nationally or temporally consistent because of different and changing criteria for closing beaches or issuing fish consumption advisories in the different states, many of which do not involve actual water quality measurements. They are therefore level 1 indicators and fail to meet the definition for ROE indicators.

Contaminated Sediments in Fresh Water - C

This DROE03 indicator is based on reported concentrations of sediment contaminants collected by a large number of organizations focusing particularly on places where sediment contamination is perceived to be a problem (the EPA National Sediment Inventory). The database suffers from a number of limitations: the data are heavily biased toward sites at which there is a known or suspected toxicity problem and to particular geographic areas (non-representative of the nation), the data cover different dates in different locations- making estimation of trends difficult, and the data and procedures used to assign sites to a toxicity category are not uniform from watershed to watershed. It is unsuitable for trend estimation.

Chemical Contamination in Streams and Groundwater – C

This DROE03 indicator is based on data from a large number of NAWQA watersheds. The sampling and analytical protocols (including the analytes measured) are not comparable across all NAWQA watersheds.

Nitrate in Farmland, Forested and Urban Streams and Groundwater
Phosphorus in Farmland, Forested, and Urban Streams – N

These DROE03 indicators are being replaced by two new indicators, "Nitrate, Phosphorus, and Pesticides in Streams in Agricultural Watersheds" and "Nitrate and Pesticides in Groundwater in Agricultural Watersheds." The NAWQA streams in forested and urban watersheds were based on a small sample size, and may not be representative of forested and urban streams in general.

Phosphorus in Large Rivers - C

The indicator is based on phosphorus concentrations in large rivers sampled periodically by the USGS National Stream Quality Accounting Network (NASQAN). Monitoring at many of the large river NASQAN sites has been discontinued.

Chemicals

Sediment Runoff Potential from Croplands and Pasturelands - C

This DROE03 indicator represents the estimated sediment runoff potential for croplands and pasturelands based on topography, weather patterns, soil characteristics, and land-use land cover and cropping patterns for the U.S. and the Universal Soil Loss equation www.brc.tamus.edu/swat. The indicator addresses "potential" and not actual/current condition, and relies on a model to predict ambient characteristics (level 4 indicators) based on level 3 measurements, which violates a fundamental ROE protocol on the use of models in indicators. Trends in this indicator would likely be associated only with trends in land cover, cropping practices, and weather (topography and soil type are unlikely to change). No reliable spatial trend data at the appropriate scale exist for either cropping practices or land cover, and consequently trends in this indicator would be difficult to calculate.

Potential Pesticide Runoff from Fields - C
Pesticide Leaching Potential - C

These DROE03 indicators represent the potential movement of agricultural pesticides from the site of application to ground and surface waters, based on estimates of pesticide leaching and runoff losses derived from soil properties, field characteristics, management practices, pesticide properties, and climate for 243 pesticides applied to 120 specific soils in growing 13 major agronomic crops. The indicators address "potential" and not actual/current condition, and rely on models to predict ambient characteristics (level 4 indicators) based on level 3 measurements, which violates a fundamental ROE protocol on the use of models in indicators.

Risk of Nitrogen Export - C
Risk of Phosphorus Export - C

These DROE03 indicators represent the potential movement of N and P from the site of application to surface waters, based on a large empirical dataset relating land use to N and P observed in receiving streams over several decades at a variety of locations. The indicators address "potential" and not actual/current conditions, and rely on statistical models to predict ambient characteristics (level 4 indicators) based on level 3 measurements, which violates a fundamental ROE protocol on the use of models in indicators.

Pesticide Use - C

Agricultural pesticide usage data, measured at the national aggregate level for all pesticides is very difficult to interpret, given the wide year to year changes in the types of pests being controlled for and changes in agricultural production/chemical usage from year to year. From one time period to another the mix of pesticides changes, pest pressures change, agricultural practices change, agricultural acreage changes, regulatory status of key uses changes, and many other important variables change. Moreover, the effects of pesticide usage are encountered at three levels of the product's life cycle: production, usage, and residues on foods. The geographic distribution of those effects renders difficult the interpretation of national usage levels for all pesticides, taken as a group. While it is of course possible to compare magnitudes of aggregates at different times, the real significance for the environment is in the differences in the content and geographic distribution of the aggregates, not in the magnitude of the aggregate.

Contaminated Lands

Number and Location of Superfund NPL Sites - D

This DROE03 indicator is a category 1 indicator (it represents an administrative decision to force a cleanup, rather than an amount of waste present or removed), and therefore does not meet the ROE07 indicator definition.

Number of RCRA Corrective Action Sites - D

This DROE03 indicator, by itself, is a category 1 indicator (it represents an administrative decision to force a cleanup, rather than an amount of waste present or removed), and therefore does not meet the ROE07 indicator definition. The data are being combined into a new indicator, Quantity of RCRA Hazardous Waste Generated and Managed (which combines information from several DROE03 indicators).

Radioactive Waste Storage and Disposal - C

This DROE03 indicator is based on production and inventory data collected by the Department of Energy. Although the data continue to be collected, they are no longer publicly available post-September 11, 2001; therefore ongoing data trends are not and will not in the future be available for this indicator. Moreover, the earlier data reflected two distinct periods in the history of waste generation in the nuclear weapons complex. The first reflected a period during which wastes and other materials were being generated as an integral part of the production of weapons grade nuclear materials and components. The period after 1989 reflected the cessation of large-scale production of such materials and the initiation of clean-up activities and wastes from those initiatives. Thus, even before the truncation of data in the post 9/11 period, there were significant issues with the comparability of the data over time.

Human Health

Cardiovascular Disease Prevalence - C

This DROE03 indicator was based on data from NHANES III (1988-1994). Currently, no national trend data are available on cardiovascular disease (CVD) prevalence.

Blood VOC – C

This DROE03 indicator was based on a convenience sample whose representativeness cannot be determined or necessarily used as a baseline for future sampling. The indicator is based on detects only, so there is no reference level, and VOCs are cleared from the bloodstream rapidly (~ 1hr), so there is a significant possibility of false negatives, considering that exposures tends to be associated with occupational and indoor settings.

Urinary Arsenic - R
This DROE03 indicator was based on data from EPA Region 5 only, and is not part of the ROE07 Regional Pilot.

Ecological Condition

The Farmland Landscape - C
This DROE03 indicator represents croplands and the forests or woodlots, wetlands, grasslands and shrublands, that surround or are intermingled with them, and the degree to which croplands dominate the landscape http://www.heinzctr.org/ecosystems/farm/lndscps.shtml. The indicator relies on data generated using early 1990's satellite data, and it is unclear whether the definition of "farmland landscape" is sufficiently precise to be replicated independently, especially with respect to any future satellite data availability.

Extent of Estuaries and Coastline – C
This DROE03 indicator is based on remote sensing data, but is unlikely to show trends unrelated to sea level rise and changing tides, so it is not a very useful indicator for trends.

Coastal Living Habitats - C
This DROE03 indicator is based on remote sensing data of coastal wetlands, mudflats, sea-grass beds, etc., but the only system for which a national indicator has been developed is coastal vegetated wetlands, which already is covered in another indicator.

Shoreline Types - C
This DROE03 indicator is based on NOAA's Environmental Sensitivity Index. The index is based on a standardized mapping approach, but coverage is not complete for large parts of the coastline and the data in some of the atlases are more than 15 years old. Consequently, this indicator is not appropriate for measurement of representative, national trends.

Extent of Ponds, Lakes, and Reservoirs – C
This DROE03 indicator is based on data from the USGS National Wetlands Inventory. While these data are based on a valid statistical sampling design, the total amount of surface water is less than half of the area of lakes, reservoirs and ponds greater than 6 acres in size in the USGS National Hydrography Data Set. Until this discrepancy is resolved, the indicator may not satisfy the ROE criteria.

At-Risk Native Species – C
At-Risk Native Grassland and Shrubland Species – C
At-Risk Native Forest Species – C
Populations of Representative Forest Species – C
Non-Native Fresh Water Species – C
At-Risk Fresh Water Plant Communities – C
The Ecological Condition chapter is being restructured from the DROE03 organization per the recommendation of EPA's Science Advisory Board and numerous stakeholders. As such, the chapter

no longer requires that the above indicators be broken out by ecosystem. In addition, the ability to track trends of many of these indicators is currently in question.

Population of Invasive and Non-invasive Bird Species – R
This DROE03 indicator is based on an analysis of USGS Breeding Bird Survey data in grassland and shrubland ecosystems for 5 year periods ranging from the late 1960s to 2000. Because the ecological condition questions are no longer directed at specific ecosystems types, this appears to be a regional indicator. It is not clear at this time that this indicator will be updated.

Bird Community Index – R
This DROE03 indicator is not national in scope or part of the ROE EPA Regional Pilot.

Fish Diversity – R
This DROE03 indicator is based on a statistical sample of fish trawls in Mid-Atlantic estuaries during 1997-98. This indicator is not part of the ROE07 Regional Pilot project, and EMAP is no longer collecting fish samples to support this indicator.

Fish Abnormalities - C
This DROE03 indicator is based on a statistical sample of fish trawls in estuaries in the Atlantic and Gulf, but the data are no longer being collected by EMAP to support this indicator.

Unusual Marine Mortalities – C
This DROE03 indicator is based on voluntary reporting of unusual mortality events to NOAA. Because there is no systematic requirement to report, these data are not suitable to support national trends in the indicator.

Animal Deaths and Deformities – C
This DROE03 indicator is based on data reported by a number of different organizations to USGS on incidences of death or deformities in waterfowl, fish, amphibians, and mammals. Trends are available only for waterfowl, and because data reporting is voluntary rather than systematic, the data are not adequate to determine actual trends versus trends in reporting.

Tree Condition – C
This DROE03 indicator is based on an ongoing statistical sample of forests across the conterminous US and comprises components that relate to crown (tree canopy condition), the ratio of dead to live wood, and the fire class. This indicator likely relates more to forest management practices than to environmental condition, and for this reason has low relevance value to EPA.

Processes Beyond the Range of Historic Variation – C
This DROE03 indicator is based on an analysis of recent Forest Inventory and Analysis data on climate events, fire frequency, and forest insect and disease outbreaks, which were then compared to anecdotal data for the period 1800-1850. Because the early data are anecdotal, and because the data mostly relate to forest management practices, etc., it is proposed that this indicator has low relevance and that trend data are of questionable utility as an ROE indicator.

Soil Compaction – C
Soil Erosion – C
These DROE03 indicator are based on an ongoing statistical sample of soils in forests across the conterminous US, but the actual indicators are based on models rather than measurement, and they likely relate more to forest management practices than to environmental condition, and for this reason have low relevance value to EPA.

Soil Quality Index - R

This DROE03 indicator was based on a survey of soils in the Mid Atlantic region during the 1990s, and was neither repeated and is not part of the Regional Pilot Project for ROE07.

Chemical Contamination – C

This DROE03 indicator combines data from the USGS NAWQA program that are not consistent in terms of sampling frequency or analytical protocols.

Attachment 6: Indicator Materials for Review

NOTE: ATTACHMENT 6 COMPRISES THE SUBSEQUENT SECTIONS OF THIS BINDER

Indicator: General Mortality (211)

Overall mortality is a key measure of health in a population. Ranking the causes of death can provide a description of the relative burden of cause-specific mortality (Anderson and Smith, 2003).

This indicator is based on mortality data recorded in the National Vital Statistics System (NVSS) which registers virtually all deaths nationwide. The temporal coverage of the data is from 1933 to present and data are collected from all 50 States and the District of Columbia.

What the Data Show

As noted in ROE03, an increase in the number of deaths in the United States has been observed over the last few decades, reflecting the increase in the size and aging of the population. This trend continued in 2001 and 2002 where 2,416,425 and 2,443,387 deaths, respectively, were recorded, an increase compared to 1999 (2,391,399 deaths). However, the age-adjusted all cause mortality rates have declined yearly since 1980 (except in years of influenza outbreaks in 1983,1985, 1988, 1993, and 1999) with the most recent available rate of 845.3 deaths per 100,000 people in 2002 (NCHS, 2004). Figure 211-1 provides some historical perspective on trends in the age-adjusted mortality rates between 1940 and 2000. The figure shows that age-adjusted rates were nearly twice as high in 1940 as they were in 2000.

The rank order of the leading causes of death was the same in 2001 and 2002 as reported in 1999 in ROE03. Figure 211-2 presents the leading causes of mortality in 2002. The three leading causes of death were heart disease, cancer, and stroke, accounting for about 60% of all deaths.

Indicator Limitations

- Ranking causes of deaths is a somewhat arbitrary procedure. Rankings only represent the causes of death that occur more frequently among eligible causes to be ranked. Thus, rankings of cause-specific mortality could change depending on the defined list of causes that are considered (Anderson and Smith, 2003).

Data Sources

Centers for Disease Control and Prevention (CDC), National Center for Injury Prevention and Control. WISQARS Leading Causes of Death Reports, 1999–2001. http://webapp.cdc.gov/sasweb/ncipc/leadcaus.html.

CDC. WONDER Compressed Mortality 1999–2001 with ICD-10 Codes. http://wonder.cdc.gov/mortICD10J.html.

National Center for Health Statistics (NCHS). 2004. Deaths Final Data 2002. National Vital Statistics Reports: Volume 53 (5). Available at: http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf.

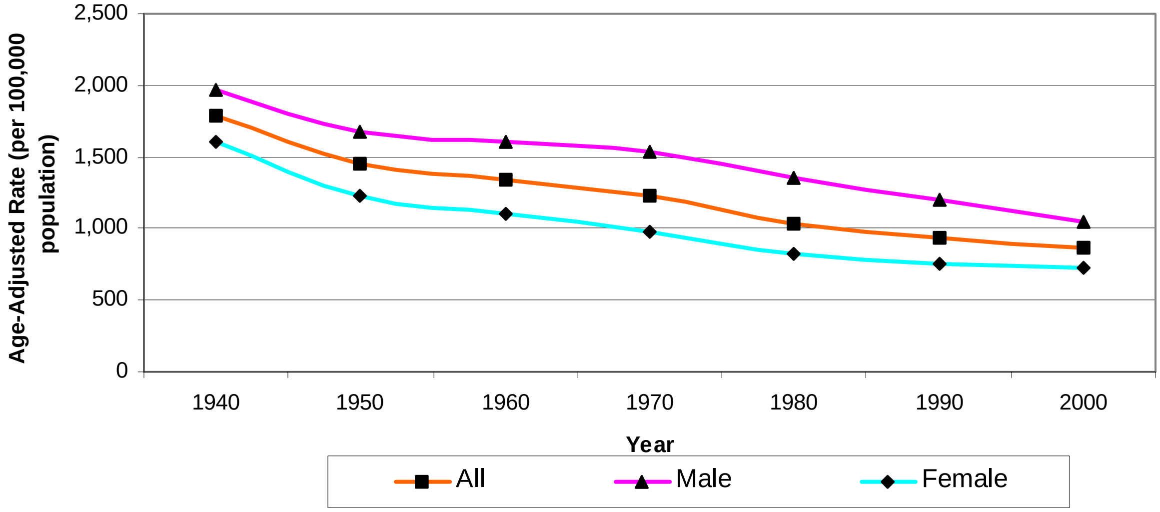
Anderson and Smith. 2003. National Vital Statistics Report (NVSR). Deaths: Leading Causes for 2001. Volume 52 (9). November 7, 2003. http://www.cdc.gov/nchs/data/nvsr/nvsr52/nvsr52_09.pdf (Alternate data source).

References

Anderson and Smith. 2003. National Vital Statistics Report (NVSR). Deaths: Leading Causes for 2001. Volume 52 (9). November 7, 2003. http://www.cdc.gov/nchs/data/nvsr/nvsr52/nvsr52_09.pdf

Graphics

Figure 211-1: National Trends in "All Cause" Mortality Rates Between 1940 and 2000



Source: NCHS. National Vital Statistics Reports, Vol. 53, No. 5, October 12, 2004. Table 1.
http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf

Figure 211-2. Leading Causes of Death in the United States, 2002

Cause of Death	Number of Deaths	Percentages
Heart Disease	696,947	28.5
Cancer (Malignant Neoplasms)	557,271	22.8
Stroke (Cerebrovascular)	162,672	6.7
Chronic Lower Respiratory Diseases	124,816	5.1
Accidents (Unintentional Injuries)	106,742	4.4
Diabetes Mellitus	73,249	3.0
Influenza and Pneumonia	65,681	2.7
Alzheimer's Disease	58,866	2.4
Nephritis, Nephritic Syndrome	40,974	1.7
Septicemia	33,865	1.4
All Other Causes	522,304	21.3

Source: National Center For Health Statistics (NCHS). 2004. Deaths Final Data 2002. National Vital Statistics Vol. 53 No. 5. http://www.cdc.gov/nchs/data/nvsr53/nvsr53_05.pdf. See Table C .

R.O.E. Indicator QA/QC

Data Set Name: GENERAL MORTALITY
Indicator Number: 211 (89105)
Data Set Source: CDC, NCHS
Data Collection Date: UNKNOWN
Data Collection Frequency: 1 yr.
Data Set Description: General Mortality
Primary ROE Question: What are the trends in health status in the U.S.?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

The National Vital Statistics System (NVSS) is the oldest and most successful example of inter-governmental data sharing in Public Health and the shared relationships, standards, and procedures form the mechanism by which NCHS collects and disseminates the Nation's official vital statistics. The methodology for collecting vital statistics is standardized and outlined in "Model State Vital Statistics Act and Regulations" Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf)

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The National Vital Statistics System is responsible for the Nation s official vital statistics. These vital statistics are provided through State-operated registration systems. Standard forms for the collection of data and model procedures for the uniform registration of the events are developed and recommended for State use through cooperative activities of the States and the NCHS (http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf). U.S. Standard Death Certificates are revised periodically. Most state certificates conform closely in content and arrangement to the standard certificate recommended by NCHS and all certificates contain a minimum data set specified by NCHS. Demographic information on the death certificate is provided by the funeral director based on information supplied by an informant. A physician, medical examiner, or coroner provides medical certification of cause of death.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The data collected by NVSS are routinely referenced and used in epidemiological studies.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Virtually all deaths are registered with the NVSS nationwide. The temporal coverage of the data is from 1933 to present. Data are collected from all 50 States including the District of Columbia.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The data set has nationwide death reporting, including sensitive populations.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Not applicable

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The sampling and quality assurance information can be found in "Model State Vital Statistics Act and Regulations" Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf). Documentation is also available at http://wonder.cdc.gov/wonder/help/mort.html Data in Table HH1 extracted from: Centers for Disease Control and Prevention (CDC), National Center for Injury Prevention and Control. WISQARS Leading Causes of Death Reports, 1999-2001. http://webapp.cdc.gov/sasweb/ncipc/leadcaus.html. CDC. WONDER Compressed Mortality 1999-2001 with ICD-10 Codes. http://wonder.cdc.gov/mortICD10J.html. Alternate Source: Anderson and Smith. 2003. National Vital Statistics Report (NVSR). Deaths: Leading Causes for 2001. Volume 52, Number 9. November 7, 2003. http://www.cdc.gov/nchs/data/nvsr/nvsr52/nvsr52_09.pdf National Center for Health Statistics (NCHS). 2004. Deaths Final Data 2002. National Vital Statistics vol 53 no. 5 http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The data can be accessed up to the county level through the electronic data warehouse for CDC at http://wonder.cdc.gov. Individual level data are not available due to confidentiality issues.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. Virtually all deaths from the 50 states, including District of Columbia, submit mortality data to the NVSS at NCHS. The recommended certificate of death is posted at http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf. The documentation for the mortality data set is http://wonder.cdc.gov/wonder/help/mort.html.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

See answer to T3Q1

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Not applicable

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Not applicable

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not applicable

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The mortality data on the Compressed Mortality File at http://wonder.cdc.gov/mortSQL.html are based on records for all deaths occurring in the fifty states and the District of Columbia. Deaths to foreign residents are excluded. Deaths to residents who died abroad are not included on this file. For purposes of comparison, it should be noted that mortality rates reported by NCHS reports differ slightly from those rates reported by CDC WONDER. NCHS uses U.S. Census Bureau population estimates for all age groups; CDC WONDER uses birth certificate data for the Under 1 Year age group and uses U.S. Census Bureau population estimates for all other age groups. The following was noted by Anderson and Smith (2003): "Ranking causes of death is to some extent an arbitrary procedure. The rank order of any particular cause of death will depend on the list of causes from which selection is made and on the rules applied in making the selection. Different cause lists and different ranking rules will typically produce different leading causes of death." The International Classification of Diseases 9th Revision (ICD 9) codes are used to specify underlying cause of death for years 1979 - 1998. Beginning in 1999, cause of death is specified with the International Classification of Diseases 10th Revision (ICD 10) codes. The two revisions differ substantially, and to prevent confusion about the significance of any specific disease code, data queries are separate.

Indicator: Infant Mortality (090)

Infant mortality is a particularly useful measure of health status because it indicates both current health status of the population and predicts the health of the next generation (NCHS, 2001). Infant mortality in the United States is defined as the death of a child before the age of 1 year.

This indicator presents infant mortality for the U.S. based on mortality data from the National Vital Statistics System (NVSS). The NVSS registers virtually all deaths and births nationwide with data coverage from 1933 to present and from all 50 States and the District of Columbia.

What the Data Show

In 2001 and 2002, a total of 27,568 and 28,034 deaths, respectively, occurred in infants under 1 year of age. As reported in ROE03, the infant mortality rate in 1999 was 7.1 per 1,000 live births, the lowest ever recorded in the U.S. (Hoyert, et al., 2001). This trend continued in 2001 with an infant mortality rate of 6.8 per 1,000 live births. However, data for 2002 suggest a slight increase in the infant mortality rate, reported as 7.0 per 1,000 live births (NCHS, 2004). Figure 090-1 presents the national trends in infant mortality between 1940 and 2000. A striking decline has occurred during this time period with overall infant mortality rates dropping from nearly 50 deaths per 1,000 live births in 1940 to just under seven deaths per 1,000 live births in 2000. Males generally had higher rates than females, although this gap has been decreasing over time.

The infant mortality rate for African Americans decreased from 14.6 per 1,000 live births in 1999 (Hoyert, et al., 2001) to 14.4 per 1,000 live births in 2002 (NCHS, 2004). However, this is still twice the rate compared to White infants, which ranged from 5.7-5.8 per 1,000 live births between 1999 and 2002. Reported mortality rates for Hispanic infants are 5.8 and 5.5 per 1,000 live births in 1999 and 2001, respectively (Hoyert, et al., 2001; Anderson and Smith, 2003).

In the U.S. in 2002, the 10 leading causes of infant mortality accounted for about 68% of all infant deaths with the subgroup consisting of congenital malformations, deformations, and chromosomal abnormalities having the highest rate at 1.40 per 1,000 live births (Figure 090-2). This category alone accounts for approximately 20% of all infant deaths in 2002.

Indicator Limitations

- Ranking causes of deaths is a somewhat arbitrary procedure. Rankings only represent the causes of death that occur more frequently among eligible causes to be ranked. Thus, rankings of cause-specific mortality could change depending on the defined list of causes that are considered (Anderson and Smith, 2003).

Data Sources

Centers for Disease Control and Prevention (CDC), National Center for Injury Prevention and Control. WISQARS Leading Causes of Death Reports, 1999–2001. http://webapp.cdc.gov/sasweb/ncipc/leadcaus.html.

CDC. WONDER Compressed Mortality 1999–2001 with ICD-10 Codes. http://wonder.cdc.gov/mortICD10J.html.

National Center for Health Statistics (NCHS). 2004. Deaths Final Data 2002. National Vital Statistics Volume 53(5). October 12, 2004: http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf. See Table E.

Anderson and Smith. 2003. National Vital Statistics Report (NVSR). Deaths: Leading Causes for 2001. Volume 52(9). November 7, 2003. http://www.cdc.gov/nchs/data/nvsr/nvsr52/nvsr52_09.pdf. (Alternate source).

References

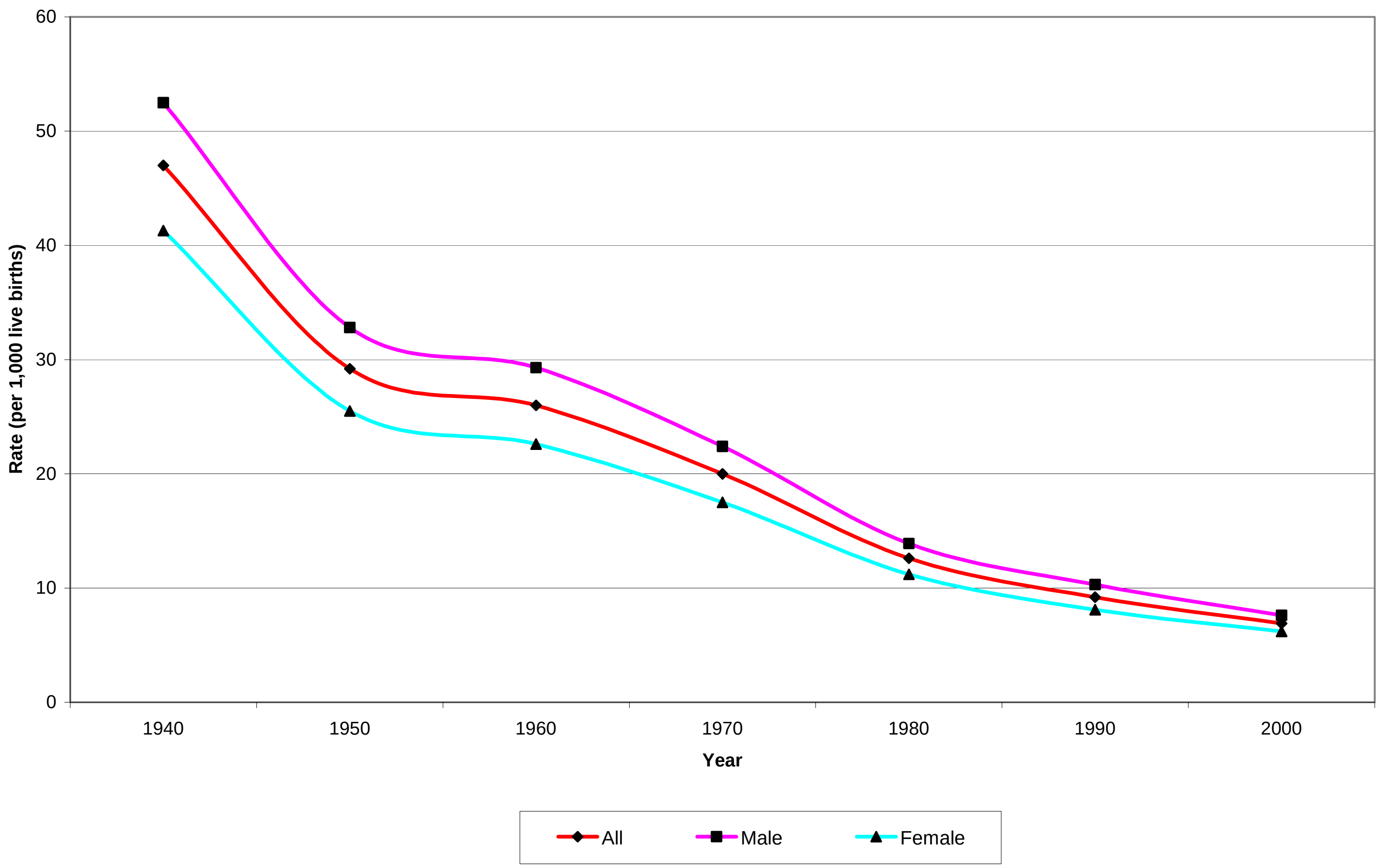
Anderson and Smith. 2003. National Vital Statistics Report (NVSR). Deaths: Leading Causes for 2001. Volume 52, Number 9. November 7, 2003. http://www.cdc.gov/nchs/data/nvsr/nvsr52/nvsr52_09.pdf.

Hoyert DL, Arias E, Smith BL, Murphy SL, Kochanek KD. Deaths: Final Data for 1999. 2001. National Vital Statistics Report (NVSR), Volume 49:6-9.

National Center for Health Statistics (NCHS). 2004. Deaths Final Data 2002. National Vital Statistics Volume 53 (5): http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf. See Table E.

Graphics

Figure 090-1: National Trends in Infant Mortality Rates Between 1940 and 2000



Source: NCHS. National Vital Statistics Reports, Vol. 53, No. 5, October 12, 2004. Table 30.
http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf

Figure 090-2. Leading Causes of Infant Death, 2002

Cause of Death	Number of Deaths	Percentages
Congenital malformations, deformations, and chromosomal abnormalities	5,623	20.1
Disorders related to short gestation and low birthweight	4,637	16.5
Sudden Infant Death Syndrome (SIDS)	2,295	8.2
Newborn affected by maternal complications of pregnancy	1,708	6.1
Newborn affected by complications of placenta, cord, and membranes	1,028	3.7
Accidents (Unintentional Injuries)	943	3.4
Respiratory distress of newborn	946	3.4
Bacterial sepsis of newborn	749	2.7
Diseases of the circulatory system	667	2.4
Intrauterine hypoxia and birth asphyxia	583	2.1
All Other Causes	8,855	31.6

Source: National Center For Health Statistics (NCHS). 2004. Deaths Final Data 2002. National Vital Statistics Vol. 53 No. 5. http://www.cdc.gov/nchs/data/nvsr53/nvsr53_05.pdf. See Table E.

R.O.E. Indicator QA/QC

Data Set Name: INFANT MORTALITY
Indicator Number: 090 (89106)
Data Set Source: CDC, NCHS
Data Collection Date: ongoing
Data Collection Frequency: yearly
Data Set Description: Infant Mortality
Primary ROE Question: What are the trends in health status in the U.S.?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The National Vital Statistics System (NVSS) is the oldest and most successful example of inter-governmental data sharing in Public Health and the shared relationships, standards, and procedures form the mechanism by which NCHS collects and disseminates the Nation's official vital statistics. The methodology for collecting vital statistics is standardized and outlined in Model State Vital Statistics Act and Regulations Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf)

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The National Vital Statistics System is responsible for the Nation s official vital statistics. These vital statistics are provided through State-operated registration systems. Standard forms for the collection of data and model procedures for the uniform registration of the events are developed and recommended for State use through cooperative activities of the States and the NCHS (http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf). U.S. Standard Death Certificates are revised periodically. Most state certificates conform closely in content and arrangement to the standard certificate recommended by NCHS and all certificates contain a minimum data set specified by NCHS. Demographic information on the death certificate is provided by the funeral director based on information supplied by an informant. A physician, medical examiner, or coroner provides medical certification of cause of death.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The data collected by NVSS are routinely referenced and used in epidemiological studies.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Virtually all deaths are registered with the NVSS nationwide. The temporal coverage of the data is from 1933 to present. Data are collected from all 50 States including the District of Columbia.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The data set has nationwide death reporting, including sensitive populations.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Not applicable

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The sampling and quality assurance information can be found in Model State Vital Statistics Act and Regulations Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf). Documentation is also available at http://wonder.cdc.gov/wonder/help/mort.html Table HH1 data sources: Sources: Centers for Disease Control and Prevention (CDC), National Center for Injury Prevention and Control. WISQARS Leading Causes of Death Reports, 1999 2001. http://webapp.cdc.gov/sasweb/ncipc/leadcaus.html. CDC. WONDER Compressed Mortality 1999 2001 with ICD-10 Codes. http://wonder.cdc.gov/mortICD10J.html. Alternate Source: Anderson and Smith. 2003. National Vital Statistics Report (NVSR). Deaths: Leading Causes for 2001. Volume 52, Number 9. November 7, 2003. http://www.cdc.gov/nchs/data/nvsr/nvsr52/nvsr52_09.pdf National Center for Health Statistics (NCHS). 2004. Deaths Final Data 2002. National Vital Statistics vol 53 no. 5 http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf see Table C and E

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The data can be accessed up to the county level through the electronic data warehouse for CDC at http://wonder.cdc.gov. Individual level data are not available due to confidentiality issues.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. Virtually all deaths from the 50 states, including District of Columbia, submit mortality data to the NVSS at NCHS. The recommended certificate of death is posted at http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf. The documentation for the mortality data set is http://wonder.cdc.gov/wonder/help/mort.html.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

See answer to T3Q1

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Not applicable

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Not applicable

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not applicable

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The mortality data on the Compressed Mortality File at http://wonder.cdc.gov/mortSQL.html are based on records for all deaths occurring in the fifty states and the District of Columbia. Deaths to foreign residents are excluded. Deaths to residents who died abroad are not included on this file. The following was noted by Anderson and Smith (2003): Ranking causes of death is to some extent an arbitrary procedure. The rank order of any particular cause of death will depend on the list of causes from which selection is made and on the rules applied in making the selection. Different cause lists and different ranking rules will typically produce different leading causes of death. The International Classification of Diseases 9th Revision (ICD 9) codes are used to specify underlying cause of death for years 1979 - 1998. Beginning in 1999, cause of death is specified with the International Classification of Diseases 10th Revision (ICD 10) codes. The two revisions differ substantially, and to prevent confusion about the significance of any specific disease code, data queries are separate.

Indicator: Life Expectancy at Birth (075)

Life expectancy at birth is often used to appraise the overall health of a given population (NCHS, 2003). Changes in life expectancy over time are commonly used to describe trends in mortality. Life expectancy is the average number of years at birth a person could expect to live if current mortality trends were to continue for the rest of that person's life.

This indicator is based on data from the National Vital Statistics System (NVSS) which registers virtually all deaths and births nationwide. The temporal coverage of the data is from 1933 to present and data are collected from all 50 States and the District of Columbia.

What the Data Show

Figure 075 presents the historical trends in life expectancy between 1940 and 2000 showing an upward trend in life expectancy in the United States over time. Life expectancy at birth has increased throughout the 20th and now into the 21st century. The overall life expectancy was a record high in 2002 at 77.3 years, a slight increase from 77.0 years in 2000 and 77.2 years in 2001. This follows seven consecutive years of increases.

Life expectancy continues to increase for both males (73.9 years in 1999 to 74.5 years in 2002) and females (79.4 years in 1999 to 79.9 years in 2002). The gap in life expectancy between males and females widened from 2.0 years to 7.8 years between 1900 and 1979. Recently, this gap narrowed for the year 2000 and remained constant for 2001and 2002 with a difference of 5.4 years between males and females (Figure 075).

The increase in life expectancy among African Americans reported for 1999 continued in 2001 and 2002 at 72.2 and 72.3 years, respectively. The difference in life expectancy between the African American and White populations was 5.4 years in 2002. In 2002, White females continued to have the highest life expectancy at 80.3 years, followed by African American females at 75.6 years, White males at 75.1 years and African American males at 68.8 years (NCHS 2004).

Indicator Limitations

- Life expectancy at birth is strongly influenced by infant and child mortality rates. It is important to consider such influences when making comparisons among subgroups since differences in life expectancy among certain subgroups may be mostly attributed to differences in prenatal care and other important determinants of infant and child mortality.

- Life expectancy in the ROE03 was reported to be 76.9 years for 2000 (NCHS 2002). Life expectancies for 2000 were revised and computed using population counts from Census 2000 which replaced the life expectancy for 2000 using 1990-based postcensal estimates (NCHS 2003).

Data Sources

National Center for Health Statistics (NCHS). 2003. Health, United States, 2003. Hyattsville, Maryland. 2003. http://www.cdc.gov/nchs/data/hus/hus03.pdf
See Table 27 http://www.cdc.gov/nchs/data/hus/tables/2003/03hus027.pdf

National Center for Health Statistics (NCHS). 2004. Deaths Final Data 2002. National Vital Statistics Volume 53 (5). http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf. See Table 7

References

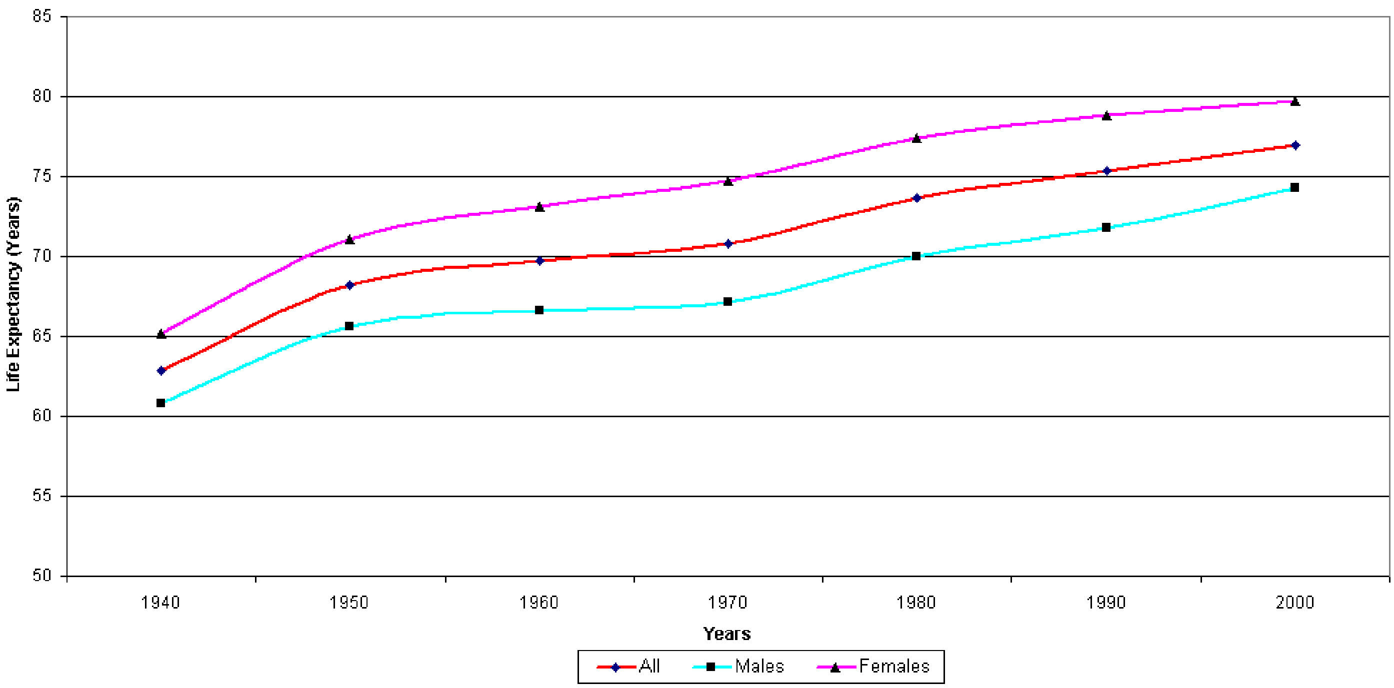
National Center for Health Statistics (NCHS). 2002. Health, United States, 2002. Hyattsville, Maryland.

NCHS. 2003. Health, United States, 2003. Hyattsville, Maryland. 2003

NCHS. 2004. Deaths Final Data 2002. National Vital Statistics Volume 53 (5) http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf. See Table 7.

Graphics

Figure 075: National Trends in Life Expectancy Between 1940 and 2000



Source: National Center for Health Statistics. Health ,United States, 2003
http://www.cdc.gov/nchs/data/hus/tables/2003/03hus027.pdf

R.O.E. Indicator QA/QC

Data Set Name: LIFE EXPECTANCY
Indicator Number: 075 (89104)
Data Set Source: CDC, NCHS
Data Collection Date: ongoing
Data Collection Frequency: 1 yr.
Data Set Description: Life Expectancy
Primary ROE Question: What are the trends in health status in the U.S.?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

The National Vital Statistics System (NVSS) is the oldest and most successful example of inter-governmental data sharing in Public Health and the shared relationships, standards, and procedures form the mechanism by which NCHS collects and disseminates the Nation's official vital statistics. The methodology for collecting vital statistics is standardized and outlined in "Model State Vital Statistics Act and Regulations" Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf).

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The National Vital Statistics System is responsible for the Nation's official vital statistics. These vital statistics are provided through State-operated registration systems. Standard forms for the collection of data and model procedures for the uniform registration of the events are developed and recommended for State use through cooperative activities of the States and the NCHS (http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf). U.S. Standard Death Certificates are revised periodically. Most state certificates conform closely in content and arrangement to the standard certificate recommended by NCHS and all certificates contain a minimum data set specified by NCHS. Demographic information on the death certificate is provided by the funeral director based on information supplied by an informant. A physician, medical examiner, or coroner provides medical certification of cause of death. Life expectancy is determined from mortality data as explained at http://www.cdc.gov/nchs/data/nvsr/nvsr51/nvsr51_05.pdf.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The data collected by NVSS are routinely referenced and used in epidemiological studies.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Virtually all deaths are registered with the NVSS nationwide. The temporal coverage of the data is from 1933 to present. Data are collected from all 50 States including the District of Columbia.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The data set has nationwide death reporting, including sensitive populations.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Not applicable

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The sampling and quality assurance information can be found in “Model State Vital Statistics Act and Regulations” Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf). Data for Tables was extracted from these two sources: National Center for Health Statistics (NCHS). 2004. Health, United States, 2004. Hyattsville, Maryland. 2003. http://www.cdc.gov/nchs/data/hus/hus03.pdf See Table 27 http://www.cdc.gov/nchs/data/hus/tables/2003/03hus027.pdf National Center for Health Statistics (NCHS). 2004. Deaths Final Data 2002. National Vital Statistics vol 53 no. 5 http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf; see Table 7

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The data can be accessed up to the county level through the electronic data warehouse for CDC at http://wonder.cdc.gov. Individual level data are not available due to confidentiality issues. Data for Tables was extracted from these two sources: National Center for Health Statistics (NCHS). 2004. Health, United States, 2004. Hyattsville, Maryland. 2003. http://www.cdc.gov/nchs/data/hus/hus03.pdf See Table 27 http://www.cdc.gov/nchs/data/hus/tables/2003/03hus027.pdf National Center for Health Statistics (NCHS). 2004. Deaths Final Data 2002. National Vital Statistics vol 53 no. 5 http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf; see Table 7

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. Virtually all deaths from the 50 states, including District of Columbia, submit mortality data to the NVSS at NCHS. The recommended certificate of death is posted at http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

See answer to T3Q1

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Not applicable

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Not applicable

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not applicable

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Life expectancy at birth is strongly influenced by infant and child mortality rates. Life expectancy in the Draft Report on the Environment was reported to be 76.9 years for 2000. Life expectancies for 2000 were revised and computed using population counts from Census 2000 which replaced the life expectancy for 2000 using 1990-based postcensal estimates.

Indicator: Asthma Mortality and Prevalence (081 and 082)

Asthma is a chronic respiratory disease characterized by inflammation of the airways and lungs. During an asthma attack, the airways that carry air to the lungs are constricted, and as a result, less air is able to flow in and out of the lungs (NHLBI, 2004). Asthma attacks can cause a multitude of symptoms ranging in severity from mild to life-threatening. These symptoms include wheezing, breathlessness, chest tightness, and coughing (NHLBI, 2004). Family history of asthma contributes to susceptibility, but mostly, it is unknown what causes the development of asthma. Environmental exposures such as environmental tobacco smoke, dust mites, cockroach allergen, outdoor air pollution, pets, and mold are considered important triggers of an asthma attack (CDC, 2005).

For this indicator, asthma diagnosis is defined as the number of people who reported that they had ever been told by a doctor, nurse, or other health practitioner that they have asthma (i.e., lifetime asthma prevalence). An asthma attack is defined as the number of people who reported an asthma episode or attack in the past 12 months (CDC, 1999; 2000; 2001). The diagnosis of lifetime asthma prevalence is based on national estimates from the National Health Interview Survey (NHIS). The NHIS is a cross-sectional household interview survey. The sampling plan follows a multistage area probability design that permits the representative sampling of households in the U.S. The survey is designed so that the sample scheduled for each week is representative of the target population, and the weekly samples are additive over time. The response rate for the ongoing portion of the survey (core) has been between 94 and 98 percent over the years. NHIS has been conducted continuously since 1957. Asthma mortality rates are based on underlying cause-of-death as entered on a death certificate by a physician and recorded in the National Vital Statistics System (NVSS) which registers virtually all deaths nationwide. The temporal coverage of the data is from 1933 to present and data are collected from all 50 states and the District of Columbia. Data are presented as age-adjusted rates, and asthma death rates are reported nationally and by EPA Region.

What the Data Show

Figure 081 presents the overall trends in asthma mortality (all ages) for the U.S. and the 10 EPA Regions for the time periods 1979-1998 and 1999-2001. Between 1979 and 1998, overall age-adjusted rates (2000 U.S. Standard Population) ranged between a low of 1.3 per 100,000 (1979) to a high of 2.2 per 100,000 (1994,1995,1996). In 2002, 4,261 people died from asthma with an age-adjusted rate (2000 U.S. Standard Population) of 1.5 per 100,000 . Between 1979 and 1998, the age-adjusted (2000 U.S. Standard Population) asthma mortality rates varied only a small amount between each of the 10 EPA Regions (e.g., a high of 3.0 per 100,000 in both 1988 [Region 8] and 1989 [Region 8] to a low of 1.1 per 100,000 in 1979 [Region 3] and again in 1982 [Region 1]). In 2001, the rates ranged from 1.2 (Region 1) to 1.8 (Region 8) per 100,000.

In 2002, approximately 30.8 million people were reported as having been diagnosed with asthma over their lifetime (CDC, 2002). Figure 082-1 provides the estimated asthma diagnosis prevalence for adults aged 18 years and older between 1997-2002. Generally, the rates increased between 1997 and 2002 with age-adjusted (2000 U.S. Standard Population) prevalences rising from 90.3 per 1,000 in 1997 to 106.5 per 1,000 in 2002. During this same time period, prevalence was consistently higher among females (range 98 – 122.6 per 1,000) than males (range 70.5 – 92.7 per 1,000).

The lifetime asthma prevalence has been increasing over time for all age groups (Figure 082-2). For each adult age category, the prevalence has increased between 1997 and 2002. In 1997 the ever diagnosed with asthma prevalence was 99.1 (ages 18-44 years), 97.2 (ages 45-64 years), 71.3 (ages 65-74 years), and 51.9 (ages 75+ years) per 1,000 population compared to rates in 2002 at 115.2 (ages 18-44 years), 105.7 (ages 45-64), 83.5 (ages 65-74 years), and 75.4 (ages 75+ years) per 1,000 population. In 2002, the reported age-adjusted (U.S. Standard Population) asthma attack prevalence among adults aged 18 and older was 68 per 1,000 and the attack rate was higher among Blacks (80 per 1,000) than Whites (67 per 1,000) (CDC, 2002).

Indicator Limitations

- Asthma mortality rates are based on underlying cause-of-death as entered on a death certificate by a physician. Some individuals may have had competing causes of death. "When more than one cause or condition is entered by the physician, the underlying cause is determined by the sequence of conditions on the certificate, provisions of the ICD, and associated selection rules and modifications" (CDC WONDER). Consequently, some misclassification of reported asthma-related mortality might occur in individuals with competing causes of death.

- In ROE03, prevalence was defined as the number of people who reported an asthma episode or attack in the past 12 months. However, recently updated statistics using these criteria for the years 1999–2001 are only available for children ages 0–17 years (see indicator for childhood asthma).

- For the years 1979, 1981-1989, and 2001, if the user selects a CDC WONDER query for the United States with data grouped by state, or selects a WONDER query for a specific state, CDC WONDER reports state population figures that do not add up to the national population reported by CDC WONDER. This is because the two different sets of populations come from different U.S. Census population estimates. (For all other years, these two sets of population data are the same.)

- The International Classification of Diseases 9th Revision (ICD-9) codes were used to specify underlying cause of death for years 1979–1998. Beginning in 1999, cause of death is specified with the International Classification of Diseases 10th Revision (ICD-10) codes. The two revisions differ substantially, and to prevent confusion about the significance of any specific disease code, data queries are separate.

Data Sources

Mortality:
CDC. CDC WONDER. Compressed Mortality File, Underlying Cause of Death. http://wonder.cdc.gov.
The complete web-link pathway from the CDC WONDER Home Page is:
-> Mortality—underlying cause of death -> Mortality for 1999–2001 with ICD 10 codes.
Note: ICD-9 code 493; ICD-10 codes J45–J46 are listed as asthma.The raw numbers for each state were downloaded from the CDC WONDER mortality database (http://wonder.cdc.gov). The raw numbers for each state within a region were combined and age-adjusted rates (2000 U.S. Standard Population) were calculated.

NCHS. National Vital Statistics Reports, 53(5): Deaths: Final Data for 2002. October 12, 2004. Available at: http://www.cdc.gov/nchs/data/nvsr/nvsr53_05.pdf.

Prevalence:
CDC, National Center for Health Statistics (NCHS), Series 10: Summary Health Statistics for U.S. Children: National Health Interview Survey, 1999 (Report 210); 2000 (Report 213); 2001 (Report 216); 2002 (Report 221). http://www.cdc.gov/nchs/products/pubs/pubd/series/sr10/ser10.htm. See Table 1.

NCHS: Summary Health Statistics for U.S. Adults: National Health Interview Survey, 1999 (Report 212); 2000 (Report 215); 2001 (Report 218). http://www.cdc.gov/nchs/products/pubs/pubd/series/sr10/ser10.htm. See Table 3.

References

CDC, National Center for Health Statistics (NCHS), Series 10: Summary Health Statistics for U.S. Children: National Health Interview Survey, 1999 (Report 210); 2000 (Report 213); 2001 (Report 216); 2002 (Report 221). http://www.cdc.gov/nchs/products/pubs/pubd/series/sr10/ser10.htm. See Table 1.

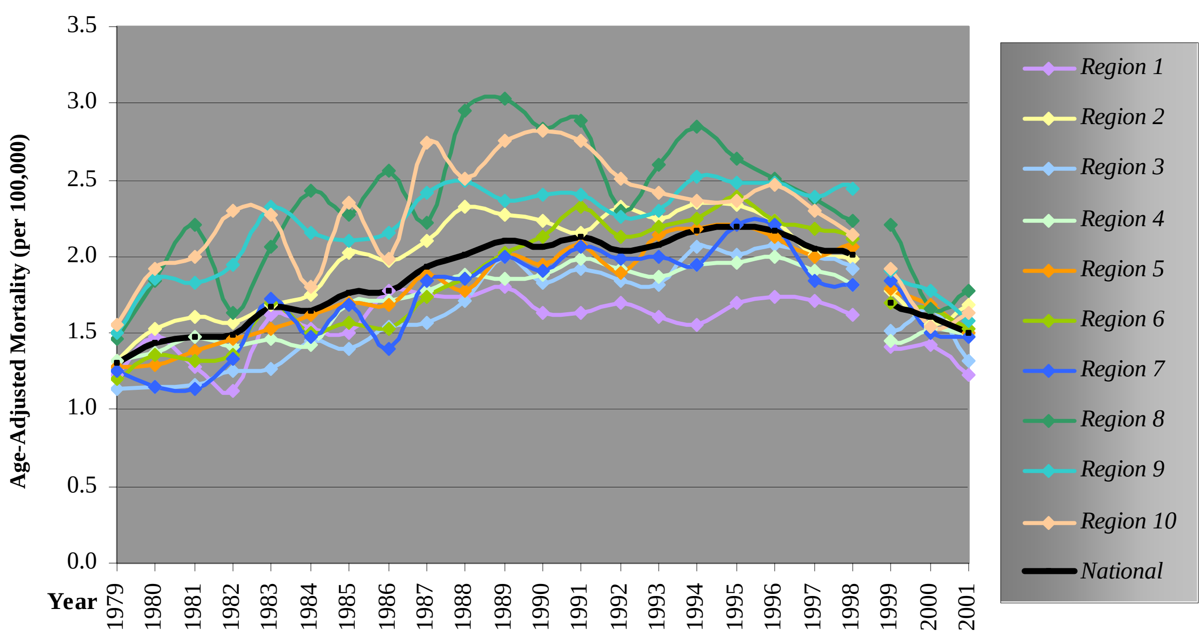
Center for Disease Control and Prevention (CDC). 2005. Basic Facts about Asthma. Accessed February 3, 2005. http://www.cdc.gov/asthma/faqs.htm

National Center for Health Statistics (NCHS). 2004. Health, United States, 2004 with Chartbook on Trends in the Health of Americans. Hyattsville, Maryland

National Heart, Lung, and Blood Institute (NHLBI). 2004. Diseases and Conditions Index. Accessed November 12, 2004. http://www.nhlbi.nih.gov/health/dci/Diseases/Asthma/Asthma_WhatIs.html

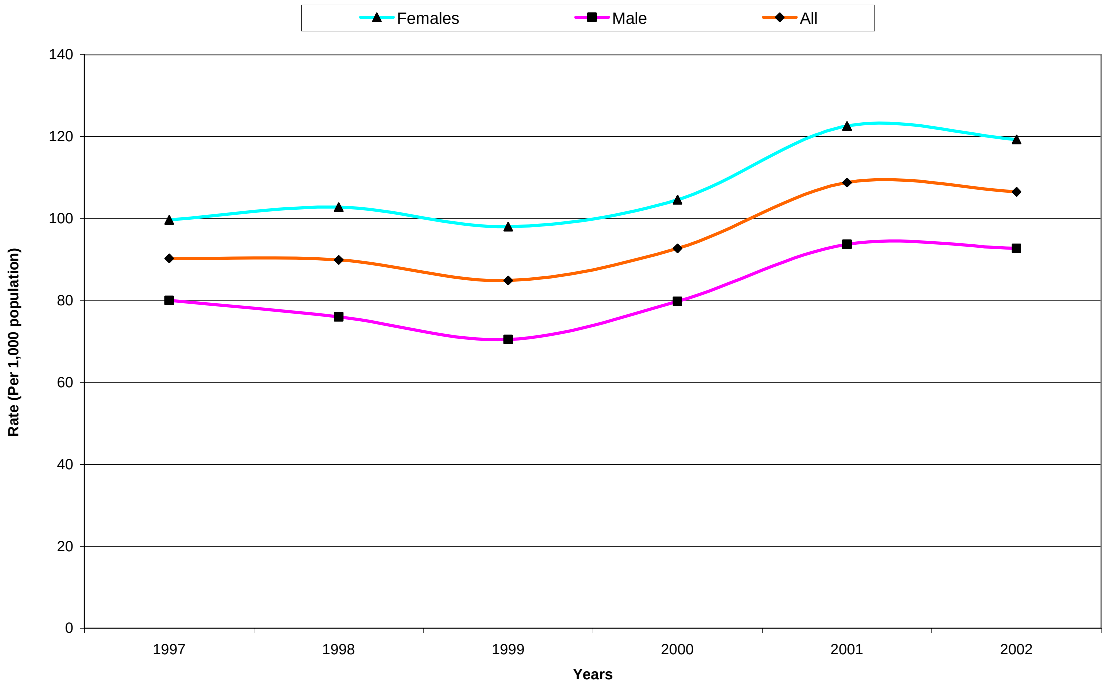
Graphics

Figure 081. Age Adjusted U.S. Asthma Mortality Rates, total U.S. and 10 EPA Regions, 1979-2001*



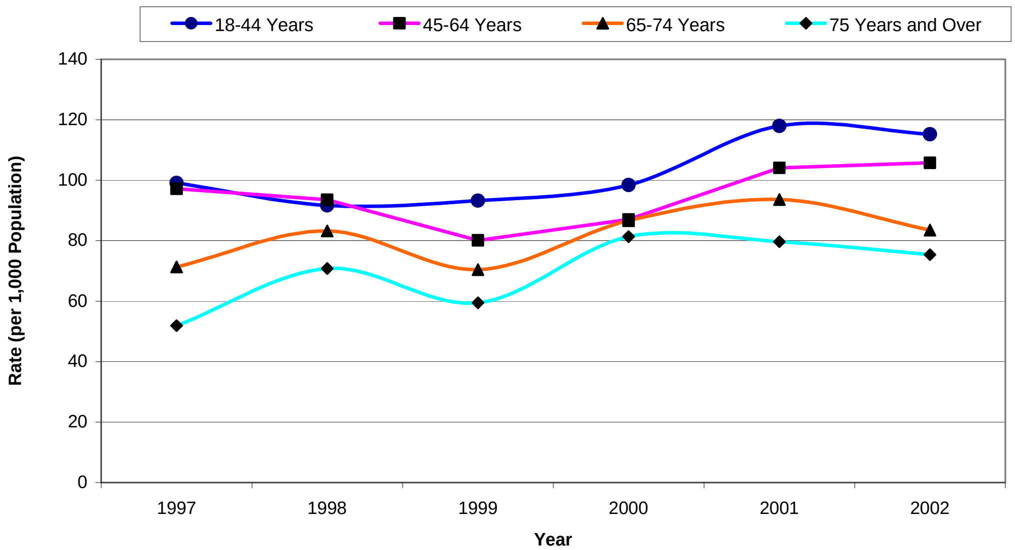
*- Due to differences in the ICD system used for classifying mortalities, data from 1979-1998 should not be directly compared to data from 1999-2001. ICD-9 CODES: 493(1979-1998); ICD-10 CODES: J45-J46(1999-2001)

Figure 082-1: Estimated Prevalence Rate of U.S. Population aged 18 and Older "Ever" Reported Having Asthma



Source: NCHS: Summary Health Statistics for U.S. Adults: National Health Interview Survey,
1999 (Report 212), 2000 (Report 215), 2001 (Report 218), 2002 (Report 222).
http://www.cdc.gov/nchs/products/pubs/pubd/series/sr10/ser10.htm. See Table 3.

Figure 082-2 Estimated Prevalence Rate of U.S. Population aged 18 and Older "Ever" Reported Having Asthma



Source: NCHS: Summary Health Statistics for U.S. Adults: National Health Interview Survey, 1999 (Report 212), 2000 (Report 215), 2001 (Report 218), 2002 (Report 222). http://www.cdc.gov/nchs/products/pubs/pubd/series/sr10/ser10.htm. See Table 3.

R.O.E. Indicator QA/QC

Data Set Name: ASTHMA PREVALENCE & MORTALITY
Indicator Number: 081 (89113)
Data Set Source: CDC, NCHS; CDC, NHIS
Data Collection Date: ongoing
Data Collection Frequency: yearly
Data Set Description: Asthma Prevalence & Mortality (combines former 081 & 082)
Primary ROE Question: What are the trends in human disease and conditions for which environmental pollutants are thought to be to risk factors including across population subgroups and geographic regions?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. Mortality: The National Vital Statistics System (NVSS) is the oldest and most successful example of inter-governmental data sharing in Public Health and the shared relationships, standards, and procedures form the mechanism by which NCHS collects and disseminates the Nation's official vital statistics. The methodology for collecting vital statistics is standardized and outlined in Model State Vital Statistics Act and Regulations Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf) Prevalence:

Asthma prevalence is measured as a question on the National Health Interview Study (NHIS) through the Centers for Disease Control. The NHIS is the principal source of information on the health of the civilian noninstitutionalized population of the United States and is one of the major data collection programs of the National Center for Health Statistics (NCHS). Complete program methodology can be found at: http://www.cdc.gov/nchs/about/major/nhis/hisdesc.htm and http://www.cdc.gov/nchs/about/major/nhis/methods.htm. Prevalence: Asthma prevalence is measured as a question on the National Health Interview Study (NHIS) through the Centers for Disease Control. The NHIS is the principal source of information on the health of the civilian noninstitutionalized population of the United States and is one of the major data collection programs of the National Center for Health Statistics (NCHS). Complete program methodology can be found at: http://www.cdc.gov/nchs/about/major/nhis/hisdesc.htm and http://www.cdc.gov/nchs/about/major/nhis/methods.htm.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Mortality: Yes. The National Vital Statistics System is responsible for the Nation s official vital statistics. These vital statistics are provided through State-operated registration systems. Standard forms for the collection of data and model procedures for the uniform registration of the events are developed and recommended for State use through cooperative activities of the States and the NCHS (http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf). U.S. Standard Death Certificates are revised periodically. Most state certificates conform closely in content and arrangement to the standard certificate recommended by NCHS and all certificates contain a minimum data set specified by NCHS. Demographic information on the death certificate is provided by the funeral director based on information supplied by an informant. A physician, medical examiner, or coroner provides medical certification of cause of death. Prevalence: The National Health Interview Survey is a cross-sectional household interview survey. Sampling and interviewing are continuous throughout each year. The sampling plan follows a multistage area probability design that permits the representative sampling of households. The sampling plan was redesigned in 1995 to include the oversampling of both Black persons and Hispanic persons, and to draw samples from each state. Although the NHIS sample is too small to provide State level data with acceptable precision for each State, this design will facilitate the use of NHIS data with State-level telephone health surveys. In 1997 the collection methodology changed from paper and pencil questionnaires to computer-assisted personal interviewing (CAPI). The NHIS questionnaire was also revised extensively in 1997. In some instances, basic concepts measured in NHIS changed and in other instances the same concepts were measured in a different way. While some questions remain the same over time, they may be preceded by different questions or topics. For some questions, there was a change in the reference period for reporting an event or condition. Because of the extensive redesign of the questionnaire in 1997 and introduction of the CAPI method of data collection, data from 1997 and later years may not be comparable with earlier years.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Mortality: Yes. The data collected by NVSS are routinely referenced and used in epidemiological studies. Regional Mortality: Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled through use of CDC WONDER. See attached file, age-adjusted regional rates.doc , for more information on the calculation of rates. Prevalence: The NHIS is one of the principal sources of information on the health of the civilian noninstitutionalized population of the United States.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Mortality: Virtually all deaths are registered with the NVSS nationwide. The temporal coverage of the data is from 1933 to present. Data are collected from all 50 States including the District of Columbia. Prevalence: The sample design plan of NHIS follows a multistage probability design that permits a continuous sampling of the civilian noninstitutionalized population residing in the United States. The survey is designed in such a way that the sample scheduled for each week is representative of the target population, and the weekly samples are additive over time. The response rate for the ongoing portion of the survey (core) has been between 94 and 98 percent over the years. Response rates for special health topics (supplements) have generally been lower.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Mortality: The data set has nationwide death reporting, including sensitive populations. Prevalence: The sample design plan of NHIS follows a multistage probability design that permits a continuous sampling of the civilian noninstitutionalized population residing in the United States. The survey is designed in such a way that the sample scheduled for each week is representative of the target population, and the weekly samples are additive over time. The response rate for the ongoing portion of the survey (core) has been between 94 and 98 percent over the years. Response rates for special health topics (supplements) have generally been lower.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Not applicable

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Mortality: The sampling and quality assurance information can be found in Model State Vital Statistics Act and Regulations Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf). Documentation is also available at http://wonder.cdc.gov/wonder/help/mort.html Source of data for Table HH2: Source: CDC. CDC WONDER. Compressed Mortality File, Underlying Cause of Death. http://wonder.cdc.gov. The complete web-link pathway from the CDC WONDER Home Page is: à Mortality underlying cause of death à Mortality for 1999 2001 with ICD 10 codes For 2002 data: National Center for Health Statistics (NCHS). 2004. Deaths Final Data 2002. National Vital Statistics vol 53 no. 5 http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf Regional Mortality: Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled through use of CDC WONDER. See attached file, age-adjusted regional rates.doc , for more information on the calculation of rates. Prevalence: Methodology for collection and analysis of NHIS data can be found at: http://www.cdc.gov/nchs/about/major/nhis/methods.htm and http://www.cdc.gov/nchs/data/series/sr_02/sr02_130.pdf. Source of data for Table HH2: CDC, National Center for Health Statistics (NCHS), Series 10: Summary Health Statistics for U.S. Children: National Health Interview Survey, 1999 (Report 210); 2000 (Report 213); 2001 (Report 216). http://www.cdc.gov/nchs/products/pubs/pubd/series/sr10/ser10.htm. See Table 1. NCHS: Summary Health Statistics for U.S. Adults: National Health Interview Survey, 1999 (Report 212),

2000 (Report 215), 2001 (Report 218).
http://www.cdc.gov/nchs/products/pubs/pubd/series/sr10/ser10.htm. See Table 3.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Mortality: The data can be accessed up to the county level through the electronic data warehouse for CDC at http://wonder.cdc.gov Individual level data are not available due to confidentiality issues. Prevalence: Data sets and accompanying documentation from 1992 through 2002 are available at: http://www.cdc.gov/nchs/about/major/nhis/quest_data_related_doc.htm

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Mortality: Yes. Virtually all deaths from the 50 states, including District of Columbia, submit mortality data to the NVSS at NCHS. The recommended certificate of death is posted at http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf The documentation for the mortality data set is http://wonder.cdc.gov/wonder/help/mort.html Prevalence: Questionnaires from the survey at various points of time are posted on the NHIS website: http://www.cdc.gov/nchs/about/major/nhis/quest_data_related_doc.htm. This study is an ongoing study.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Mortality: See answer to T3Q1 Prevalence: Quality assurance and quality control is provided in the document Design and Estimation for the National Health Interview Survey, 1995-2004 (http://www.cdc.gov/nchs/data/series/sr_02/sr02_130.pdf).

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Prevalence: All Statistical methods used in evaluating the data set can be found at: http://www.cdc.gov/nchs/about/major/nhis/methods.htm.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Not applicable

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not applicable

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Mortality: The mortality data on the Compressed Mortality File at http://wonder.cdc.gov/mortSQL.html are based on records for all deaths occurring in the fifty states and the District of Columbia. Deaths to foreign residents are excluded. Deaths to residents who died abroad are not included on this file. Asthma mortality rates are based on under-lying cause-of-death as entered on a death certificate by a physician. Some individuals may have had competing causes of death. When more than one cause or condition is entered by the physician, the underlying cause is determined by the sequence of conditions on the certificate, provisions of the ICD, and associated selection rules and modifications. (CDC WONDER database) The 2002 mortality rates were not yet available in CDC WONDER database at the time of this indicator write-up. The age-adjusted mortality rates were obtained through National Center for Health Statistics publication. For purposes of comparison, it should be noted that mortality rates reported by NCHS reports differ slightly from those rates reported by CDC WONDER. NCHS uses U.S. Census Bureau population estimates for all age groups; CDC WONDER uses birth certificate data for the Under 1 Year age group and uses U.S. Census Bureau population estimates for all other age groups The International Classification of Diseases 9th Revision (ICD 9) codes are used to specify underlying cause of death for years 1979 - 1998. Beginning in 1999, cause of death is specified with the International Classification of Diseases 10th Revision (ICD 10) codes. The two revisions differ substantially, and to prevent confusion about the significance of any specific disease code, data queries are separate. Regional data: Mortality data are not available for the U.S. territories in CDC WONDER. Thus, Regions 2 and 9 are calculated to include only States. Note that for the years 1979, 1981-1989, and 2001, if the user selects a WONDER query for the United States with data grouped by state, or selects a WONDER query for a specific state, WONDER reports state population figures that do not add up to the national population reported by WONDER. This is because the two different sets of populations come from different U.S. Census population estimates. (For all other years, these two sets of population data are the same.) Prevalence: Persons excluded from this study are patients in long-term care facilities; persons on active duty with the Armed Forces (though their dependents are included); and U.S. nationals living in foreign countries. The response rate for the ongoing portion of the survey (core) has been between 94 and 98 percent over the years. Response rates for special health topics (supplements) have generally been lower. In the Draft Report on the Environment 2003, prevalence was reported based on episode of asthma attack during the preceding 12 months. Updates of these results were only available for children (see indicator for childhood asthma).

Calculation of Age-Adjusted Regional Mortality Rates Using State Data from CDC WONDER

Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled as detailed below. (Mortality data for 2002 and later are not yet available through CDC WONDER.)

Identifying relevant data

- Each mortality indicator (e.g., cancer, cardiovascular disease, asthma) was reviewed based on EPA's 2003 Draft Report on the Environment and a National Center for Health Statistics (NCHS) report that discusses ICD (International Classification of Diseases) to obtain the ICD codes that describe each of these indicators. Due to a revision of the ICD system in 1999, ICD-9 codes were obtained for the years 1979-1998 and ICD-10 codes for the years 1999-2001.

Downloading and organizing the data

- Mortality data were accessed through CDC's WONDER database (http://wonder.cdc.gov/).

- We downloaded a file for each year that regional mortality indicators were requested (1979-2001) and saved these data into separate sheets in Microsoft Excel (one workbook for each indicator). Both raw and compiled data are presented in each of these Excel workbooks. For example, '1999D' is the sheet with the raw data for the year 1999 and '1999' is the sheet with the calculations for that year.

- The calculation worksheet is organized as follows:

    - The first table arranges the raw data by state and age group. For each age group and state, two numbers are presented: the mortality cases and the associated population.

    - The second table (Regional Breakdown) groups the mortality cases and populations for the 50 states plus Washington, D.C., into the ten EPA regions, to obtain the total cases and total population for each region, by age group. (For a map of the EPA regions, refer to http://www.epa.gov/epahome/whereyou-live.htm.)

    - The third table (Regional Breakdown [combine certain groups]) merges two sets of age groups with each other (5-9 years with 10-14 years; 15-19 years with 20-24 years) to match the age-adjustment methodology used to calculate age-adjusted mortality rates in CDC WONDER (see below).

    - The fourth table on the worksheet (Regional Breakdown [Computation of Age-Adjusted Rate Components]) presents the basic steps of calculating age-adjusted mortality rates for each region (see below).

    - The final table on the Excel sheet (Regional Summary) lists the age-adjusted rates for each region and for the entire US; these values are compiled into the summary sheet

that covers all regions for all years for an indicator, accompanied by a trend chart that graphically depicts the regional data.

Calculating age-adjusted regional rates

The steps followed in calculating age-adjusted regional rates are detailed below, followed by a sample calculation.

Step 1

Using the following equation, the *crude death (or mortality) rate* is obtained by dividing the mortality cases ($Cases_i$) by the population for that age group ($Population_i$), then by multiplying by 100,000 (to get the cases per 100,000). This is done for each age group within each region. (The "i" subscript is included to indicate that this calculation is performed for several age groups, i.e. $CrudeRate_{<1\ year}$, $CrudeRate_{1\text{-}4\ years}$, etc.)

$$CrudeRate_i = \frac{Cases_i}{Population_i} \times 100{,}000$$

Step 2

For each age group, the weighted age-adjusted factor is calculated, using 2000 U.S. standard population factors provided by NCHS (See Table 1 below). The age-specific crude death rate is multiplied by that age group's standard population for the year 2000 ($2000\ Population_i$), and then divided by the total standard population for the year 2000 ($2000\ Population_{total}$). (For details on the standard population, see "Age-Adjustment of Death Rates" on the web page http://wonder.cdc.gov/wonder/help/mort.html[1]).

$$WeightedFactor = CrudeRate \times \frac{2000\,Population_i}{2000\,Population_{total}}$$

Table 1. United States Standard Population*

Age	**Number**
Under I year	13,818
1-4 years	55,317
5-14 years	145,565
15-24 years	138,646
25-34 years	135,573
35-44 years	162,613
45-54 years	134,834
55-64 years	87,247
65-74 years	66,037
75-84 years	44,842
85 years and over	15,508
All ages	1,000,000

* Based on year 2000 projected population

[1] The source cited by CDC WONDER for the age-adjustment data is the following NCHS report: *Anderson RN, Rosenberg HM. Age standardization of death rates: Implementation of the year 2000 standard. National Vital Statistics Reports; Vol 47 No 3. Hyattsville, Maryland. National Center for Health Statistics. 1998.*

Step 3
The age-adjusted mortality rate is then obtained by adding together the individual weighted factors for each age group:

$$AgeAdjustedRate = \sum_i WeightedFactor_i$$

Sample Calculation

Table 2 (below) shows the output of a sample calculation of the age-adjusted mortality rate for cancer (across all age groups) in EPA Region 9 in 1982. (Note that we have presented this in a format that is not used in the Excel workbook, in order to illustrate the calculations for a single region. However, all of the steps and calculations are identical.)

For each age group, the number of mortality cases is the sum of the mortality cases for Arizona, California, Hawaii, and Nevada, for that age group in that year; the population is the sum of the populations of these same four states for that age group in that year. For example, for the 35-44 years age group, the number of cancer mortalities for these states are 112 (Arizona), 1,413 (California), 53 (Hawaii), and 55 (Nevada), with the sum equaling 1,633. Similarly, the population is the sum of the respective states 338,654 (Arizona), 3,152,885 (California), 124,743 (Hawaii), and 120,463 (Nevada), which equals 3,736,745. The crude rate (43.70) for this age group is therefore equal to the total number of mortality cases (1,633) divided by the total population (3,736,745), multiplied by 100,000.

Table 1. Cancer Mortality, All Age Groups, EPA Region 9, 1982.

Age Group (Years)	Mortality Cases	Year 1982 Population	Crude Death Rate	2000 Std. Population	Weighted Factor
<1 year	32	515,809	6.20	13,818	0.09
1- 4 years	108	1,824,635	5.92	55,317	0.33
5- 9 years	114	1,977,487	N/A		
10-14 years	94	2,188,828	N/A		
5-14 years	208	4,166,315	4.99	145,565	0.73
15-19 years	139	2,432,939	N/A		
20-24 years	180	2,884,175	N/A		
15-24 years	319	5,317,114	6.00	138,646	0.83
25-34 years	694	5,551,792	12.50	135,573	1.69
35-44 years	1,633	3,736,745	43.70	162,613	7.11
45-54 years	4,662	2,793,603	166.88	134,834	22.50
55-64 years	11,283	2,679,802	421.04	87,247	36.73
65-74 years	15,423	1,876,606	821.86	66,037	54.27
75-84 years	11,397	912,865	1248.49	44,842	55.98
85+ years	4,424	269,593	1640.99	15,508	25.45
Unknown	27	0	N/A	0	0
Total	*50,210*	*29,644,879*	*N/A*	*1,000,000*	N/A
Age-Adjusted Mortality Rate					**205.7**

As described above, the Weighted Factor is the Crude Death Rate multiplied by the 2000 Standard Population for that age group and divided by the total Standard Population (the total of the age-group populations). For example, the weighted factor for the 35-44 years age group is the crude rate (43.70) times the 2000 population for that group (162,613), divided by the total 2000 Standard Population (1,000,000), which equals 7.11. The 1982 Region 9 age-adjusted mortality rate, 205.7, is the sum of the weighted factors of all age groups.

Notes:

- For the 5-14 and 15-24 years categories it is necessary to merge two sets of age ranges to match the age-adjustment grouping used within WONDER.

- For mortality indicators that were also compiled for children (ages 0-19 years), we only used the data for the age groups 0-1, 1-4, 5-9, 10-14, and 15-19 years, and then we age-adjusted these data using a set of age-adjustment factors that only cover to age 19 years.

- For the file that compiles birth defect mortality rates, the only data used from CDC WONDER are for the <1 year age group, so the crude rate equals the age-adjusted rate.

- Although data were queried for individual states to compile regional data, we did this by querying data for the entire United States from the CDC WONDER system, and specifying that the data be grouped by age and by year. Due to a quirk of CDC WONDER, if the user selects a single state for a query (instead of the entire United States), the population data are taken from a different data source: there are small discrepancies between these numbers and so the state-specific query should not be used to verify these compiled data.

Indicator: Birth Defect Mortality and Incidence (096 and 097)

Congenital anomalies, or birth defects, are structural defects that are present in the fetus at birth. Although birth defects are the leading cause of infant mortality (deaths occurring to those <1 year of age) in the United States, the cause is unknown for approximately 70% of all cases (CDC, 2005). Many different factors are associated with the development of birth defects such as genetic and/or chromosomal aberrations, exposure to viruses or bacteria, uncontrolled diabetes, cigarette smoke, use of drugs and alcohol during pregnancy, and prenatal exposure to dangerous chemicals in the workplace or pollutants in the environment. All of these factors can change normal infant growth or development resulting in different types of birth defects (NICHD, 2005).

This indicator presents birth defects mortality and incidence among infants in the United States as recorded in the National Vital Statistics System (NVSS) which registers virtually all deaths and births nationwide. The temporal coverage of the data is from 1933 to present and data are collected from all 50 States and the District of Columbia. Birth defects are recorded on the Birth Certificate for 49 States and the District of Columbia with coverage of 99% of all births within the United States.

What the Data Show

Birth defects continue to be the leading cause of infant mortality, accounting for 5,623 (20%) of the 28,034 infant deaths in 2002 (Figure 090-2). Figure 096 presents the overall trends in birth defects mortality (<1 year of age) on the National scale for the time periods of 1979-1998 and 1999-2001. Between 1979 to 1998 a decline in the National birth defects mortality rate has been observed ranging from 255.4 per 100,000 live births in 1979 to 157.6 per 100,000 in 1998. The continuation of this trend starting in 1999 is uncertain. In 2001, the birth defect mortality rate was 136.9 per 100,000 infants (Figure 096). The most frequently occurring types of birth defects were other musculoskeletal/integumental anomalies, other circulatory/respiratory system anomalies, and heart malformations (Table 097 Birth Defects Incidence).

Figure 096 presents the overall trends in birth defects mortality (<1 year of age) for the 10 EPA Regions for the time periods 1979-1998 and 1999-2001. Overall birth defects mortality rates among the 10 EPA Regions have been declining during the years 1979-1998 where the range in rates in 1979 was 234.3 (Region 8) to 270.8 (Region 10) per 100,000 and in 1998 121.1 (Region 1) to 182.8 (Region 8) per 100,000. The rates in 2001 were a high of 152.1 per 100,000 to a low of 82.9 per 100,000.

Birth defect mortality has been reported to be higher among Black compared to White infants. In 2001, the rate among Black male and female infants was 174.4 and 165.9 per 100,000 infants, respectively, and among White male and female infants was 141.6 and 125.4 per 100,000 infants, respectively.

Indicator Limitations

- Congenital anomalies are reported on the birth certificates of 49 States and the District of Columbia.

- Birth defects mortality rates are based on underlying cause-of-death as entered on a death certificate by a physician. Some individuals may have had competing causes of death. “When more than one cause or condition is entered by the physician, the underlying cause is determined by the sequence of conditions on the certificate, provisions of the ICD, and associated selection rules and modifications” (CDC WONDER). Consequently, some misclassification of reported mortality might occur in individuals with competing causes of death.

- Because some birth defects are not recognized immediately, they are often underreported on both the death and birth certificates (Friis and Sellers, 1999).

- Caution should be used in comparing yearly rates for a specific anomaly as a small change in the number of anomalies reported can result in a relatively large change in rates.

- The International Classification of Diseases 9th Revision (ICD-9) codes were used to specify underlying cause of death for years 1979 - 1998. Beginning in 1999, cause of death is specified with the International Classification of Diseases 10th Revision (ICD-10) codes. The two revisions differ substantially, and to prevent confusion about the significance of any specific disease code, data queries are separate. The relatively large difference between birth defect mortality rates reported between 1979—1998 and those reported beginning in 1999 may be due to some changes in the criteria used to report birth defect mortality during the switch from ICD-9 to ICD-10.

Data Sources

Mortality:
CDC. CDC WONDER. Compressed Mortality File, Underlying Cause of Death. http://wonder.cdc.gov. The complete web-link pathway from the CDC WONDER Home Page is:
-> Mortality—underlying cause of death -> Mortality for 1999–2001 with ICD 10 codes (age range = <364 days). Note: ICD-9 codes 740-759; ICD-10 codes Q00–Q99 congenital malformations, deformations, and chromosomal abnormalities

The raw numbers for each state were downloaded from the CDC WONDER mortality database (http://wonder.cdc.gov). The raw numbers for each state within a region were combined and age-adjusted rates (2000 U.S. Standard Population) were calculated.

National Center for Health Statistics. 2004. Deaths: Final Data for 2002. National Vital Statistics Reports. 53(5). http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf.

Incidence:
National Center for Health Statistics. 2001. Births Final Data for 1999. National Vital Statistics Reports. 49(1). http://www.cdc.gov/nchs/data/nvsr/nvsr49/nvsr49_01.pdf see Table 49.

National Center for Health Statistics. 2002. Births Final Data for 2000. National Vital Statistics Reports. 50(5). http://www.cdc.gov/nchs/data/nvsr/nvsr50/nvsr50_05.pdf see Table 49.

National Center for Health Statistics. 2002. Births Final Data for 2001. National Vital Statistics Reports. 51(2). http://www.cdc.gov/nchs/data/nvsr/nvsr51/nvsr51_02.pdf see Table 49.

National Center for Health Statistics. 2003. Births Final Data for 2002. National Vital Statistics Reports. 52(10). http://www.cdc.gov/nchs/data/nvsr/nvsr52/nvsr52_10.pdf see Table 49.

References

Centers for Disease Control and Prevention (CDC). 2005. Birth Defects. (Last Accessed February 7, 2005) http://www.cdc.gov/ncbddd/bd/

Friis, RH and Sellers TA. 1999. Epidemiology for Public Health Practice, Second Edition. Gaithersburg, MD: Aspen Publishers, Inc.

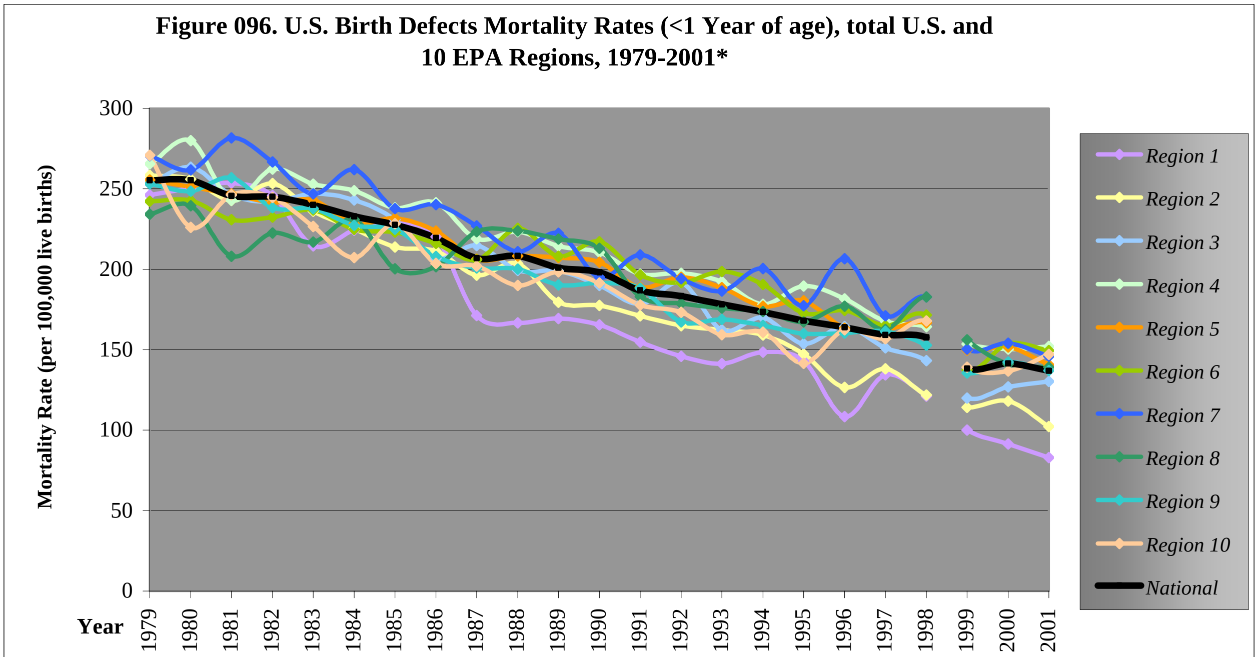
National Institute of Child Health & Human Development (NICHD). 2005. Birth Defects and Human Development. Accessed February 3, 2005.
http://www.nichd.nih.gov/about/womenhealth/birth_defects.cfm

Graphics

Figure 090-2. Leading Causes of Infant Death, 2002

Cause of Death	Number of Deaths	Percentages
Congenital malformations, deformations, and chromosomal abnormalities	5,623	20.1
Disorders related to short gestation and low birthweight	4,637	16.5
Sudden Infant Death Syndrome (SIDS)	2,295	8.2
Newborn affected by maternal complications of pregnancy	1,708	6.1
Newborn affected by complications of placenta, cord, and membranes	1,028	3.7
Accidents (Unintentional Injuries)	943	3.4
Respiratory distress of newborn	946	3.4
Bacterial sepsis of newborn	749	2.7
Diseases of the circulatory system	667	2.4
Intrauterine hypoxia and birth asphyxia	583	2.1
All Other Causes	8,855	31.6

Source: National Center For Health Statistics (NCHS). 2004. Deaths Final Data 2002. National Vital Statistics Vol. 53 No. 5. http://www.cdc.gov/nchs/data/nvsr53/nvsr53_05.pdf. See Table E.



* - Due to differences in the ICD system used for classifying mortalities, data from 1979-1998 should not be directly compared to data from 1999-2001.
ICD-9 CODES: 740-759 (1979-1998); ICD-10 CODES: Q00-Q99 (1999-2001)

Table 097Birth Defects Incidence. Rate of Live Births with Specific Birth Defect (Congenital Anomaly), United States, 1999-2002[1]

Congenital Anomaly	1999	2000	2001	2002
Anencephalus	11.0	10.7	9.9	9.9
Spina bifida/Meningocele	20.1	20.7	19.9	20.0
Hydrocephalus	21.5	23.7	22.5	22.5
Microcephalus	5.9	7.2	5.6	5.5
Other central nervous system anomalies	20.0	20.7	24.8	22.2
Heart malformations	119.8	124.9	122.5	129.9
Other circulatory/respiratory anomalies	140.6	138.1	139.6	131.7
Rectal atresia/stenosis	9.0	8.4	9.0	8.3
Tracheo-esophageal fistula/Esophageal atresia	13.3	12.1	12.0	10.8
Omphalocele/Gastroschisis	30.2	29.7	31.8	30.3
Other gastrointestinal anomalies	29.8	29.9	34.2	36.1
Malformed genitalia	76.3	84.2	88.4	86.6
Renal agenesis	13.7	13.8	14.8	15.4
Other urogenital anomalies	99.0	99.3	102.8	101.8
Cleft lip/palate	80.9	82.1	80.6	78.5
Polydactyly/Syndactyly/Adactyly	87.9	87.2	82.4	82.2
Clubfoot	55.7	57.2	58.6	59.6
Diaphragmatic hernia	13.1	10.8	11.4	12.1
Other musculoskeletal/integumental anomalies	239.9	217.0	226.4	228.9
Down’s syndrome	45.5	46.9	45.5	46.7
Other chromosomal anomalies	36.9	39.7	36.2	31.6

[1] Note: Rates are per 100,000 live births

Source : National Center for Health Statistics. 2001. Births Final Data for 1999. National Vital Statistics Reports; vol 49 no.1
http://www.cdc.gov/nchs/data/nvsr/nvsr49/nvsr49_01.pdf see Table 49
National Center for Health Statistics. 2002. Births Final Data for 2000. National Vital Statistics Reports; vol 50 no. 5
http://www.cdc.gov/nchs/data/nvsr/nvsr50/nvsr50_05.pdf see Table 49
National Center for Health Statistics. 2002. Births Final Data for 2001. National Vital Statistics Reports; vol 51 no.2
http://www.cdc.gov/nchs/data/nvsr/nvsr51/nvsr51_02.pdf see Table 49
National Center for Health Statistics. 2003. Births Final Data for 2002. National Vital Statistics Reports; vol 52 no.10
http://www.cdc.gov/nchs/data/nvsr/nvsr52/nvsr52_10.pdf see Table 49

R.O.E. Indicator QA/QC

Data Set Name: BIRTH DEFECTS INCIDENCE AND MORTALITY
Indicator Number: 096 (89097)
Data Set Source: CDC, NCHS
Data Collection Date: ongoing
Data Collection Frequency: yearly
Data Set Description: Birth Defects Incidence and Mortality (combines 096 & 097)
Primary ROE Question: What are the trends in human disease and conditions for which environmental pollutants are thought to be to risk factors including across population subgroups and geographic regions?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The National Vital Statistics System (NVSS) is the oldest and most successful example of inter-governmental data sharing in Public Health and the shared relationships, standards, and procedures form the mechanism by which NCHS collects and disseminates the Nation's official vital statistics. The methodology for collecting vital statistics is standardized and outlined in "Model State Vital Statistics Act and Regulations" Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf)

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The National Vital Statistics System is responsible for the Nation s official vital statistics. These vital statistics are provided through State-operated registration systems. Standard forms for the collection of data and model procedures for the uniform registration of the events are developed and recommended for State use through cooperative activities of the States and the NCHS (http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf). U.S. Standard Death Certificates are revised periodically. Most state certificates conform closely in content and arrangement to the standard certificate recommended by NCHS and all certificates contain a minimum data set specified by NCHS. Demographic information on the death certificate is provided by the funeral director based on information supplied by an informant. A physician, medical examiner, or coroner provides medical certification of cause of death. U.S. Standard Birth Certificates are revised periodically. Most state certificates conform closely in content and arrangement to the standard certificate recommended by NCHS and all certificates contain a minimum data set specified by NCHS. One section of the Standard Birth Certificate is reserved for congenital abnormalities.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The data collected by NVSS are routinely referenced and used in epidemiological studies.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Virtually all deaths are registered with the NVSS nationwide. The temporal coverage of the data is from 1933 to present. Data are collected from all 50 States including the District of Columbia.

Virtually all births are registered with the NVSS nationwide. The temporal coverage of the data is from 1933 to present. Data are collected from all 50 States including the District of Columbia. Birth defects is recorded on the Birth Certificate for 49 States and the District of Columbia with coverage of 99% of all births within the United States.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The data set has nationwide death reporting, including sensitive populations.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Not applicable

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The sampling and quality assurance information can be found in Model State Vital Statistics Act and Regulations Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf). Documentation is also available at http://wonder.cdc.gov/wonder/help/mort.html Data source for Table HH3: Mortality: CDC. CDC WONDER. Compressed Mortality File, Underlying Cause of Death. http://wonder.cdc.gov. The complete web-link pathway from the CDC WONDER Home Page is: à Mortality underlying cause of death à Mortality for 1999 2001 with ICD 10 codes (age range <=364 days). Note: ICD codes Q00 Q99 congenital malformations, deformations, and chromosomal abnormalities Incidence: National Center for Health Statistics. 2001. Births Final Data for 1999. National Vital Statistics Reports; vol 49 no.1 http://www.cdc.gov/nchs/data/nvsr/nvsr49/nvsr49_01.pdf see Table 49 National Center for Health Statistics. 2002. Births Final Data for 2000. National Vital Statistics Reports; vol 50 no. 5 http://www.cdc.gov/nchs/data/nvsr/nvsr50/nvsr50_05.pdf see Table 49 National Center for Health Statistics. 2002. Births Final Data for 2001. National Vital Statistics Reports; vol 51 no.2 http://www.cdc.gov/nchs/data/nvsr/nvsr51/nvsr51_02.pdf see Table 49 National Center for Health Statistics. 2003. Births Final Data for 2002. National Vital Statistics Reports; vol 52 no.10 http://www.cdc.gov/nchs/data/nvsr/nvsr52/nvsr52_10.pdf see Table 49

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The data can be accessed up to the county level through the electronic data warehouse for CDC at http://wonder.cdc.gov/nataJ.html. Individual level data are not available due to confidentiality issues.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. Virtually all deaths from the 50 states, including District of Columbia, submit mortality data to the NVSS at NCHS. The recommended certificate of death is posted at http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf. The documentation for the mortality data set is http://wonder.cdc.gov/wonder/help/mort.html. Yes. Virtually all births from the 50 states, including District of Columbia, submit birth data to the NVSS at NCHS. The recommended birth certificate is posted at http://www.cdc.gov/nchs/data/dvs/birth11-03final-ACC.pdf. The documentation for the birth set is at http://wonder.cdc.gov/wonder/help/nata.html.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

See answer to T3Q1

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Not applicable, data represent all births and deaths.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Not applicable

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not applicable

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Because some birth defects are not recognized immediately, they are underreported on both the death and birth certificates. Caution should be used in comparing yearly rates for a specific anomaly as a small change in the number of anomalies reported can result in a relatively large change in rates. The mortality data on the Compressed Mortality File at http://wonder.cdc.gov/mortSQL.html are based on records for all deaths occurring in the fifty states and the District of Columbia. Deaths to foreign residents are excluded. Deaths to residents who died abroad are not included on this file. For purposes of comparison, it should be noted that mortality rates reported by NCHS reports differ slightly from those rates reported by CDC WONDER. NCHS uses U.S. Census Bureau population estimates for all age groups; CDC WONDER uses birth certificate data for the Under 1 Year age group and uses U.S. Census Bureau population estimates for all other age groups. The International Classification of Diseases 9th Revision (ICD 9) codes are used to specify underlying cause of death for years 1979 - 1998. Beginning in 1999, cause of death is specified with the International Classification of Diseases 10th Revision (ICD 10) codes. The two revisions differ substantially, and to prevent confusion about the significance of any specific disease code, data queries are separate. Regional data: Mortality data are not available for the U.S. territories in CDC WONDER. Thus, Regions 2 and 9 are calculated to include only States. Note that for the years 1979, 1981-1989, and 2001, if the user selects a WONDER query for the United States with data grouped by state, or selects a WONDER query for a specific state, WONDER reports state population figures that do not add up to the national population reported by WONDER. This is because the two different sets of populations come from different U.S. Census population estimates. (For all other years, these two sets of population data are the same.) Congenital anomalies are reported on the birth certificates of 49 States and the District of Columbia.

Calculation of Age-Adjusted Regional Mortality Rates Using State Data from CDC WONDER

Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled as detailed below. (Mortality data for 2002 and later are not yet available through CDC WONDER.)

Identifying relevant data

- Each mortality indicator (e.g., cancer, cardiovascular disease, asthma) was reviewed based on EPA's 2003 Draft Report on the Environment and a National Center for Health Statistics (NCHS) report that discusses ICD (International Classification of Diseases) to obtain the ICD codes that describe each of these indicators. Due to a revision of the ICD system in 1999, ICD-9 codes were obtained for the years 1979-1998 and ICD-10 codes for the years 1999-2001.

Downloading and organizing the data

- Mortality data were accessed through CDC's WONDER database (http://wonder.cdc.gov/).

- We downloaded a file for each year that regional mortality indicators were requested (1979-2001) and saved these data into separate sheets in Microsoft Excel (one workbook for each indicator). Both raw and compiled data are presented in each of these Excel workbooks. For example, '1999D' is the sheet with the raw data for the year 1999 and '1999' is the sheet with the calculations for that year.

- The calculation worksheet is organized as follows:

    - The first table arranges the raw data by state and age group. For each age group and state, two numbers are presented: the mortality cases and the associated population.

    - The second table (Regional Breakdown) groups the mortality cases and populations for the 50 states plus Washington, D.C., into the ten EPA regions, to obtain the total cases and total population for each region, by age group. (For a map of the EPA regions, refer to http://www.epa.gov/epahome/whereyou-live.htm.)

    - The third table (Regional Breakdown [combine certain groups]) merges two sets of age groups with each other (5-9 years with 10-14 years; 15-19 years with 20-24 years) to match the age-adjustment methodology used to calculate age-adjusted mortality rates in CDC WONDER (see below).

    - The fourth table on the worksheet (Regional Breakdown [Computation of Age-Adjusted Rate Components]) presents the basic steps of calculating age-adjusted mortality rates for each region (see below).

    - The final table on the Excel sheet (Regional Summary) lists the age-adjusted rates for each region and for the entire US; these values are compiled into the summary sheet

that covers all regions for all years for an indicator, accompanied by a trend chart that graphically depicts the regional data.

Calculating age-adjusted regional rates

The steps followed in calculating age-adjusted regional rates are detailed below, followed by a sample calculation.

Step 1

Using the following equation, the *crude death (or mortality) rate* is obtained by dividing the mortality cases ($Cases_i$) by the population for that age group ($Population_i$), then by multiplying by 100,000 (to get the cases per 100,000). This is done for each age group within each region. (The "i" subscript is included to indicate that this calculation is performed for several age groups, i.e. $CrudeRate_{<1\ year}$, $CrudeRate_{1\text{-}4\ years}$, etc.)

$$CrudeRate_i = \frac{Cases_i}{Population_i} \times 100{,}000$$

Step 2

For each age group, the weighted age-adjusted factor is calculated, using 2000 U.S. standard population factors provided by NCHS (See Table 1 below). The age-specific crude death rate is multiplied by that age group's standard population for the year 2000 (*2000* $Population_i$), and then divided by the total standard population for the year 2000 (*2000* $Population_{total}$). (For details on the standard population, see "Age-Adjustment of Death Rates" on the web page http://wonder.cdc.gov/wonder/help/mort.html[1]).

$$WeightedFactor = CrudeRate \times \frac{2000\,Population_i}{2000\,Population_{total}}$$

Table 1. United States Standard Population*

Age	**Number**
Under I year	13,818
1-4 years	55,317
5-14 years	145,565
15-24 years	138,646
25-34 years	135,573
35-44 years	162,613
45-54 years	134,834
55-64 years	87,247
65-74 years	66,037
75-84 years	44,842
85 years and over	15,508
All ages	1,000,000

* Based on year 2000 projected population

[1] The source cited by CDC WONDER for the age-adjustment data is the following NCHS report: *Anderson RN, Rosenberg HM. Age standardization of death rates: Implementation of the year 2000 standard. National Vital Statistics Reports; Vol 47 No 3. Hyattsville, Maryland. National Center for Health Statistics. 1998.*

Step 3

The age-adjusted mortality rate is then obtained by adding together the individual weighted factors for each age group:

$$AgeAdjustedRate = \sum_i WeightedFactor_i$$

Sample Calculation

Table 2 (below) shows the output of a sample calculation of the age-adjusted mortality rate for cancer (across all age groups) in EPA Region 9 in 1982. (Note that we have presented this in a format that is not used in the Excel workbook, in order to illustrate the calculations for a single region. However, all of the steps and calculations are identical.)

For each age group, the number of mortality cases is the sum of the mortality cases for Arizona, California, Hawaii, and Nevada, for that age group in that year; the population is the sum of the populations of these same four states for that age group in that year. For example, for the 35-44 years age group, the number of cancer mortalities for these states are 112 (Arizona), 1,413 (California), 53 (Hawaii), and 55 (Nevada), with the sum equaling 1,633. Similarly, the population is the sum of the respective states 338,654 (Arizona), 3,152,885 (California), 124,743 (Hawaii), and 120,463 (Nevada), which equals 3,736,745. The crude rate (43.70) for this age group is therefore equal to the total number of mortality cases (1,633) divided by the total population (3,736,745), multiplied by 100,000.

Table 1. Cancer Mortality, All Age Groups, EPA Region 9, 1982.

Age Group (Years)	Mortality Cases	Year 1982 Population	Crude Death Rate	2000 Std. Population	Weighted Factor
<1 year	32	515,809	6.20	13,818	0.09
1- 4 years	108	1,824,635	5.92	55,317	0.33
5- 9 years	114	1,977,487	N/A		
10-14 years	94	2,188,828	N/A		
5-14 years	208	4,166,315	4.99	145,565	0.73
15-19 years	139	2,432,939	N/A		
20-24 years	180	2,884,175	N/A		
15-24 years	319	5,317,114	6.00	138,646	0.83
25-34 years	694	5,551,792	12.50	135,573	1.69
35-44 years	1,633	3,736,745	43.70	162,613	7.11
45-54 years	4,662	2,793,603	166.88	134,834	22.50
55-64 years	11,283	2,679,802	421.04	87,247	36.73
65-74 years	15,423	1,876,606	821.86	66,037	54.27
75-84 years	11,397	912,865	1248.49	44,842	55.98
85+ years	4,424	269,593	1640.99	15,508	25.45
Unknown	27	0	N/A	0	0
Total	*50,210*	*29,644,879*	*N/A*	*1,000,000*	N/A
Age-Adjusted Mortality Rate					**205.7**

As described above, the Weighted Factor is the Crude Death Rate multiplied by the 2000 Standard Population for that age group and divided by the total Standard Population (the total of the age-group populations). For example, the weighted factor for the 35-44 years age group is the crude rate (43.70) times the 2000 population for that group (162,613), divided by the total 2000 Standard Population (1,000,000), which equals 7.11. The 1982 Region 9 age-adjusted mortality rate, 205.7, is the sum of the weighted factors of all age groups.

Notes:

- For the 5-14 and 15-24 years categories it is necessary to merge two sets of age ranges to match the age-adjustment grouping used within WONDER.

- For mortality indicators that were also compiled for children (ages 0-19 years), we only used the data for the age groups 0-1, 1-4, 5-9, 10-14, and 15-19 years, and then we age-adjusted these data using a set of age-adjustment factors that only cover to age 19 years.

- For the file that compiles birth defect mortality rates, the only data used from CDC WONDER are for the <1 year age group, so the crude rate equals the age-adjusted rate.

- Although data were queried for individual states to compile regional data, we did this by querying data for the entire United States from the CDC WONDER system, and specifying that the data be grouped by age and by year. Due to a quirk of CDC WONDER, if the user selects a single state for a query (instead of the entire United States), the population data are taken from a different data source: there are small discrepancies between these numbers and so the state-specific query should not be used to verify these compiled data.

Indicator: Cancer Mortality and Incidence (076 and 077)

Cancer is the second leading cause of death in the United States, accounting for about 23% of all deaths in 2001 (Anderson and Smith, 2003). The term “cancer” is used to characterize diseases in which abnormal cells divide without control. A cancerous cell loses its ability to regulate its own growth, control cell division, and communicate with other cells. Cancer cells can invade nearby tissues and can spread through the bloodstream and lymphatic system to other parts of the body (NCI, 2004). The risk of developing cancer increases with age and the environment (as broadly defined), genetic predisposition, certain viruses, and socioeconomic factors may all pay a role in the development and progression of the disease.

The contribution of environmental factors to the development of cancer has been and continues to be a major focus of research. Factors including individual food and beverage preferences, use of tobacco products, exposure to natural and medical radiation (including sunlight), workplace exposures, and pharmaceutical use as well as exposure to substances in the air, water and soil all may contribute individually (additive) or synergistically (i.e., an effect greater than the sum of each factor acting alone) to the development of cancer (NTP, 2004). Only in a small number of cases is it known what specific environmental factor(s) or condition(s) are responsible for the onset and development of cancers (NTP, 2004).

This indicator presents mortality and incidence for all U.S. cancers using data collected through the National Vital Statistics System, maintained by the National Center for Health Statistics (mortality) and the National Cancer Institute’s Surveillance, Epidemiology, and End Results (SEER) Program (incidence). The National Vital Statistics System (NVSS) registers virtually all deaths and births nationwide with data coverage from 1933 to present and from all 50 States and the District of Columbia. The SEER Program collects and publishes cancer incidence and survival data from 14 population-based cancer registries and three supplemental registries covering approximately 26 % of the U.S. population.

What the Data Show

In the United States, 553,768 and 557,271 people died of cancer in 2001 and 2002, respectively. Figure 076-1 presents the overall trends in cancer mortality for U.S. and the 10 EPA Regions for the time periods 1979-1998 and 1999-2001. The age-adjusted (2000 U.S. Standard Population) cancer mortality rate peaked around 1990 (216.0 per 100,000) and has been decreasing through 1998 with an overall rate of 200.7 per 100,000. A decline appears to continue between 1999-2001. In 1979, the Regional cancer mortality rates age-adjusted to the 2000 U.S. Standard Population ranged from 192.9 (Region 6) to 219.9 (Region 2) per 100,000 while age-adjusted rates in 1998 ranged from 177.3 (Region 8) to 210.4 (Region 3) per 100,000. Figure 076-2 presents a map of the 10 EPA Regions for the overall age-adjusted cancer mortality rates during 1999-2001. The rates on the map were divided into quartiles. The rates during that time period ranged between 172.7 (Region 8) and 211.3 (Region 3) per 100,000.

Like mortality, overall cancer incidence has been declining. Figure 077 presents the overall trend in cancer incidence between 1973-2000. Although a slow steady increase in cancer incidence occurred between 1973 and 1992 (peaked in 1992 with an age-adjusted cancer incidence of 509.9 per 100,000), overall incidence rates appear to have stabilized over the last ten years.

Differences exist in both mortality and incidence rates among gender, racial, and age groups, although rates within the different groups have been declining overtime. During 2001, those aged 65 and older had the highest cancer mortality (1,102.9 per 100,000) and incidence rates (2,158.7 per 100,000) compared to all other age categories. Both mortality and incidence rates are higher for men compared to women, and for blacks compared to whites. In 2001, the age-adjusted cancer mortality rate for black men was 330.9

per 100,000 compared to 239.2, 191.3, and 164.0 per 100,000 among white men, black women and white women, respectively (Anderson and Smith. 2003). Figure 077 presents age-adjusted cancer incidence for males and females between 1973-2000. Males peaked in 1992 with an age-adjusted incidence rate of 657.1 per 100,000 whereas the age-adjusted cancer incidence rates among women have slowly been increasing over time.

For cancer incidence, differences also occur between race and gender. The age-adjusted cancer incidence rate in 2001 for black men was 652.0 per 100,000 compared to 552.9 per 100,000 for white men; among women, the age-adjusted cancer incidence rate was 425.0 per 100,000 for white women compared to 380.1 per 100,000 among black women.

Indicator Limitations

- Cancer mortality rates are based on under-lying cause-of-death as entered on a death certificate by a physician. Some individuals may have had competing causes of death. "When more than one cause or condition is entered by the physician, the underlying cause is determined by the sequence of conditions on the certificate, provisions of the ICD, and associated selection rules and modifications" (CDC WONDER). Consequently, some misclassification of reported mortality might occur in individuals with competing causes of death.

- The difference in overall cancer mortality rate for 1999 quoted in ROE03 (201.6 per 100,000) versus the rate quoted in this updated reported (200.8 per 100,000) is that the rate in ROE03 was based on 1990 Census projections and the rate has since been adjusted for 2000 standard population

- The SEER Program currently only collects and publishes cancer incidence and survival data from 14 population-based cancer registries and three supplemental registries covering approximately 26 % of the U.S. population. However, the sampled population is considered representative of the national population (NCI, 2005).

- The International Classification of Diseases 9th Revision (ICD-9) codes are used to specify underlying cause of death for years 1979 - 1998. Beginning in 1999, cause of death is specified with the International Classification of Diseases 10th Revision (ICD-10) codes. The two revisions differ substantially, and to prevent confusion about the significance of any specific disease code, data queries are separate.

Data Sources

Cancer Mortality: CDC. CDC WONDER. Compressed Mortality File, Underlying Cause of Death. http://wonder.cdc.gov.
The complete web-link pathway from the CDC WONDER Home Page is:
— Mortality—underlying cause of death — Mortality for 1999–2001 with ICD 10 codes.
Note: ICD-10 codes C00–C97 are listed as malignant neoplasms

For 2002 data: National Center for Health Statistics (NCHS). 2004. Deaths: Final Data for 2002. National Vital Statistics Reports.53(5). October 12, 2004.
http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf

Cancer Incidence: National Cancer Institute (NCI). Surveillance, Epidemiology, and End Results (SEER)*Stat Database: Incidence –SEER 9 Regions Public Use, November 2003 Sub (1973-2001), NCI,

DCCPS, Surveillance Research Program, Cancer Statistics Branch, released April 15, 2004, based on the November 2003 submission. http://wonder.cdc.gov/seerJ.html.
The complete web-link pathway from the CDC WONDER Home Page (http://wonder.cdc.gov/) is:
— Cancer Incidence — SEER Cancer Query System — SEER Incidence and US Mortality Statistics
Selection criteria: Age Adjusted Rates, Standard Population = 2000 Census, Nine SEER Registry, All Sites; All Ages.

The raw numbers for each state were downloaded from the CDC WONDER mortality database (http://wonder.cdc.gov). The raw numbers for each state within a region were combined and age-adjusted rates (2000 U.S. Standard Population) were calculated.

References

Anderson and Smith. 2003. National Vital Statistics Report (NVSR). Deaths: Leading Causes for 2001. Volume 52, Number 9. November 7, 2003. http://www.cdc.gov/nchs/data/nvsr/nvsr52/nvsr52_09.pdf.

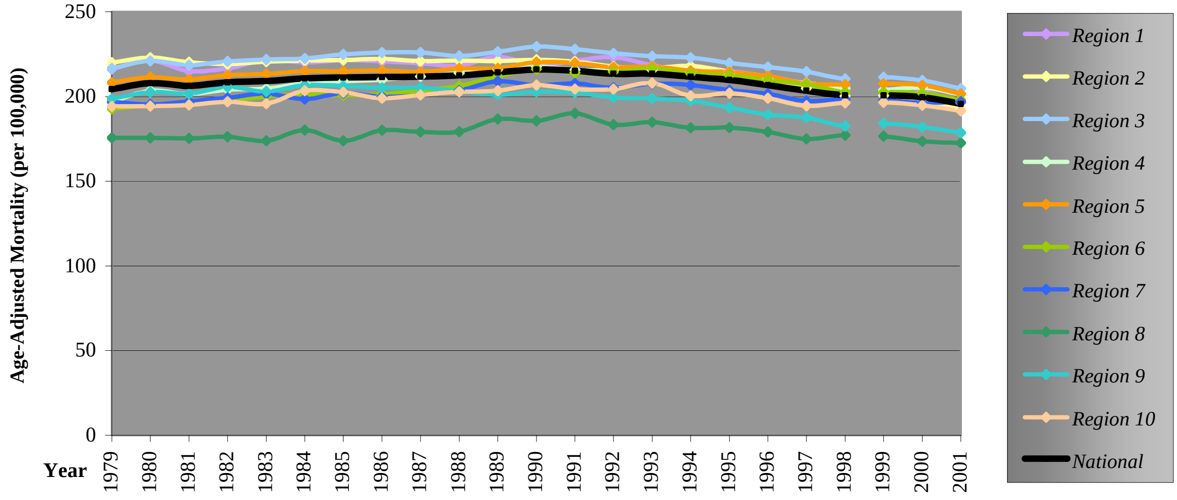
National Cancer Institute (NCI). Accessed October 7, 2004. http://cancer.gov/dictionary/

National Cancer Institute (NCI). Accessed January 11, 2005. http://seer.cancer.gov/about/

National Toxicology Program (NTP). 2004. Report on Carcinogens, Eleventh Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program. Accessed February 2, 2005. http://ntp.niehs.nih.gov/ntp/roc/toc11.html

Graphics

Figure 076-1. Age Adjusted U.S. Cancer Mortality Rates, total U.S. and 10 EPA Regions, 1979-2001*



* - Due to differences in the ICD system used for classifying mortalities, data from 1979-1998 should not be directly compared to data from 1999-2001.
ICD-9 CODES: 140-208 (1979-1998); ICD-10 CODES: C00-C97 (1999-2001)

Figure 076-2. Age Adjusted U.S. Cancer Mortality Rates in Quartiles, 10 EPA Regions, 1999-2001

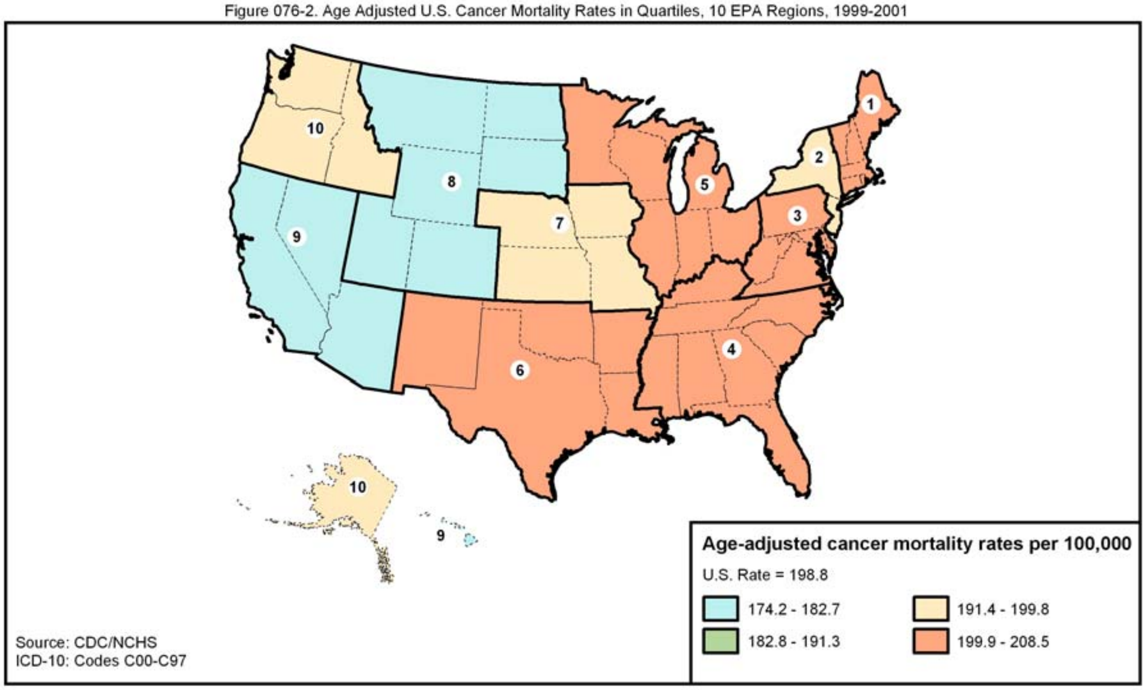
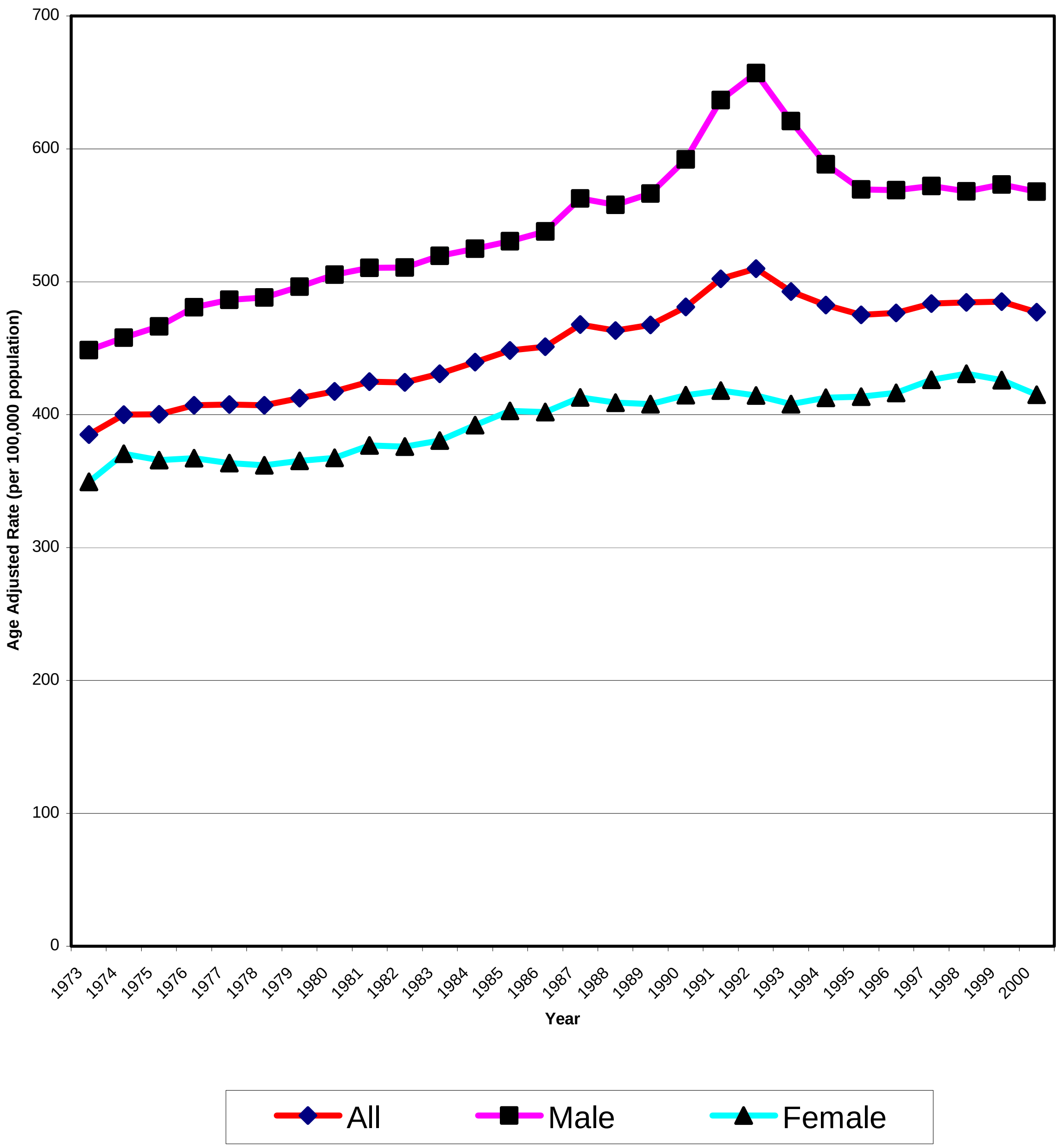


Figure 077: National Trends in Cancer Incidence Between 1973 and 2000



Source: NCI. Surveillance, Epidemiology, and End Results (SEER)*Stat Database: Incidence - SEER 9 Regions Public Use, November 2003 Sub (1973-2001), NCI DCCPS, Surveillance Research Program, Cancer Statistics Branch, Released April, 15, 2004. http://wonder.cdc.gov/seerJ.html.

R.O.E. Indicator QA/QC

Data Set Name: CANCER INCIDENCE & MORTALITY
Indicator Number: 076 (89117)
Data Set Source: CDC, NCHS - mortality; NCI - incidence
Data Collection Date: ongoing
Data Collection Frequency: yearly
Data Set Description: Cancer Incidence & Mortality (combines indicators 076 & 077)
Primary ROE Question: What are the trends in human disease and conditions for which environmental pollutants are thought to be to risk factors including across population subgroups and geographic regions?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. Mortality: The National Vital Statistics System (NVSS) is the oldest and most successful example of inter-governmental data sharing in Public Health and the shared relationships, standards, and procedures form the mechanism by which NCHS collects and disseminates the Nation's official vital statistics. The methodology for collecting vital statistics is standardized and outlined in "Model State Vital Statistics Act and Regulations" Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf) Incidence: The Surveillance, Epidemiology, and End Results (SEER) Program of the National Cancer Institute is an authoritative source of information on cancer incidence and survival in the United States, and is considered the standard for quality among cancer registries around the world. The SEER Program currently collects and publishes cancer incidence and survival data from 14 population-based cancer registries and three supplemental registries covering approximately 26 percent of the US population. Information on more than 3 million in situ and invasive cancer cases is included in the SEER database, and approximately 170,000 new cases are added each year within the SEER coverage areas. An overview of SEER can be found at http://seer.cancer.gov/about/. Incidence: The Surveillance, Epidemiology, and End Results (SEER) Program of the National Cancer Institute is an authoritative source of information on cancer incidence and survival in the United States, and is considered the standard for quality among cancer registries around the world. The SEER Program currently collects and publishes cancer incidence and survival data from 14 population-based cancer registries and three supplemental registries covering approximately 26 percent of the US population. Information on more than 3 million in situ and invasive cancer cases is included in the SEER database, and approximately 170,000 new cases are added each year within the SEER coverage areas. An overview of SEER can be found at http://seer.cancer.gov/about/.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Mortality: Yes. The National Vital Statistics System is responsible for the Nation's official vital statistics. These vital statistics are provided through State-operated registration systems. Standard forms for the collection of data and model procedures for the uniform registration of the events are developed and recommended for State use through cooperative activities of the States and the NCHS (http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf). U.S. Standard Death Certificates are revised periodically. Most state certificates conform closely in content and arrangement to the standard certificate recommended by NCHS and all certificates contain a minimum data set specified by NCHS. Demographic information on the death certificate is provided by the funeral director based on information supplied by an informant. A physician, medical examiner, or coroner provides medical certification of cause of death. Incidence: Yes. The SEER Registries routinely collect data on patient demographics, primary tumor site, morphology, stage at diagnosis, first course of treatment, and follow-up for vital status. The SEER Program is the only comprehensive source of population-based information in the United States that includes stage of cancer at the time of diagnosis and survival rates within each stage. Additionally, studies are conducted on a yearly basis in SEER areas to evaluate the quality and completeness of the data being reported. (http://seer.cancer.gov/about/quality.html)

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Mortality: Yes. The data collected by NVSS are routinely referenced and used in epidemiological studies. Regional Mortality: Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled through use of CDC WONDER. Maps were created for this same data. See attached file, Calculating data for GIS mortality maps and regional trends.doc , for more information on the calculation of rates. Data file for maps can be found in file MapDataSummaries.xls . Incidence: Yes. The data are published routinely referenced in scientific journals. Incidence: Yes. The data are published routinely referenced in scientific journals.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Mortality: Virtually all deaths are registered with the NVSS nationwide. The temporal coverage of the data is from 1933 to present. Data are collected from all 50 States including the District of Columbia. Incidence: Collection began in 1973 and covers approximately 26 percent of the US population. However, this 26 percent is representative of the national population (http://seer.cancer.gov/registries/characteristics.html).

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Mortality: The data set has nationwide death reporting, including sensitive populations. Incidence: This is nationally representative data

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Not applicable

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Mortality: The sampling and quality assurance information can be found in Model State Vital Statistics Act and Regulations Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf). Documentation is also available at http://wonder.cdc.gov/wonder/help/mort.html Table HH2 data source: CDC. CDC WONDER. Compressed Mortality File, Underlying Cause of Death. http://wonder.cdc.gov. The complete web-link pathway from the CDC WONDER Home Page is: à Mortality underlying cause of death à Mortality for 1999 2001 with ICD 10 codes For 2002 data: National Center for Health

Statistics (NCHS). 2004. Deaths Final Data 2002. National Vital Statistics vol 53 no. 5 http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf Regional Mortality: Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled through use of CDC WONDER. Maps were created for this same data. See attached file, Calculating data for GIS mortality maps and regional trends.doc , for more information on the calculation of rates. Data file for maps can be found in file MapDataSummaries.xls . Incidence: Each data registry uses its own procedure for collecting and recording data. A complete list of registries and contact information can be found at http://seer.cancer.gov/registries/. Additionally, the North American Association of Central Cancer Registries (http://www.naaccr.org/) helps to guide all state registries to achieve data content and compatibility acceptable for pooling data and improving national estimates. The SEER team is currently developing computer applications to unify cancer registration systems and to analyze and disseminate population-based data. Table HH2 data source: National Cancer Institute (NCI). Surveillance, Epidemiology, and End Results (SEER)*Stat Database: Incidence SEER 9 Regions Public Use, November 2003 Sub (1973-2001), NCI, DCCPS, Surveillance Research Program, Cancer Statistics Branch, released April 15, 2004, based on the November 2003 submission. http://wonder.cdc.gov/seerJ.html. The complete web-link pathway from the CDC WONDER Home Page (http://wonder.cdc.gov/) is: à Cancer Incidence à SEER Cancer Query System à SEER Incidence and US Mortality Statistics Selection criteria: Age Adjusted Rates, Standard Population = 2000 Census, Nine SEER Registry, All Sites; All Ages

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Mortality: The data can be accessed up to the county level through the electronic data warehouse for CDC at http://wonder.cdc.gov. Individual level data are not available due to confidentiality issues. Incidence: Yes. The public-use data set can be accessed at http://seer.cancer.gov/publicdata/. Data located here includes SEER incidence and population data associated by age, sex, race, year of diagnosis, and geographic areas (including SEER registry and county). Furthermore, SEER distributes tools, such as the SEER*Stat (http://seer.cancer.gov/seerstat/) and SEER*Prep (http://seer.cancer.gov/seerprep/) software, for the analysis of SEER and other cancer databases. SEER data and resources are made available on the sites listed above, free of charge. Individual level data are not available due to confidentiality issues.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Mortality: Yes. Virtually all deaths from the 50 states, including District of Columbia, submit mortality data to the NVSS at NCHS. The recommended certificate of death is posted at http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf. The documentation for the mortality data set is http://wonder.cdc.gov/wonder/help/mort.html. Incidence: Yes. See questions T3Q1 and T3Q2 above.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Mortality: See answer to T3Q1 Incidence: The SEER Program is considered as the standard for quality among cancer registries around the world. Quality control has been an integral part of SEER since its inception. Every year, studies are conducted in the SEER areas to evaluate the quality and completeness of the data being reported (SEER's standard for case ascertainment is 98 percent). In some studies, a sample of cases is reabstracted to evaluate the accuracy of each of the data elements collected from the medical records. In other studies, targeted information gathering is performed to address specific data quality needs. Computer edits also are used by registries to ensure accurate and consistent data.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Not applicable

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Not applicable

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not applicable

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Mortality: The mortality data on the Compressed Mortality File at http://wonder.cdc.gov/mortSQL.html are based on records for all deaths occurring in the fifty states and the District of Columbia. Deaths to foreign residents are excluded. Deaths to residents who died abroad are not included on this file. The difference in overall cancer mortality rate for 1999 quoted in ROE03 (201.6 per 100,000) versus the rate quoted in this updated reported (200.8 per 100,000) is that the rate in ROE03 was based on 1990 Census projections and the rate has since been adjusted for 2000 standard population. Cancer mortality rates are based on under-lying cause-of-death as entered on a death certificate by a physician. Some individuals may have had competing causes of death. When more than one cause or condition is entered by the physician, the underlying cause is determined by the sequence of conditions on the certificate, provisions of the ICD, and associated selection rules and modifications. (CDC WONDER database) The 2002 mortality rates were not yet available in CDC WONDER database at the time of this indicator write-up. The age-adjusted mortality rates were obtained through National Center for Health Statistics publication. For purposes of comparison, it should be noted that mortality rates reported by NCHS reports differ slightly from those rates reported by CDC WONDER. NCHS uses U.S. Census Bureau population estimates for all age groups; CDC WONDER uses birth certificate data for the Under 1 Year age group and uses U.S. Census Bureau population estimates for all other age groups. The International Classification of Diseases 9th Revision (ICD 9) codes are used to specify underlying cause of death for years 1979 - 1998. Beginning in 1999, cause of death is specified with the International Classification of Diseases 10th Revision (ICD 10) codes. The two revisions differ substantially, and to prevent confusion about the significance of any specific disease code, data queries are separate. Regional data: Mortality data are not available for the U.S. territories in CDC WONDER. Thus, Regions 2 and 9 are calculated to include only States. Note that for the years 1979, 1981-1989, and 2001, if the user selects a WONDER query for the United States with data grouped by state, or selects a WONDER query for a specific state, WONDER reports state population figures that do not add up to the national population reported by WONDER. This is because the two different sets of populations come from different U.S. Census population estimates. (For all other years, these two sets of population data are the same.) Incidence: The SEER Program currently collects and publishes cancer incidence and survival data from 14 population-based cancer registries and three supplemental registries covering approximately 26 percent of the US population. However, the sampled population is representative of the national population.

Data set name(s): Indicator Maps
Cancer Mortality by EPA Region
Chronic Obstructive Pulmonary Disease (COPD) by EPA Region

Data set date(s): 1999-2001

Data source: CDC. WONDER Compressed Mortality 1999–2001 with ICD-10 Codes. http://wonder.cdc.gov/mortICD10J.html.

Data description: Mortality rates are for the U.S. population over the combined years of 1999, 2000, and 2001 (rates per 100,000 population, age-adjusted to the 2000 U.S. standard population). Underlying data were compiled from the WONDER system by age group and by state. Age-adjusted regional mortality rates for the period 1999-2001 were generated using the procedure described in "Calculation of Age-Adjusted Regional Mortality Rates Using State Data from CDC WONDER" (attached).

The mortality rates for each indicator were broken down into equal quartiles

ICD Codes:
Cancer: ICD-10 codes C00 – C97.
COPD: ICD-10 codes J40 – J47.

Supporting data files (represent a subset of the 1979-2001 regional trend data):
MapDataSummary.xls (see attached)

Calculation of Age-Adjusted Regional Mortality Rates Using State Data from CDC WONDER

Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled as detailed below. (Mortality data for 2002 and later are not yet available through CDC WONDER.)

Identifying relevant data

- For each mortality indicator (e.g., cancer, cardiovascular disease, asthma) was reviewed based on EPA's 2003 Draft Report on the Environment and the National Center for Health Statistics (NCHS) report that discusses ICD (International Classification of Diseases) to obtain the ICD codes that describe each of these indicators. Due to a revision of the ICD system in 1999, we obtained ICD-9 codes for the years 1979-1998 and ICD-10 codes for the years 1999-2001.

Downloading and organizing the data

- Mortality data was accessed through CDC's WONDER database (http://wonder.cdc.gov/).

- We downloaded a file for each year that regional mortality indicators were requested (1979-2001) and saved these data into separate sheets in Microsoft Excel (one workbook for each indicator). Both raw and compiled data are presented in each of these Excel workbooks. For example, '1999D' is the sheet with the raw data for the year 1999 and '1999' is the sheet with the calculations for that year.

- The calculation worksheet is organized as follows:

    - The first table arranges the raw data by state and age group. For each age group and state, two numbers are presented: the mortality cases and the associated population.

    - The second table (Regional Breakdown) groups the mortality cases and populations for the 50 states plus Washington, D.C., into the ten EPA regions, to obtain the total cases and total population for each region, by age group. (For a map of the EPA regions, refer to http://www.epa.gov/epahome/whereyou-live.htm.)

    - The third table (Regional Breakdown [combine certain groups]) merges two sets of age groups with each other (5-9 years with 10-14 years; 15-19 years with 20-24 years) to match the age-adjustment methodology used to calculate age-adjusted mortality rates in CDC WONDER (see below).

    - The fourth table on the worksheet (Regional Breakdown [Computation of Age-Adjusted Rate Components]) presents the basic steps of calculating age-adjusted mortality rates for each region (see below).

    - The final table on the Excel sheet (Regional Summary) lists the age-adjusted rates for each region and for the entire US; these values are compiled into the summary sheet

that covers all regions for all years for an indicator, accompanied by a trend chart that graphically depicts the regional data.

Calculating age-adjusted regional rates

The steps followed in calculating age-adjusted regional rates are detailed below, followed by a sample calculation.

Step 1
Using the following equation, the *crude death (or mortality) rate* is obtained by dividing the mortality cases ($Cases_i$) by the population for that age group ($Population_i$), then by multiplying by 100,000 (to get the cases per 100,000). This is done for each age group within each region. (The "i" subscript is included to indicate that this calculation is performed for several age groups, i.e. $CrudeRate_{<1\ year}$, $CrudeRate_{1\text{-}4\ years}$, etc.)

$$CrudeRate_i = \frac{Cases_i}{Population_i} \times 100{,}000$$

Step 2
For each age group, the weighted age-adjusted factor is calculated, using 2000 U.S. standard population factors provided by NCHS (See Table 1 below). The age-specific crude death rate is multiplied by that age group's standard population for the year 2000 (*2000* $Population_i$), and then divided by the total standard population for the year 2000 (*2000* $Population_{total}$). (For details on the standard population, see "Age-Adjustment of Death Rates" on the web page http://wonder.cdc.gov/wonder/help/mort.html[1]).

$$WeightedFactor = CrudeRate \times \frac{2000\,Population_i}{2000\,Population_{total}}$$

Table 1. United States Standard Population*

Age	**Number**
Under I year	13,818
1-4 years	55,317
5-14 years	145,565
15-24 years	138,646
25-34 years	135,573
35-44 years	162,613
45-54 years	134,834
55-64 years	87,247
65-74 years	66,037
75-84 years	44,842
85 years and over	15,508
All ages	1,000,000

* Based on year 2000 projected population

[1] The source cited by CDC WONDER for the age-adjustment data is the following NCHS report: *Anderson RN, Rosenberg HM. Age standardization of death rates: Implementation of the year 2000 standard. National Vital Statistics Reports; Vol 47 No 3. Hyattsville, Maryland. National Center for Health Statistics. 1998.*

Step 3

The age-adjusted mortality rate is then obtained by adding together the individual weighted factors for each age group:

$$AgeAdjustedRate = \sum_i WeightedFactor_i$$

Sample Calculation

Table 2 (below) shows the output of a sample calculation of the age-adjusted mortality rate for cancer (across all age groups) in EPA Region 9 in 1982. (Note that we have presented this in a format that is not used in the Excel workbook, in order to illustrate the calculations for a single region. However, all of the steps and calculations are identical.)

For each age group, the number of mortality cases is the sum of the mortality cases for Arizona, California, Hawaii, and Nevada, for that age group in that year; the population is the sum of the populations of these same four states for that age group in that year. For example, for the 35-44 years age group, the number of cancer mortalities for these states are 112 (Arizona), 1,413 (California), 53 (Hawaii), and 55 (Nevada), with the sum equaling 1,633. Similarly, the population is the sum of the respective states 338,654 (Arizona), 3,152,885 (California), 124,743 (Hawaii), and 120,463 (Nevada), which equals 3,736,745. The crude rate (43.70) for this age group is therefore equal to the total number of mortality cases (1,633) divided by the total population (3,736,745), multiplied by 100,000.

Table 1. Cancer Mortality, All Age Groups, EPA Region 9, 1982.

Age Group (Years)	Mortality Cases	Year 1982 Population	Crude Death Rate	2000 Std. Population	Weighted Factor
<1 year	32	515,809	6.20	13,818	0.09
1- 4 years	108	1,824,635	5.92	55,317	0.33
5- 9 years	114	1,977,487	N/A		
10-14 years	94	2,188,828	N/A		
5-14 years	208	4,166,315	4.99	145,565	0.73
15-19 years	139	2,432,939	N/A		
20-24 years	180	2,884,175	N/A		
15-24 years	319	5,317,114	6.00	138,646	0.83
25-34 years	694	5,551,792	12.50	135,573	1.69
35-44 years	1,633	3,736,745	43.70	162,613	7.11
45-54 years	4,662	2,793,603	166.88	134,834	22.50
55-64 years	11,283	2,679,802	421.04	87,247	36.73
65-74 years	15,423	1,876,606	821.86	66,037	54.27
75-84 years	11,397	912,865	1248.49	44,842	55.98
85+ years	4,424	269,593	1640.99	15,508	25.45
Unknown	27	0	N/A	0	0
Total	*50,210*	*29,644,879*	*N/A*	*1,000,000*	N/A
Age-Adjusted Mortality Rate					**205.7**

As described above, the Weighted Factor is the Crude Death Rate multiplied by the 2000 Standard Population for that age group and divided by the total Standard Population (the total of the age-group populations). For example, the weighted factor for the 35-44 years age group is the crude rate (43.70) times the 2000 population for that group (162,613), divided by the total 2000 Standard Population (1,000,000), which equals 7.11. The 1982 Region 9 age-adjusted mortality rate, 205.7, is the sum of the weighted factors of all age groups.

Notes:

- For the 5-14 and 15-24 years categories it is necessary to merge two sets of age ranges to match the age-adjustment grouping used within WONDER.

- For mortality indicators that were also compiled for children (ages 0-19 years), we only used the data for the age groups 0-1, 1-4, 5-9, 10-14, and 15-19 years, and then we age-adjusted these data using a set of age-adjustment factors that only cover to age 19 years.

- For the file that compiles birth defect mortality rates, the only data used from CDC WONDER are for the <1 year age group, so the crude rate equals the age-adjusted rate.

- Although data was queried for individual states to compile regional data, we did this by querying data for the entire United States from the CDC WONDER system, and specifying that the data be grouped by age and by year. Due to a quirk of CDC WONDER, if the user selects a single state for a query (instead of the entire United States), the population data are taken from a different data source: there are small discrepancies between these numbers and so the state-specific query should not be used to verify the compiled data.

Indicator: Childhood Asthma Mortality and Prevalence (094 and 095)

Asthma is a chronic respiratory disease characterized by inflammation of the airways and lungs. During an asthma attack, the airways that carry air to the lungs are constricted, and as a result, less air is able to flow in and out of the lungs (NHLBI, 2004). Asthma attacks can cause a multitude of symptoms ranging in severity from mild to life-threatening. These symptoms include wheezing, breathlessness, chest tightness, and coughing (NHLBI, 2004). Currently, there is no cure for asthma; however, children and adolescents who have asthma can still lead quality, productive lives if they control their asthma. Asthma can be controlled by taking medication and avoiding contact with environmental "triggers." Environmental triggers include cockroaches, dust mites, furry pets, mold, tobacco smoke, and certain chemicals (CDC 2004). For purposes of this discussion, asthma diagnosis is defined as the number of people who reported that they had ever been told by a doctor, nurse, or other health practitioner that they have asthma. An asthma attack is defined as the number of people who reported an asthma episode or attack in the past 12 months (CDC; 1999; 2000; 2001).

This indicator reflects childhood deaths (age 0-19 years) in the United States due to asthma as recorded in the National Vital Statistics System (NVSS), as well as the prevalence of asthma diagnosis and annual reported attacks among children (age 0-17 years) as recorded by the Center for Disease Control and Prevention's (CDC's) National Health Interview Study (NHIS). Virtually all deaths are registered with the NVSS nationwide. The temporal coverage of the data is from 1933 to present and data are collected from all 50 States and the District of Columbia. The National Health Interview Survey is a cross-sectional household interview survey. The sampling plan follows a multistage area probability design that permits the representative sampling of households in the U.S. The survey is designed so that the sample scheduled for each week is representative of the target population, and the weekly samples are additive over time. The response rate for the ongoing portion of the survey (core) has been between 94 and 98 percent over the years.

What the Data Show

Figure 094 presents trends in childhood (ages 0-19 years) asthma mortality for the U.S. overall and by EPA Region for the time periods 1979-1998 and 1999-2001. Nationally, the childhood age-adjusted (2000 U.S. Standard Population) asthma mortality has ranged between 0.2 per 100,000 and 0.4 per 100,000 during these periods. In 2001, 200 children (aged 0-19 years) died from asthma with an age-adjusted rate (2000 U.S. Standard Population) of 0.2 per 100,000 (Figure 094).

Among the 10 EPA Regions, the childhood age-adjusted mortality rate (2000 U.S. Standard Population) for asthma ranged between 0.0 and 0.8 per 100,000 between 1979 and 1998 and 0.1 and 0.5 between 1999 and 2001 (Figure 094). Region 7 had the largest variability in childhood asthma mortality rates during the 1979 to 1998 time-period, ranging from 0.1 to 0.8 per 100,000. Region 10 consistently had the lowest rates of childhood asthma during the entire period observed (i.e., 1979 –2001).

In 2002, approximately nine million children within the United States (aged 0-17 years) were reported as ever having a diagnosis of asthma and more than four million reported experiencing an asthma episode or attack during the previous 12 months (CDC, 2002). National trends in the age-adjusted (2000 U.S. Standard Population) attack prevalence rate have been increasing, from 52.7 per 1,000 in 1999 to 57.7 per 1,000 in 2002, however, a slight decrease (54.6 per 1,000) was observed for 2003 (Figure 095). Boys were more likely to have been diagnosed with asthma than girls. In 2002, the age-adjusted lifetime asthma prevalence among boys was 140 per 1,000 compared to girls at 104 per 1,000. Boys in 2002 also had a higher asthma attack prevalence at 68 per 1,000 compared to girls at 47 per 1,000 (CDC, 2002). Lifetime asthma prevalence was higher among Black children than White or Hispanic. In 2002, the age-adjusted (2000 Standard Population) lifetime asthma prevalence among Black children was 177 per 1,000 compared to 111 per 1,000 among White children and 103 per 1,000 among Hispanic children. Black children also had a higher attack prevalence. In 2002, Black children had an asthma attack prevalence of 86 per 1,000 compared to 52 per 1,000 among White children and 44 per 1,000 among Hispanic children (CDC, 2002).

Indicator Limitations

- Asthma mortality rates are based on underlying cause-of-death as entered on a death certificate by a physician. Some individuals may have had competing causes of death. "When more than one cause or condition is entered by the physician, the underlying cause is determined by the sequence of conditions on the certificate, provisions of the ICD, and associated selection rules and modifications" (CDC WONDER). Consequently, some misclassification of reported mortality might occur in individuals with competing causes of death.

- Lifetime asthma diagnosis prevalence and asthma attack within last 12 months are based on national estimates from the National Health Interview Survey. The National Health Interview Survey (NHIS) is a continuing nationwide sample survey in which data are collected through personal household interviews. Information is obtained by self-reporting.

- For the years 1979, 1981-1989, and 2001, if the user selects a CDC WONDER query for the United States with data grouped by state, or selects a WONDER query for a specific state, CDC WONDER reports state population figures that do not add up to the national population reported by CDC WONDER. This is because the two different sets of populations come from different U.S. Census population estimates. (For all other years, these two sets of population data are the same.)

- The International Classification of Diseases 9th Revision (ICD-9) codes were used to specify underlying cause of death for years 1979 - 1998. Beginning in 1999, cause of death is specified with the International Classification of Diseases 10th Revision (ICD-10) codes. The two revisions differ substantially, and to prevent confusion about the significance of any specific disease code, data queries are separate.

Data Sources

Mortality:
CDC. CDC WONDER. Compressed Mortality File, Underlying Cause of Death. http://wonder.cdc.gov.
The complete web-link pathway from the CDC WONDER Home Page is:
— Mortality—underlying cause of death — Mortality for 1999–2001 with ICD-10 codes.
Note: ICD-9 code 493; ICD-10 codes J45–J46 are listed as asthma.

The raw numbers for each state were downloaded from the CDC WONDER mortality database (http://wonder.cdc.gov). The raw numbers for each state within a region were combined and age-adjusted rates (2000 Standard Population) were calculated.

Prevalence:
CDC, National Center for Health Statistics (NCHS), Series 10: Summary Health Statistics for U.S. Children: National Health Interview Survey, 1999 (Report 210); 2000 (Report 213); 2001 (Report 216); 2002 (221). http://www.cdc.gov/nchs/products/pubs/pubd/series/sr10/ser10.htm. See Table 1.

References

Center for Disease Control and Prevention (CDC). 2004. Asthma's impact on children and adolescents. (Last Accessed November 22, 2004) http://www.cdc.gov/asthma/children.htm

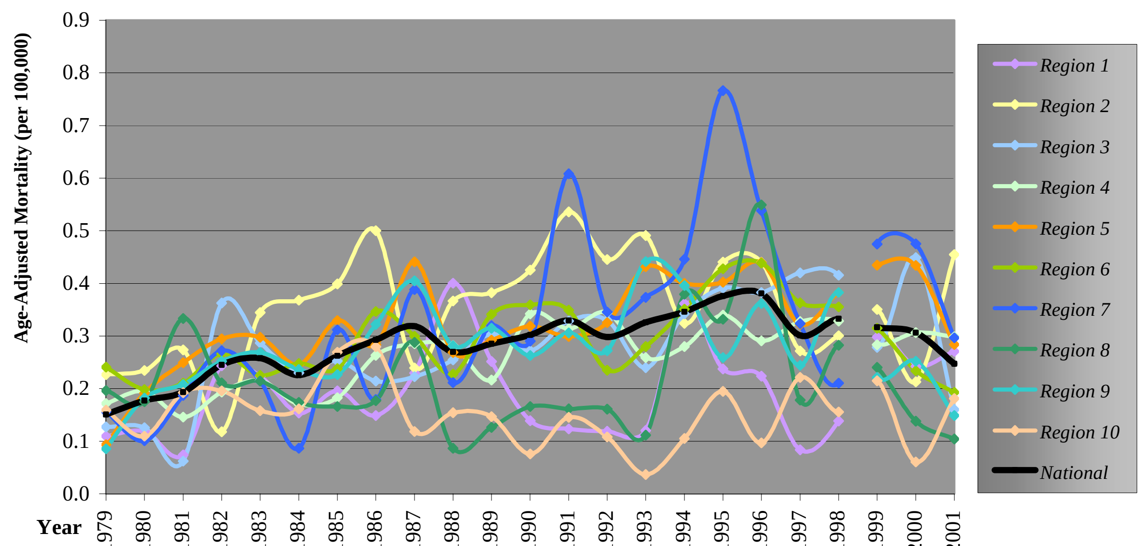
CDC, National Center for Health Statistics (NCHS), Series 10: Summary Health Statistics for U.S. Children: National Health Interview Survey, 1999 (Report 210); 2000 (Report 213); 2001 (Report 216); 2002 (221). http://www.cdc.gov/nchs/products/pubs/pubd/series/sr10/ser10.htm.

National Center for Health Statistics (NCHS). 2004. Health, United States, 2004 with Chartbook on Trends in the Health of Americans. Hyattsville, Maryland

National Heart, Lung, and Blood Institute (NHLBI). 2004. Diseases and Conditions Index. http://www.nhlbi.nih.gov/health/dci/Diseases/Asthma/Asthma_WhatIs.html Accessed November 12, 2004.

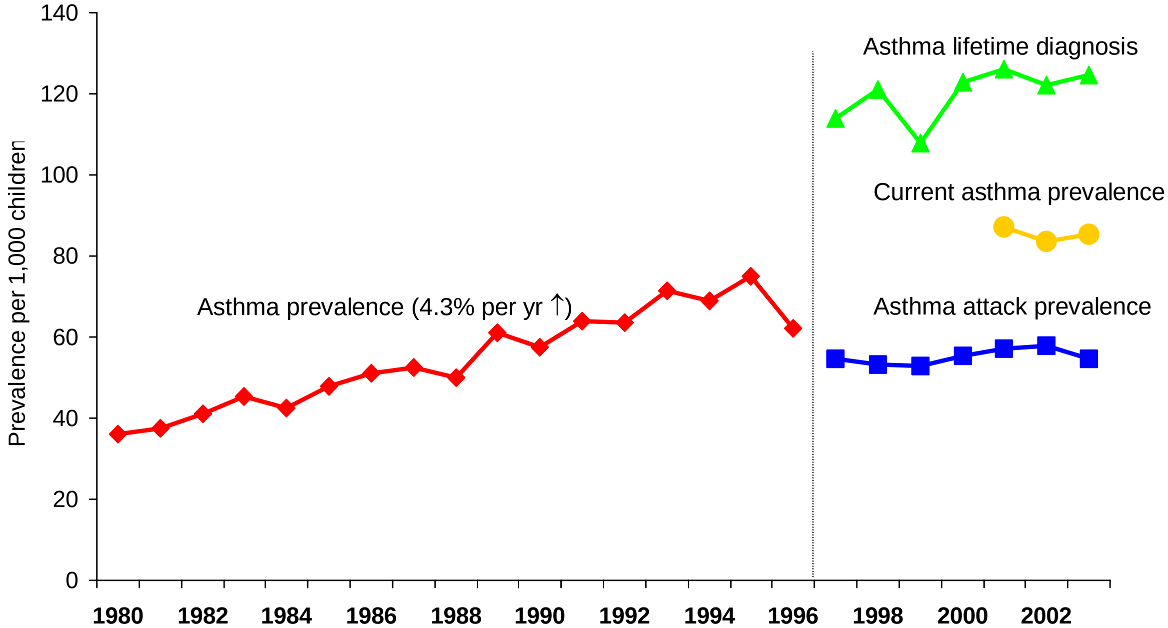
Graphics

Figure 094. Age Adjusted U.S. Childhood Asthma Mortality Rates (Ages 0-19 years), 10 EPA Regions, 1979-2001*



* - Due to differences in the ICD system used for classifying mortalities, data from 1979-1998 should not be directly compared to data from 1999-2001.
ICD-9 CODES: 493(1979-1998); ICD-10 CODES: J45-J46(1999-2001)

Figure 095. Asthma prevalence, 1980-96, lifetime diagnosis & asthma attack prevalence, 1997-2003, NHIS, children 0-17 years



Based on and updated from Akinbami, LJ and Schoendorf KC. 2002. Trends in Childhood Asthma: Prevalence, Health Care Utilization and Mortality. Data from CDC, National Center for Health Statistics, National Health Interview Surveys, 1980-2003.

R.O.E. Indicator QA/QC

Data Set Name: CHILDHOOD ASTHMA PREVALENCE & MORTALITY
Indicator Number: 094 (89095)
Data Set Source: CDC, NCHS; CDC, NHIS
Data Collection Date: ongoing
Data Collection Frequency: yearly
Data Set Description: Childhood Asthma Prevalence & Mortality (094 & 095)
Primary ROE Question: What are the trends in human disease and conditions for which environmental pollutants are thought to be to risk factors including across population subgroups and geographic regions?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Mortality: The National Vital Statistics System (NVSS) is the oldest and most successful example of inter-governmental data sharing in Public Health and the shared relationships, standards, and procedures form the mechanism by which NCHS collects and disseminates the Nation's official vital statistics. The methodology for collecting vital statistics is standardized and outlined in Model State Vital Statistics Act and Regulations Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf) Prevalence: Asthma prevalence is measured as a question on the National Health Interview Study (NHIS) through the Centers for Disease Control. The NHIS is the principal source of information on the health of the civilian noninstitutionalized population of the United States and is one of the major data collection programs of the National Center for Health Statistics (NCHS). Complete program methodology can be found at: http://www.cdc.gov/nchs/about/major/nhis/hisdesc.htm and http://www.cdc.gov/nchs/about/major/nhis/methods.htm. Prevalence: Asthma prevalence is measured as a question on the National Health Interview Study (NHIS) through the Centers for Disease Control. The NHIS is the principal source of information on the health of the civilian noninstitutionalized population of the United States and is one of the major data collection programs of the National Center for Health Statistics (NCHS). Complete program methodology can be found at: http://www.cdc.gov/nchs/about/major/nhis/hisdesc.htm and http://www.cdc.gov/nchs/about/major/nhis/methods.htm.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Mortality: Yes. The National Vital Statistics System is responsible for the Nation s official vital statistics. These vital statistics are provided through State-operated registration systems. Standard forms for the collection of data and model procedures for the uniform registration of the events are developed and recommended for State use through cooperative activities of the States and the NCHS (http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf). U.S. Standard Death Certificates are revised periodically. Most state certificates conform closely in content and arrangement to the standard certificate recommended by NCHS and all certificates contain a minimum data set specified by NCHS. Demographic information on the death certificate is provided by the funeral director based on information supplied by an informant. A physician, medical examiner, or coroner provides medical certification of cause of death. Prevalence: The National Health Interview Survey is a cross-sectional household interview survey. Sampling and interviewing are continuous throughout each year. The sampling plan follows a multistage area probability design that permits the representative sampling of households. The sampling plan was redesigned in 1995 to include the oversampling of both Black persons and Hispanic persons, and to draw samples from each state. Although the NHIS sample is too small to provide State level data with acceptable precision for each State, this design will facilitate the use of NHIS data with State-level telephone health surveys. In 1997 the collection methodology changed from paper and pencil questionnaires to computer-assisted personal interviewing (CAPI). The NHIS questionnaire was also revised extensively in 1997. In some instances, basic concepts measured in NHIS changed and in other instances the same concepts were measured in a different way. While some questions remain the same over time, they may be preceded by different questions or topics. For some questions, there was a change in the reference period for reporting an event or condition. Because of the extensive redesign of the questionnaire in 1997 and introduction of the CAPI method of data collection, data from 1997 and later years may not be comparable with earlier years.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Mortality: Yes. The data collected by NVSS are routinely referenced and used in epidemiological studies. Regional Mortality: Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled through use of CDC

WONDER. See attached file, "age-adjusted regional rates.doc", for more information on the calculation of rates. Prevalence: The NHIS is one of the principal sources of information on the health of the civilian noninstitutionalized population of the United States.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Mortality: Virtually all deaths are registered with the NVSS nationwide. The temporal coverage of the data is from 1933 to present. Data are collected from all 50 States including the District of Columbia. Prevalence: The sample design plan of NHIS follows a multistage probability design that permits a continuous sampling of the civilian noninstitutionalized population residing in the United States. The survey is designed in such a way that the sample scheduled for each week is representative of the target population, and the weekly samples are additive over time. The response rate for the ongoing portion of the survey (core) has been between 94 and 98 percent over the years. Response rates for special health topics (supplements) have generally been lower.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Mortality: The data set has nationwide death reporting, including sensitive populations. Prevalence: The sample design plan of NHIS follows a multistage probability design that permits a continuous sampling of the civilian noninstitutionalized population residing in the United States. The survey is designed in such a way that the sample scheduled for each week is representative of the target population, and the weekly samples are additive over time. The response rate for the ongoing portion of the survey (core) has been between 94 and 98 percent over the years. Response rates for special health topics (supplements) have generally been lower.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

No.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Mortality: The sampling and quality assurance information can be found in Model State Vital Statistics Act and Regulations Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf). Documentation is also available at http://wonder.cdc.gov/wonder/help/mort.html Source of data for Table HH2: Source: CDC. CDC WONDER. Compressed Mortality File, Underlying Cause of Death. http://wonder.cdc.gov. The complete web-link pathway from the CDC WONDER Home Page is: à Mortality underlying cause of death à Mortality for 1999 2001 with ICD 10 codes For 2002 data: National Center for Health Statistics (NCHS). 2004. Deaths Final Data 2002. National Vital Statistics vol 53 no. 5 http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf Regional Mortality: Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled through use of CDC WONDER. See attached file, "age-adjusted regional rates.doc", for more information on the calculation of rates. Prevalence: Methodology for collection and analysis of NHIS data can be found at: http://www.cdc.gov/nchs/about/major/nhis/methods.htm and http://www.cdc.gov/nchs/data/series/sr_02/sr02_130.pdf. Source of data for Table HH3: Mortality: CDC. CDC WONDER. Compressed Mortality File, Underlying Cause of Death. http://wonder.cdc.gov. The complete web-link pathway from the CDC WONDER Home Page is:

à Mortality underlying cause of death à Mortality for 1999 2001 with ICD 10 codes. Note: ICD codes J45 J46 are listed as asthma. Prevalence: CDC, National Center for Health Statistics (NCHS), Series 10: Summary Health Statistics for U.S. Children: National Health Interview Survey, 1999 (Report 210); 2000 (Report 213); 2001 (Report 216). http://www.cdc.gov/nchs/products/pubs/pubd/series/sr10/ser10.htm. See Table 1.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Mortality: The data can be accessed up to the county level through the electronic data warehouse for CDC at http://wonder.cdc.gov Individual level data are not available due to confidentiality issues. Prevalence: Data sets and accompanying documentation from 1992 through 2002 are available at: http://www.cdc.gov/nchs/about/major/nhis/quest_data_related_doc.htm

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Mortality: Yes. Virtually all deaths from the 50 states, including District of Columbia, submit mortality data to the NVSS at NCHS. The recommended certificate of death is posted at http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf The documentation for the mortality data set is http://wonder.cdc.gov/wonder/help/mort.html Prevalence: Questionnaires from the survey at various points of time are posted on the NHIS website: http://www.cdc.gov/nchs/about/major/nhis/quest_data_related_doc.htm. This study is an ongoing study.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Mortality: See answer to T3Q1 Prevalence: Quality assurance and quality control is provided in the document Design and Estimation for the National Health Interview Survey, 1995-2004 (http://www.cdc.gov/nchs/data/series/sr_02/sr02_130.pdf).

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Prevalence: All Statistical methods used in evaluating the data set can be found at: http://www.cdc.gov/nchs/about/major/nhis/methods.htm.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Not applicable

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not applicable

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Mortality: The mortality data on the Compressed Mortality File at http://wonder.cdc.gov/mortSQL.html are based on records for all deaths occurring in the fifty states and the District of Columbia. Deaths to foreign residents are excluded. Deaths to residents who died abroad are not included on this file. Asthma mortality rates are based on under-lying cause-of-death as entered on a death certificate by a physician. Some individuals may have had competing causes of death. When more than one cause or condition is entered by the physician, the underlying cause is determined by the sequence of conditions on the certificate, provisions of the ICD, and associated selection rules and modifications. (CDC WONDER database) The International Classification of Diseases 9th Revision (ICD 9) codes are used to specify underlying cause of death for years 1979 - 1998. Beginning in 1999, cause of death is specified with the International Classification of Diseases 10th Revision (ICD 10) codes. The two revisions differ substantially, and to prevent confusion about the significance of any specific disease code, data queries are separate. For purposes of comparison, it should be noted that mortality rates reported by NCHS reports differ slightly from those rates reported by CDC WONDER. NCHS uses U.S. Census Bureau population estimates for all age groups; CDC WONDER uses birth certificate data for the Under 1 Year age group and uses U.S. Census Bureau population estimates for all other age groups. Regional data: Mortality data are not available for the U.S. territories in CDC WONDER. Thus, Regions 2 and 9 are calculated to include only States. Note that for the years 1979, 1981-1989, and 2001, if the user selects a WONDER query for the United States with data grouped by state, or selects a WONDER query for a specific state, WONDER reports state population figures that do not add up to the national population reported by WONDER. This is because the two different sets of populations come from different U.S. Census population estimates. (For all other years, these two sets of population data are the same.) Prevalence: Persons excluded from this study are patients in long-term care facilities; persons on active duty with the Armed Forces (though their dependents are included); and U.S. nationals living in foreign countries. The response rate for the ongoing portion of the survey (core) has been between 94 and 98 percent over the years. Response rates for special health topics (supplements) have generally been lower.

Calculation of Age-Adjusted Regional Mortality Rates Using State Data from CDC WONDER

Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled as detailed below. (Mortality data for 2002 and later are not yet available through CDC WONDER.)

Identifying relevant data

- Each mortality indicator (e.g., cancer, cardiovascular disease, asthma) was reviewed based on EPA's 2003 Draft Report on the Environment and a National Center for Health Statistics (NCHS) report that discusses ICD (International Classification of Diseases) to obtain the ICD codes that describe each of these indicators. Due to a revision of the ICD system in 1999, ICD-9 codes were obtained for the years 1979-1998 and ICD-10 codes for the years 1999-2001.

Downloading and organizing the data

- Mortality data were accessed through CDC's WONDER database (http://wonder.cdc.gov/).

- We downloaded a file for each year that regional mortality indicators were requested (1979-2001) and saved these data into separate sheets in Microsoft Excel (one workbook for each indicator). Both raw and compiled data are presented in each of these Excel workbooks. For example, '1999D' is the sheet with the raw data for the year 1999 and '1999' is the sheet with the calculations for that year.

- The calculation worksheet is organized as follows:

    - The first table arranges the raw data by state and age group. For each age group and state, two numbers are presented: the mortality cases and the associated population.

    - The second table (Regional Breakdown) groups the mortality cases and populations for the 50 states plus Washington, D.C., into the ten EPA regions, to obtain the total cases and total population for each region, by age group. (For a map of the EPA regions, refer to http://www.epa.gov/epahome/whereyou-live.htm.)

    - The third table (Regional Breakdown [combine certain groups]) merges two sets of age groups with each other (5-9 years with 10-14 years; 15-19 years with 20-24 years) to match the age-adjustment methodology used to calculate age-adjusted mortality rates in CDC WONDER (see below).

    - The fourth table on the worksheet (Regional Breakdown [Computation of Age-Adjusted Rate Components]) presents the basic steps of calculating age-adjusted mortality rates for each region (see below).

    - The final table on the Excel sheet (Regional Summary) lists the age-adjusted rates for each region and for the entire US; these values are compiled into the summary sheet

that covers all regions for all years for an indicator, accompanied by a trend chart that graphically depicts the regional data.

Calculating age-adjusted regional rates

The steps followed in calculating age-adjusted regional rates are detailed below, followed by a sample calculation.

Step 1
Using the following equation, the *crude death (or mortality) rate* is obtained by dividing the mortality cases ($Cases_i$) by the population for that age group ($Population_i$), then by multiplying by 100,000 (to get the cases per 100,000). This is done for each age group within each region. (The "i" subscript is included to indicate that this calculation is performed for several age groups, i.e. $CrudeRate_{<1\ year}$, $CrudeRate_{1\text{-}4\ years}$, etc.)

$$CrudeRate_i = \frac{Cases_i}{Population_i} \times 100{,}000$$

Step 2
For each age group, the weighted age-adjusted factor is calculated, using 2000 U.S. standard population factors provided by NCHS (See Table 1 below). The age-specific crude death rate is multiplied by that age group's standard population for the year 2000 ($2000\ Population_i$), and then divided by the total standard population for the year 2000 ($2000\ Population_{total}$). (For details on the standard population, see "Age-Adjustment of Death Rates" on the web page http://wonder.cdc.gov/wonder/help/mort.html[1]).

$$WeightedFactor = CrudeRate \times \frac{2000 Population_i}{2000 Population_{total}}$$

Table 1. United States Standard Population*

Age	**Number**
Under I year	13,818
1-4 years	55,317
5-14 years	145,565
15-24 years	138,646
25-34 years	135,573
35-44 years	162,613
45-54 years	134,834
55-64 years	87,247
65-74 years	66,037
75-84 years	44,842
85 years and over	15,508
All ages	1,000,000

* Based on year 2000 projected population

[1] The source cited by CDC WONDER for the age-adjustment data is the following NCHS report: *Anderson RN, Rosenberg HM. Age standardization of death rates: Implementation of the year 2000 standard. National Vital Statistics Reports; Vol 47 No 3. Hyattsville, Maryland. National Center for Health Statistics. 1998.*

Step 3

The age-adjusted mortality rate is then obtained by adding together the individual weighted factors for each age group:

$$AgeAdjustedRate = \sum_i WeightedFactor_i$$

Sample Calculation

Table 2 (below) shows the output of a sample calculation of the age-adjusted mortality rate for cancer (across all age groups) in EPA Region 9 in 1982. (Note that we have presented this in a format that is not used in the Excel workbook, in order to illustrate the calculations for a single region. However, all of the steps and calculations are identical.)

For each age group, the number of mortality cases is the sum of the mortality cases for Arizona, California, Hawaii, and Nevada, for that age group in that year; the population is the sum of the populations of these same four states for that age group in that year. For example, for the 35-44 years age group, the number of cancer mortalities for these states are 112 (Arizona), 1,413 (California), 53 (Hawaii), and 55 (Nevada), with the sum equaling 1,633. Similarly, the population is the sum of the respective states 338,654 (Arizona), 3,152,885 (California), 124,743 (Hawaii), and 120,463 (Nevada), which equals 3,736,745. The crude rate (43.70) for this age group is therefore equal to the total number of mortality cases (1,633) divided by the total population (3,736,745), multiplied by 100,000.

Table 1. Cancer Mortality, All Age Groups, EPA Region 9, 1982.

Age Group (Years)	Mortality Cases	Year 1982 Population	Crude Death Rate	2000 Std. Population	Weighted Factor
<1 year	32	515,809	6.20	13,818	0.09
1- 4 years	108	1,824,635	5.92	55,317	0.33
5- 9 years	114	1,977,487	N/A		
10-14 years	94	2,188,828	N/A		
5-14 years	208	4,166,315	4.99	145,565	0.73
15-19 years	139	2,432,939	N/A		
20-24 years	180	2,884,175	N/A		
15-24 years	319	5,317,114	6.00	138,646	0.83
25-34 years	694	5,551,792	12.50	135,573	1.69
35-44 years	1,633	3,736,745	43.70	162,613	7.11
45-54 years	4,662	2,793,603	166.88	134,834	22.50
55-64 years	11,283	2,679,802	421.04	87,247	36.73
65-74 years	15,423	1,876,606	821.86	66,037	54.27
75-84 years	11,397	912,865	1248.49	44,842	55.98
85+ years	4,424	269,593	1640.99	15,508	25.45
Unknown	27	0	N/A	0	0
Total	*50,210*	*29,644,879*	*N/A*	*1,000,000*	N/A
Age-Adjusted Mortality Rate					**205.7**

As described above, the Weighted Factor is the Crude Death Rate multiplied by the 2000 Standard Population for that age group and divided by the total Standard Population (the total of the age-group populations). For example, the weighted factor for the 35-44 years age group is the crude rate (43.70) times the 2000 population for that group (162,613), divided by the total 2000 Standard Population (1,000,000), which equals 7.11. The 1982 Region 9 age-adjusted mortality rate, 205.7, is the sum of the weighted factors of all age groups.

Notes:

- For the 5-14 and 15-24 years categories it is necessary to merge two sets of age ranges to match the age-adjustment grouping used within WONDER.

- For mortality indicators that were also compiled for children (ages 0-19 years), we only used the data for the age groups 0-1, 1-4, 5-9, 10-14, and 15-19 years, and then we age-adjusted these data using a set of age-adjustment factors that only cover to age 19 years.

- For the file that compiles birth defect mortality rates, the only data used from CDC WONDER are for the <1 year age group, so the crude rate equals the age-adjusted rate.

- Although data were queried for individual states to compile regional data, we did this by querying data for the entire United States from the CDC WONDER system, and specifying that the data be grouped by age and by year. Due to a quirk of CDC WONDER, if the user selects a single state for a query (instead of the entire United States), the population data are taken from a different data source: there are small discrepancies between these numbers and so the state-specific query should not be used to verify these compiled data.

Indicator: Childhood Cancer Mortality and Incidence (092 and 093)

The term “cancer” is used to characterize diseases in which abnormal cells divide without control. A cancerous cell loses its ability to regulate its own growth, control cell division, and communicate with other cells. The cellular changes caused by cancer cells are complex and occur over a period of time. This may be accelerated in children. The classification of cancers in children differs from the classification used for adult cancers. The International Classification of Childhood Cancer (ICCC) classifies childhood cancer based on tumor morphology rather than, as for adults, the site of the tumor. If left unchecked, cancer cells can invade nearby tissues and can spread through the bloodstream and lymphatic system to other parts of the body (NCI, 2004).

The causes of childhood cancers are largely unknown. Only a small percentage of cases can be explained by a few conditions such as specific chromosomal/genetic abnormalities (e.g., Down syndrome) and ionizing radiation exposure (NCI, 2002). Environmental exposures have long been suspected of increasing the risk of certain childhood cancers. Much research continues examining environmental influences on childhood cancer.

This indicator presents mortality and incidence for childhood cancers using data collected through the National Vital Statistics System, maintained by the National Center for Health Statistics (mortality) and the National Cancer Institute’s Surveillance, Epidemiology, and End Results (SEER) Program (incidence). The National Vital Statistics System (NVSS) registers virtually all deaths and births nationwide with data coverage from 1933 to present and from all 50 States and the District of Columbia. The SEER Program collects and publishes cancer incidence and survival data from 14 population-based cancer registries and three supplemental registries covering approximately 26 % of the U.S. population.

What the Data Show

Figure 092 presents the overall trends in childhood (ages 0-19 years) cancer mortality for U.S. and the 10 EPA Regions for the time periods 1979-1998 and 1999-2001. Between 1973 and 1998, the age-adjusted (2000 U.S. Standard Population) childhood cancer mortality rate has decreased. In 2001, 2,226 deaths occurred due to cancer in children and adolescents under 20 years of age compared with 2,243 deaths in 1999. However, the age-adjusted childhood (ages 0-19 years) cancer mortality rate (2000 U.S. Standard Population) has been stable at 2.8 per 100,000 people in years 1999 - 2001 (Figure 092). In 2001 the cancer mortality rate for those aged 1-4 years, 5-9 years, 10-14 years, and 15-19 years was 2.7, 2.4, 2.5 and 3.6 per 100,000, respectively. Although some regions have more variation in rates than others, an overall downward trend in the age-adjusted mortality rates (2000 U.S. Standard Population) for childhood cancer within the 10 EPA regions occurred between 1979 and 1998. In 2001, the rates ranged from 2.2 (Region 8) to 3.2 per 100,000 (Region 9).

Figure 093 presents the overall trends in childhood (ages 0-19 years) cancer incidence for the U.S. between 1973-2000. Generally, childhood cancer incidence has been increasing over time from an age-adjusted incidence rate of 12.9 per 100,000 in 1975 compared to 16.8 per 100,000 in 2000. Males generally had higher rates than females, although for some years there was cross-over (Figure 093). For those aged 0-14 years, the age-adjusted (2000 U.S. Standard Population) cancer incidence rate was 15.2 per 100,000 in 2001. Incidence among Black females and males aged 0-14 years was lower compared to White female and males at the same age. In 2001, Black females and males had age-adjusted childhood cancer incidence rates of 11.1 and 10.1 per 100,000, respectively, compared to White females and males with rates of 15.9 and 16.8 per 100,000, respectively.

Indicator Limitations

- Cancer mortality rates are based on under-lying cause-of-death as entered on a death certificate by a physician. Some individuals may have had competing causes of death. When more than one cause or condition is entered by the physician, the underlying cause is determined by the sequence of conditions on the certificate, provisions of the ICD, and associated selection rules and modifications (CDC WONDER). Consequently, some misclassification of reported mortality might occur in individuals with competing causes of death.

- The SEER Program currently collects and publishes cancer incidence and survival data from 14 population-based cancer registries and three supplemental registries covering approximately 26 percent of the U.S. population. However, the sampled population is representative of the national population (NCI, 2005).

- The overall cancer incidence rates listed in ROE03 were age adjusted to the 1970 standard population. The data presented in this report were updated for the 2000 standard population.

- For the years 1979, 1981-1989, and 2001, ~~if~~ the user selects a CDC WONDER query for the United States with data grouped by state, or selects a WONDER query for a specific state, CDC WONDER reports state population figures that do not add up to the national population. This is because the two different sets of populations come from different U.S. Census population estimates. (For all other years, these two sets of population data are the same.)

- The International Classification of Diseases 9th Revision (ICD-9) codes are used to specify underlying cause of death for years 1979 - 1998. Beginning in 1999, cause of death is specified with the International Classification of Diseases 10th Revision (ICD-10) codes. The two revisions differ substantially, and to prevent confusion about the significance of any specific disease code, data queries are separate.

Data Sources

Cancer Mortality: CDC. CDC WONDER. Compressed Mortality File, Underlying Cause of Death. http://wonder.cdc.gov.
The complete web-link pathway from the CDC WONDER Home Page is:
— Mortality—underlying cause of death — Mortality for 1999–2001 with ICD 10 codes.
Note: ICD-9 codes 140-208 and ICD-10 codes C00–C97 are listed as malignant neoplasms

The raw numbers for each state were downloaded from the CDC WONDER mortality database (http://wonder.cdc.gov). The raw numbers for each state within a region were combined and age adjusted rates (2000 Standard Population) were calculated.

Cancer Incidence: National Cancer Institute (NCI). Surveillance, Epidemiology, and End Results (SEER) Stat Database: Incidence –SEER 9 Regions Public Use, November 2003 Sub (1973-2001), NCI, DCCPS, Surveillance Research Program, Cancer Statistics Branch, released April 15, 2004, based on the November 2003 submission. http://wonder.cdc.gov/seerJ.html.

The complete web-link pathway from the CDC WONDER Home Page (http://wonder.cdc.gov/) is:
— Cancer Incidence — SEER Cancer Query System — SEER Incidence and US Mortality Statistics
Selection criteria: Age Adjusted Rates, Standard Population = 2000 Census, Nine SEER Registry, All Sites; All Ages

References

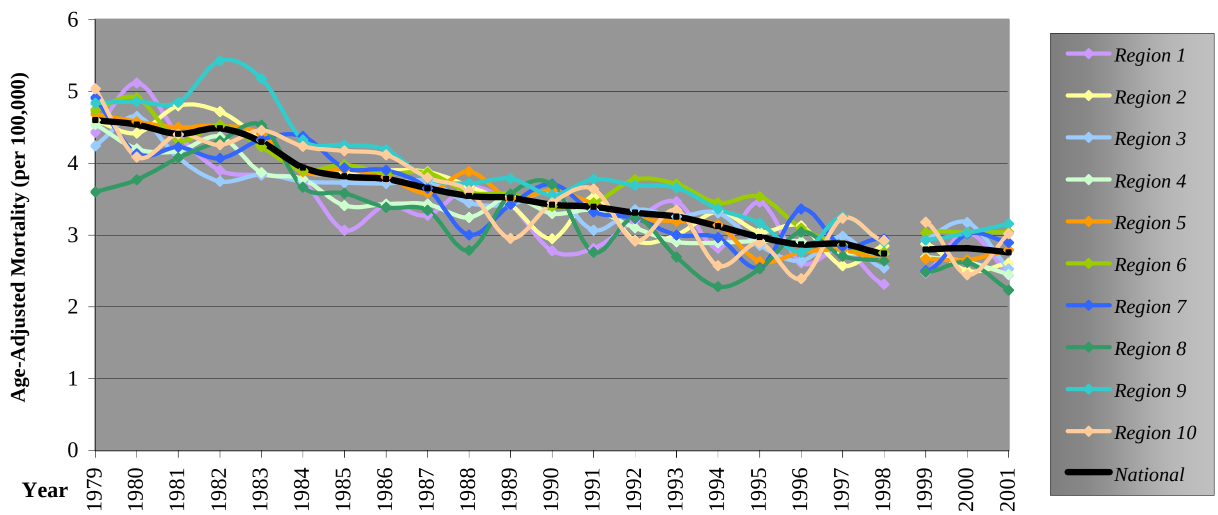
National Cancer Institute (NCI). 2002. Cancer Facts: National Cancer Institute Research on Childhood Cancers. Accessed February 2, 2005. http://cis.nci.nih.gov/fact/pdfdraft/6_sites/fs6_40.pdf

National Cancer Institute (NCI). 2004. Dictionary of Cancer Terms. Accessed October 7, 2004. http://cancer.gov/dictionary/

National Cancer Institute (NCI). 2005. About SEER. Accessed January 11, 2005. http://seer.cancer.gov/about/

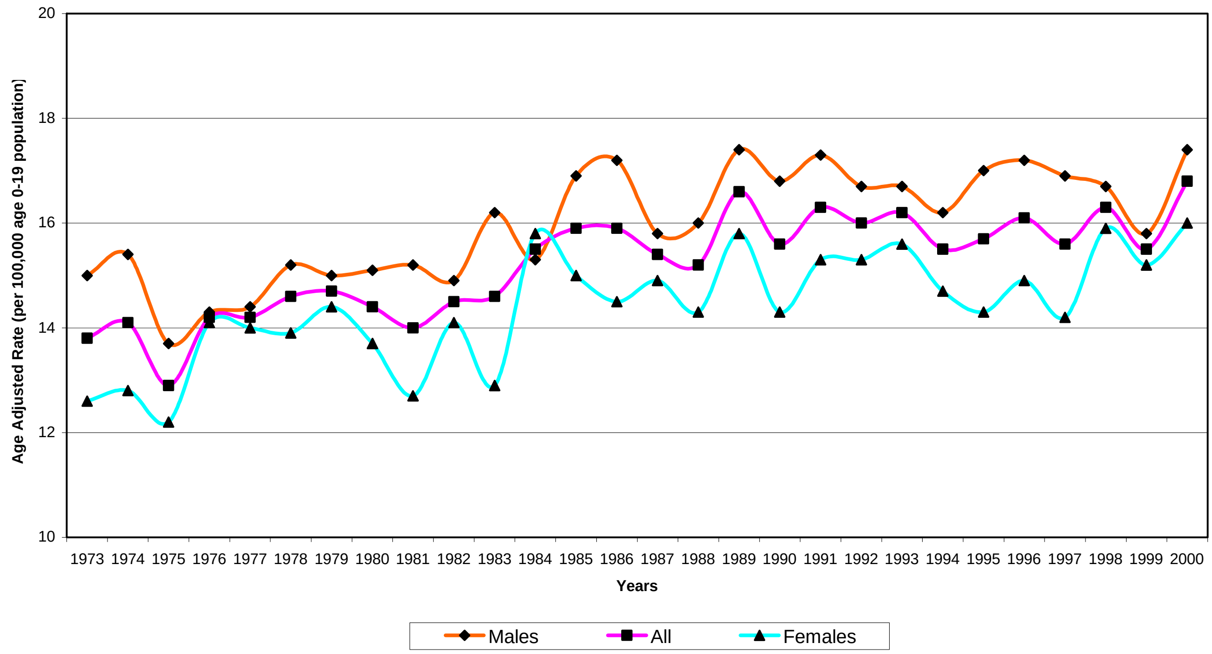
Graphics

Figure 092. Age Adjusted U.S. Childhood Cancer Mortality Rates (Ages 0-19 years), total U.S. and 10 EPA Regions, 1979-2001*



* - Due to differences in the ICD system used for classifying mortalities, data from 1979-1998 should not be directly compared to data from 1999-2001.
ICD-9 CODES: 140-208 (1979-1998); ICD-10 CODES: C00-C97 (1999-2001)

Figure 093: National Trends in Childhood Cancer Incidence (Ages 0-19 Years) Between 1973 and 2000



Source: NCI. Surveillance, Epidemiology, and End Results (SEER)*Stat Database: Incidence - SEER 9 Regions Public Use, November 2003 Sub (1973-2001), NCI DCCPS, Surveillance Research Program, Cancer Statistics Branch, Released April, 15, 2004. http://wonder.cdc.gov/seerJ.html.

R.O.E. Indicator QA/QC

Data Set Name: CHILDHOOD CANCER INCIDENCE & MORTALITY
Indicator Number: 092 (89093)
Data Set Source: CDC, NCHS; NCI, SEER
Data Collection Date: ongoing
Data Collection Frequency: yearly
Data Set Description: Childhood Cancer Incidence & Mortality (combines 092 & 093)
Primary ROE Question: What are the trends in human disease and conditions for which environmental pollutants are thought to be to risk factors including across population subgroups and geographic regions?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Mortality: Yes. The National Vital Statistics System (NVSS) is the oldest and most successful example of inter-governmental data sharing in Public Health and the shared relationships, standards, and procedures form the mechanism by which NCHS collects and disseminates the Nation's official vital statistics. The methodology for collecting vital statistics is standardized and outlined in Model State Vital Statistics Act and Regulations Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf) Incidence: The Surveillance, Epidemiology, and End Results (SEER) Program of the National Cancer Institute is an authoritative source of information on cancer incidence and survival in the United States, and is considered the standard for quality among cancer registries around the world. The SEER Program currently collects and publishes cancer incidence and survival data from 14 population-based cancer registries and three supplemental registries covering approximately 26 percent of the US population. Information on more than 3 million in situ and invasive cancer cases is included in the SEER database, and approximately 170,000 new cases are added each year within the SEER coverage areas. An overview of SEER can be found at http://seer.cancer.gov/about/. Incidence: The Surveillance, Epidemiology, and End Results (SEER) Program of the National Cancer Institute is an authoritative source of information on cancer incidence and survival in the United States, and is considered the standard for quality among cancer registries around the world. The SEER Program currently collects and publishes cancer incidence and survival data from 14 population-based cancer registries and three supplemental registries covering approximately 26 percent of the US population. Information on more than 3 million in situ and invasive cancer cases is included in the SEER database, and approximately 170,000 new cases are added each year within the SEER coverage areas. An overview of SEER can be found at http://seer.cancer.gov/about/.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Mortality: Yes. The National Vital Statistics System is responsible for the Nation s official vital statistics. These vital statistics are provided through State-operated registration systems. Standard forms for the collection of data and model procedures for the uniform registration of the events are developed and recommended for State use through cooperative activities of the States and the NCHS (http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf). U.S. Standard Death Certificates are revised periodically. Most state certificates conform closely in content and arrangement to the standard certificate recommended by NCHS and all certificates contain a minimum data set specified by NCHS. Demographic information on the death certificate is provided by the funeral director based on information supplied by an informant. A physician, medical examiner, or coroner provides medical certification of cause of death. Incidence: Yes. The SEER Registries routinely collect data on patient demographics, primary tumor site, morphology, stage at diagnosis, first course of treatment, and follow-up for vital status. The SEER Program is the only comprehensive source of population-based information in the United States that includes stage of cancer at the time of diagnosis and survival rates within each stage. Additionally, studies are conducted on a yearly basis in SEER areas to evaluate the quality and completeness of the data being reported. (http://seer.cancer.gov/about/quality.html)

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Mortality: Yes. The data collected by NVSS are routinely referenced and used in epidemiological studies. Regional Mortality: Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled through use of CDC WONDER. See attached file, age-adjusted regional rates.doc , for more information on the calculation of rates. Incidence: Yes. The data are published routinely referenced in scientific journals.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Mortality: Virtually all deaths are registered with the NVSS nationwide. The temporal coverage of the data is from 1933 to present. Data are collected from all 50 States including the District of Columbia. Incidence: Collection began in 1973 and covers approximately 26 percent of the US population. However, this 26 percent is representative to the national population (http://seer.cancer.gov/registries/characteristics.html).

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Mortality: The data set has nationwide death reporting, including sensitive populations. Incidence: This is nationally representative data

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Not applicable

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Mortality: The sampling and quality assurance information can be found in Model State Vital Statistics Act and Regulations Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf). Documentation is also available at http://wonder.cdc.gov/wonder/help/mort.html Regional Mortality: Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled through use of CDC WONDER. See attached file, age-adjusted regional rates.doc , for more information on the calculation of rates. Table HH2 data source: CDC. CDC WONDER. Compressed Mortality File, Underlying Cause of Death. http://wonder.cdc.gov. The complete web-link pathway from the CDC WONDER Home Page is: à Mortality underlying cause of death à Mortality for 1999 2001 with ICD 10 codes For 2002 data: National Center for Health Statistics (NCHS). 2004. Deaths Final Data 2002. National Vital Statistics vol 53 no. 5 http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf Incidence: Each data registry uses its own procedure for collecting and recording data. A complete list of registries and contact information can be found at http://seer.cancer.gov/registries/. Additionally, the North American Association of Central Cancer Registries (http://www.naaccr.org/) helps to guide all state registries to achieve data content and compatibility acceptable for pooling data and improving national estimates. The SEER team is currently developing computer applications to unify cancer registration systems and to analyze and disseminate population-based data. Table HH3 data source: Cancer Mortality: CDC. CDC WONDER. Compressed Mortality File, Underlying Cause of Death. http://wonder.cdc.gov. The complete web-link pathway from the CDC WONDER Home Page is: à Mortality underlying cause of death à Mortality for 1999 2001 with ICD 10 codes. Note: ICD-10 codes C00 C97 are listed as malignant neoplasms Cancer Incidence: National Cancer Institute (NCI). Surveillance, Epidemiology, and End Results (SEER)*Stat Database: Incidence SEER 9 Regions Public Use, November 2003 Sub (1973-2001), NCI, DCCPS, Surveillance Research Program, Cancer Statistics Branch, released April 15, 2004, based on the November 2003 submission. http://wonder.cdc.gov/seerJ.html. The complete web-link pathway from the CDC WONDER Home Page (http://wonder.cdc.gov/) is: à Cancer Incidence à SEER Cancer Query System à SEER Incidence and US Mortality Statistics

Selection criteria: Age Adjusted Rates, Standard Population = 2000 Census, Nine SEER Registry, All Sites; All Ages.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Mortality: The data can be accessed up to the county level through the electronic data warehouse for CDC at http://wonder.cdc.gov. Individual level data are not available due to confidentiality issues. Incidence: Yes. The public-use data set can be accessed at http://seer.cancer.gov/publicdata/. Data located here includes SEER incidence and population data associated by age, sex, race, year of diagnosis, and geographic areas (including SEER registry and county). Furthermore, SEER distributes tools, such as the SEER*Stat (http://seer.cancer.gov/seerstat/) and SEER*Prep (http://seer.cancer.gov/seerprep/) software, for the analysis of SEER and other cancer databases. SEER data and resources are made available on the sites listed above, free of charge. Individual level data are not available due to confidentiality issues.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Mortality: Yes. Virtually all deaths from the 50 states, including District of Columbia, submit mortality data to the NVSS at NCHS. The recommended certificate of death is posted at http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf. The documentation for the mortality data set is http://wonder.cdc.gov/wonder/help/mort.html. Incidence: Yes. See questions T3Q1 and T3Q2 above.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Mortatlity: See answer to T3Q1 Incidence: The SEER Program is considered as the standard for quality among cancer registries around the world. Quality control has been an integral part of SEER since its inception. Every year, studies are conducted in the SEER areas to evaluate the quality and completeness of the data being reported (SEER's standard for case ascertainment is 98 percent). In some studies, a sample of cases is reabstracted to evaluate the accuracy of each of the data elements collected from the medical records. In other studies, targeted information gathering is performed to address specific data quality needs. Computer edits also are used by registries to ensure accurate and consistent data.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Not applicable

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Not applicable

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not applicable

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Mortality: The mortality data on the Compressed Mortality File at http://wonder.cdc.gov/mortSQL.html are based on records for all deaths occurring in the fifty states and the District of Columbia. Deaths to foreign residents are excluded. Deaths to residents who died abroad are not included on this file. For purposes of comparison, it should be noted that mortality rates reported by NCHS reports differ slightly from those rates reported by CDC WONDER. NCHS uses U.S. Census Bureau population estimates for all age groups; CDC WONDER uses birth certificate data for the Under 1 Year age group and uses U.S. Census Bureau population estimates for all other age groups. Regional data: Mortality data are not available for the U.S. territories in CDC WONDER. Thus, Regions 2 and 9 are calculated to include only States. Note that for the years 1979, 1981-1989, and 2001, if the user selects a WONDER query for the United States with data grouped by state, or selects a WONDER query for a specific state, WONDER reports state population figures that do not add up to the national population reported by WONDER. This is because the two different sets of populations come from different U.S. Census population estimates. (For all other years, these two sets of population data are the same.) Cancer mortality rates are based on under-lying cause-of-death as entered on a death certificate by a physician. Some individuals may have had competing causes of death. When more than one cause or condition is entered by the physician, the underlying cause is determined by the sequence of conditions on the certificate, provisions of the ICD, and associated selection rules and modifications. (CDC WONDER database) The International Classification of Diseases 9th Revision (ICD 9) codes are used to specify underlying cause of death for years 1979 - 1998. Beginning in 1999, cause of death is specified with the International Classification of Diseases 10th Revision (ICD 10) codes. The two revisions differ substantially, and to prevent confusion about the significance of any specific disease code, data queries are separate. Incidence: The SEER Program currently collects and publishes cancer incidence and survival data from 14 population-based cancer registries and three supplemental registries covering approximately 26 percent of the US population. However, the sampled population is representative of the national population.

Calculation of Age-Adjusted Regional Mortality Rates Using State Data from CDC WONDER

Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled as detailed below. (Mortality data for 2002 and later are not yet available through CDC WONDER.)

Identifying relevant data

- Each mortality indicator (e.g., cancer, cardiovascular disease, asthma) was reviewed based on EPA's 2003 Draft Report on the Environment and a National Center for Health Statistics (NCHS) report that discusses ICD (International Classification of Diseases) to obtain the ICD codes that describe each of these indicators. Due to a revision of the ICD system in 1999, ICD-9 codes were obtained for the years 1979-1998 and ICD-10 codes for the years 1999-2001.

Downloading and organizing the data

- Mortality data were accessed through CDC's WONDER database (http://wonder.cdc.gov/).

- We downloaded a file for each year that regional mortality indicators were requested (1979-2001) and saved these data into separate sheets in Microsoft Excel (one workbook for each indicator). Both raw and compiled data are presented in each of these Excel workbooks. For example, '1999D' is the sheet with the raw data for the year 1999 and '1999' is the sheet with the calculations for that year.

- The calculation worksheet is organized as follows:

    - The first table arranges the raw data by state and age group. For each age group and state, two numbers are presented: the mortality cases and the associated population.

    - The second table (Regional Breakdown) groups the mortality cases and populations for the 50 states plus Washington, D.C., into the ten EPA regions, to obtain the total cases and total population for each region, by age group. (For a map of the EPA regions, refer to http://www.epa.gov/epahome/whereyou-live.htm.)

    - The third table (Regional Breakdown [combine certain groups]) merges two sets of age groups with each other (5-9 years with 10-14 years; 15-19 years with 20-24 years) to match the age-adjustment methodology used to calculate age-adjusted mortality rates in CDC WONDER (see below).

    - The fourth table on the worksheet (Regional Breakdown [Computation of Age-Adjusted Rate Components]) presents the basic steps of calculating age-adjusted mortality rates for each region (see below).

    - The final table on the Excel sheet (Regional Summary) lists the age-adjusted rates for each region and for the entire US; these values are compiled into the summary sheet

that covers all regions for all years for an indicator, accompanied by a trend chart that graphically depicts the regional data.

Calculating age-adjusted regional rates

The steps followed in calculating age-adjusted regional rates are detailed below, followed by a sample calculation.

Step 1
Using the following equation, the *crude death (or mortality) rate* is obtained by dividing the mortality cases ($Cases_i$) by the population for that age group ($Population_i$), then by multiplying by 100,000 (to get the cases per 100,000). This is done for each age group within each region. (The "i" subscript is included to indicate that this calculation is performed for several age groups, i.e. $CrudeRate_{<1\ year}$, $CrudeRate_{1\text{-}4\ years}$, etc.)

$$CrudeRate_i = \frac{Cases_i}{Population_i} \times 100{,}000$$

Step 2
For each age group, the weighted age-adjusted factor is calculated, using 2000 U.S. standard population factors provided by NCHS (See Table 1 below). The age-specific crude death rate is multiplied by that age group's standard population for the year 2000 ($2000\ Population_i$), and then divided by the total standard population for the year 2000 ($2000\ Population_{total}$). (For details on the standard population, see "Age-Adjustment of Death Rates" on the web page http://wonder.cdc.gov/wonder/help/mort.html[1]).

$$WeightedFactor = CrudeRate \times \frac{2000Population_i}{2000Population_{total}}$$

Table 1. United States Standard Population*

Age	Number
Under I year	13,818
1-4 years	55,317
5-14 years	145,565
15-24 years	138,646
25-34 years	135,573
35-44 years	162,613
45-54 years	134,834
55-64 years	87,247
65-74 years	66,037
75-84 years	44,842
85 years and over	15,508
All ages	1,000,000

* Based on year 2000 projected population

[1] The source cited by CDC WONDER for the age-adjustment data is the following NCHS report: *Anderson RN, Rosenberg HM. Age standardization of death rates: Implementation of the year 2000 standard. National Vital Statistics Reports; Vol 47 No 3. Hyattsville, Maryland. National Center for Health Statistics. 1998.*

Step 3
The age-adjusted mortality rate is then obtained by adding together the individual weighted factors for each age group:

$$AgeAdjustedRate = \sum_i WeightedFactor_i$$

Sample Calculation

Table 2 (below) shows the output of a sample calculation of the age-adjusted mortality rate for cancer (across all age groups) in EPA Region 9 in 1982. (Note that we have presented this in a format that is not used in the Excel workbook, in order to illustrate the calculations for a single region. However, all of the steps and calculations are identical.)

For each age group, the number of mortality cases is the sum of the mortality cases for Arizona, California, Hawaii, and Nevada, for that age group in that year; the population is the sum of the populations of these same four states for that age group in that year. For example, for the 35-44 years age group, the number of cancer mortalities for these states are 112 (Arizona), 1,413 (California), 53 (Hawaii), and 55 (Nevada), with the sum equaling 1,633. Similarly, the population is the sum of the respective states 338,654 (Arizona), 3,152,885 (California), 124,743 (Hawaii), and 120,463 (Nevada), which equals 3,736,745. The crude rate (43.70) for this age group is therefore equal to the total number of mortality cases (1,633) divided by the total population (3,736,745), multiplied by 100,000.

Table 1. Cancer Mortality, All Age Groups, EPA Region 9, 1982.

Age Group (Years)	Mortality Cases	Year 1982 Population	Crude Death Rate	2000 Std. Population	Weighted Factor
<1 year	32	515,809	6.20	13,818	0.09
1- 4 years	108	1,824,635	5.92	55,317	0.33
5- 9 years	114	1,977,487	N/A		
10-14 years	94	2,188,828	N/A		
5-14 years	208	4,166,315	4.99	145,565	0.73
15-19 years	139	2,432,939	N/A		
20-24 years	180	2,884,175	N/A		
15-24 years	319	5,317,114	6.00	138,646	0.83
25-34 years	694	5,551,792	12.50	135,573	1.69
35-44 years	1,633	3,736,745	43.70	162,613	7.11
45-54 years	4,662	2,793,603	166.88	134,834	22.50
55-64 years	11,283	2,679,802	421.04	87,247	36.73
65-74 years	15,423	1,876,606	821.86	66,037	54.27
75-84 years	11,397	912,865	1248.49	44,842	55.98
85+ years	4,424	269,593	1640.99	15,508	25.45
Unknown	27	0	N/A	0	0
Total	*50,210*	*29,644,879*	*N/A*	*1,000,000*	N/A
Age-Adjusted Mortality Rate					**205.7**

As described above, the Weighted Factor is the Crude Death Rate multiplied by the 2000 Standard Population for that age group and divided by the total Standard Population (the total of the age-group populations). For example, the weighted factor for the 35-44 years age group is the crude rate (43.70) times the 2000 population for that group (162,613), divided by the total 2000 Standard Population (1,000,000), which equals 7.11. The 1982 Region 9 age-adjusted mortality rate, 205.7, is the sum of the weighted factors of all age groups.

Notes:

- For the 5-14 and 15-24 years categories it is necessary to merge two sets of age ranges to match the age-adjustment grouping used within WONDER.

- For mortality indicators that were also compiled for children (ages 0-19 years), we only used the data for the age groups 0-1, 1-4, 5-9, 10-14, and 15-19 years, and then we age-adjusted these data using a set of age-adjustment factors that only cover to age 19 years.

- For the file that compiles birth defect mortality rates, the only data used from CDC WONDER are for the <1 year age group, so the crude rate equals the age-adjusted rate.

- Although data were queried for individual states to compile regional data, we did this by querying data for the entire United States from the CDC WONDER system, and specifying that the data be grouped by age and by year. Due to a quirk of CDC WONDER, if the user selects a single state for a query (instead of the entire United States), the population data are taken from a different data source: there are small discrepancies between these numbers and so the state-specific query should not be used to verify these compiled data.

Indicator: Chronic Obstructive Pulmonary Disease Mortality (080)

Chronic obstructive pulmonary disease (COPD), sometimes referred to as chronic lung disease, is a disease that damages lung tissue or restricts airflow through the bronchioles and bronchi (NHLBI, 2003). Chronic bronchitis and emphysema are the most frequently occurring COPDs. Smoking is the most common cause of COPD, including cigarette, pipe, and cigars (NHLBI, 2003). Other factors involved in the development and progression of COPD include second hand smoke, asthma, heavy exposure to air pollutants in the ambient air and workplace environment, genetic factors, and respiratory infections (CDC, 2005; American Lung Association, 2004).

This indicator presents U.S. mortality for COPD using data collected through the National Vital Statistics System (NVSS), maintained by the National Center for Health Statistics. The NVSS registers virtually all deaths and births nationwide with data coverage from 1933 to present and from all 50 States and the District of Columbia.

What the Data Show

In 2001 and 2002, COPD continues to be the fourth leading cause of mortality accounting for 123,013 and 124,816 deaths, respectively. Figure 080-1 presents the overall trends in COPD mortality for U.S. and the 10 EPA Regions for the time periods 1979-1998 and 1999-2001. The age-adjusted (2000 U.S. Standard Population) mortality rate for COPD ranged from 25.6 per 100,000 in 1979 to 41.8 per 100,000 in 1998. It is not apparent if this trend continues for the time period 1999-2002 where rates range from 45.4 per 100,000 in 1999 to 43.5 per 100,000 in 2002.

The age-adjusted COPD mortality rates (2000 U.S. Standard Population) have been increasing in each of the 10 Regions from 1979 to 1998. The rates ranged from 22.2 (Region 2) to 31.2 (Region 8) per 100,000 in 1979 and 33.5 (Region 2) to 47.9 (Region 8) per 100,000 in 1998. Figure 080-2 presents a map of the 10 EPA Regions for the overall age adjusted COPD mortality rates during 1999-2001. The rates on the map were divided into quartiles. The majority of regions have rates in the highest quartile (45.6 to 49.1 per 100,000).

COPD age-adjusted mortality rates have slowly been declining for males over time with rates of 58.7, 55.8 and 54.0 per 100,000 in 1999, 2000, and 2001, respectively. For females, the rates are lower than males and have been stable over the above three years (37.7, 37.4, and 37.6 per 100,000 in 1999, 2000, 2001, respectively). The COPD age-adjusted mortality rate is higher among Whites (45.6 per 100,000 in 2001) compared to Blacks (30.9 per 100,000 in 2001). COPD mortality rate increases with age with the rate at 0.3, 1.2, 22.5, and 301.6 per 100,000 for those aged 0-14 years, 15-44 years, 45-64 years and 65 years and older, respectively.

Indicator Limitations

- COPD mortality rates are based on under-lying cause-of-death as entered on a death certificate by a physician. Some individuals may have had competing causes of death. “When more than one cause or condition is entered by the physician, the underlying cause is determined by the sequence of conditions on the certificate, provisions of the ICD, and associated selection rules and modifications” (CDC WONDER). Consequently, some misclassification of reported mortality might occur in individuals with competing causes of death.

- The difference in overall the COPD mortality rate for 1999 quoted in ROE03 (45.8 per 100,000) versus the rate quoted in this updated reported (44.5 per 100,000) is that the rate in ROE03 was based on 1990 Census projections and the rate has since been adjusted for 2000 standard population.

- For the years 1979, 1981-1989, and 2001, if the user selects a CDC WONDER query for the United States with data grouped by state, or selects a WONDER query for a specific state, CDC WONDER reports state population figures that do not add up to the national population reported by CDC WONDER. This is because the two different sets of populations come from different U.S. Census population estimates. (For all other years, these two sets of population data are the same.)

- The International Classification of Diseases 9th Revision (ICD-9) codes were used to specify underlying cause of death for years 1979 - 1998. Beginning in 1999, cause of death is specified with the International Classification of Diseases 10th Revision (ICD-10) codes. The two revisions differ substantially, and to prevent confusion about the significance of any specific disease code, data queries are separate.

Data Sources

CDC. CDC WONDER. Compressed Mortality File, Underlying Cause of Death. http://wonder.cdc.gov.
The complete web-link pathway from the CDC WONDER Home Page is:
→ Mortality—underlying cause of death → Mortality for 1999–2001 with ICD 10 codes.
Note: ICD-10 codes J40-J47 are listed as all chronic lower respiratory diseases.
The raw numbers for each state were downloaded from the CDC WONDER mortality database (http://wonder.cdc.gov). The raw numbers for each state within a region were combined and age-adjusted rates (2000 U.S. Standard Population) were calculated.

National Center for Health Statistics. National Vital Statistics Reports, 53(5): Deaths: Final Data for 2002. October 12, 2004. Available at: http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf.

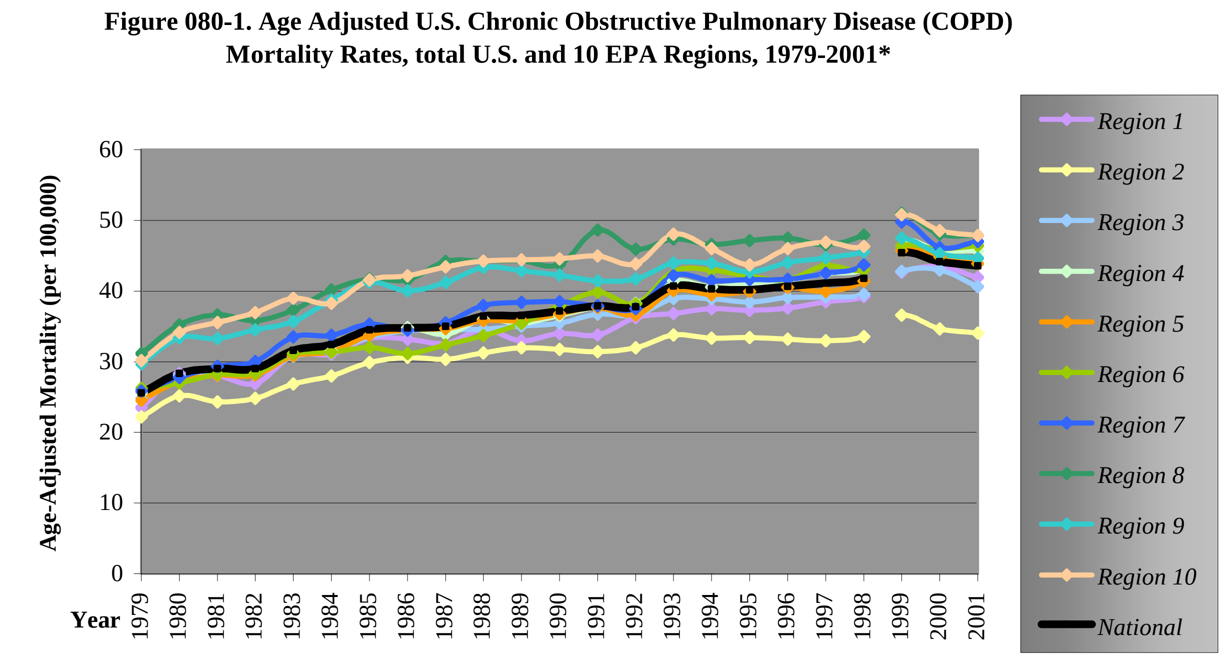
References

Center for Disease Control and Prevention (CDC). 2005. Facts About Chronic Obstructive Pulmonary Disease (COPD). Accessed February 7, 2005. http://www.cdc.gov/nceh/airpollution/copd/copdfaq.htm

National Heart, Lung, and Blood Institute (NHLBI). 2003. Chronic Obstructive Pulmonary Disease Fact Sheet. Bethesda, Maryland: U.S. Department of Health and Human Services, NIH, NHLBI. NIH publication No. 03-5229. Accessed October 29, 2004.
http://www.nhlbi.nih.gov/health/public/lung/other/copd_fact.pdf .

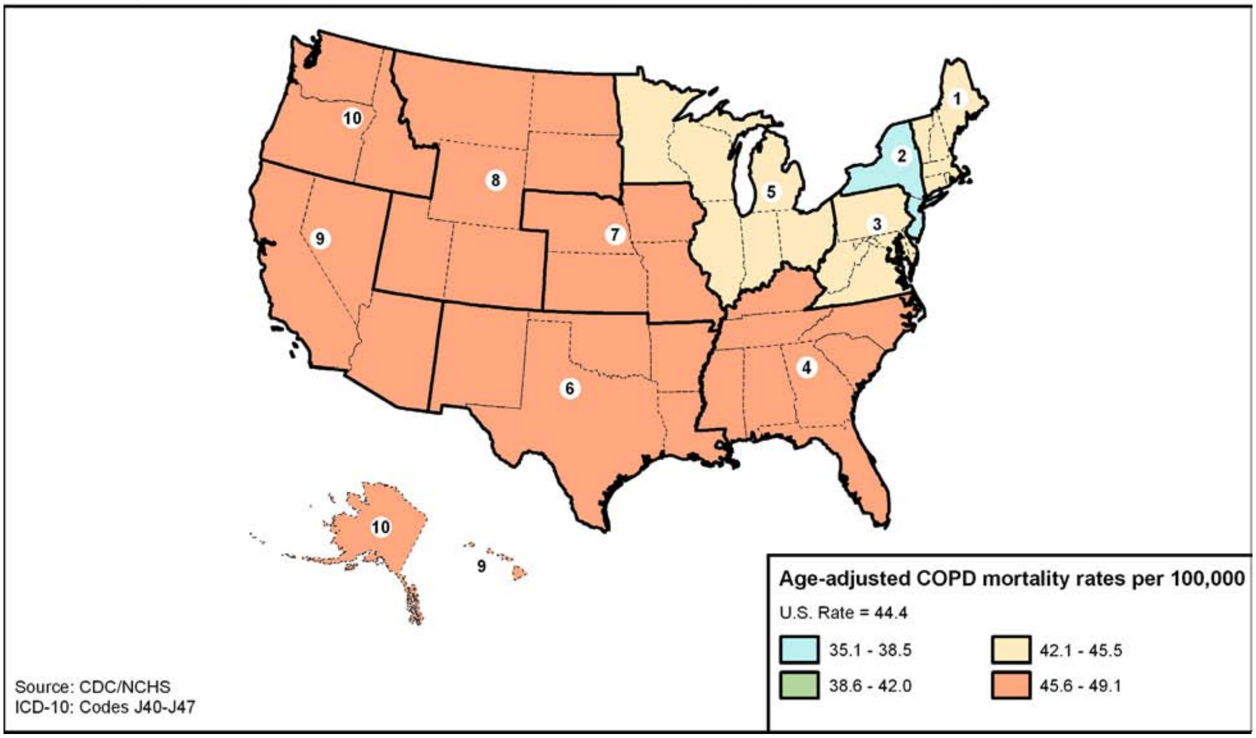
American Lung Association. November 2004. Chronic Obstructive Pulmonary Disease (COPD) Fact Sheet. Accessed February 7, 2005.
http://www.lungusa.org/site/pp.asp?c=dvLUK9O0E&b=35020

Graphics



* - Due to differences in the ICD system used for classifying mortalities, data from 1979-1998 should not be directly compared to data from 1999-2001.
ICD-9 CODES: 490-494, 496 (1979-1998); ICD-10 CODES: J40-J47 (1999-2001)

Figure 080-2. Age Adjusted U.S. Chronic Obstructive Pulmonary Disease Mortality Rates in Quartiles, 10 EPA Regions, 1999-2001



Source: CDC/NCHS
ICD-10: Codes J40-J47

R.O.E. Indicator QA/QC

Data Set Name: COPD MORTALITY
Indicator Number: 080 (89110)
Data Set Source: CDC, NCHS
Data Collection Date: ongoing
Data Collection Frequency: yearly
Data Set Description: COPD Mortality
Primary ROE Question: What are the trends in human disease and conditions for which environmental pollutants are thought to be to risk factors including across population subgroups and geographic regions?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The National Vital Statistics System (NVSS) is the oldest and most successful example of inter-governmental data sharing in Public Health and the shared relationships, standards, and procedures form the mechanism by which NCHS collects and disseminates the Nation's official vital statistics. The methodology for collecting vital statistics is standardized and outlined in Model State Vital Statistics Act and Regulations Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf)

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The National Vital Statistics System is responsible for the Nation's official vital statistics. These vital statistics are provided through State-operated registration systems. Standard forms for the collection of data and model procedures for the uniform registration of the events are developed and recommended for State use through cooperative activities of the States and the NCHS (http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf). U.S. Standard Death Certificates are revised periodically. Most state certificates conform closely in content and arrangement to the standard certificate recommended by NCHS and all certificates contain a minimum data set specified by NCHS. Demographic information on the death certificate is provided by the funeral director based on information supplied by an informant. A physician, medical examiner, or coroner provides medical certification of cause of death.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The data collected by NVSS are routinely referenced and used in epidemiological studies. Regional Mortality: Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled through use of CDC WONDER. Maps were created for this same data. See attached file, Calculating data for GIS mortality maps and regional trends.doc , for more information on the calculation of rates. Data file for maps can be found in file MapDataSummaries.xls.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Virtually all deaths are registered with the NVSS nationwide. The temporal coverage of the data is from 1933 to present. Data are collected from all 50 States including the District of Columbia.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The data set has nationwide death reporting, including sensitive populations.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Not applicable

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The sampling and quality assurance information can be found in Model State Vital Statistics Act and Regulations Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf). Documentation is also available at http://wonder.cdc.gov/wonder/help/mort.html Data source for Table HH2: CDC. CDC WONDER. Compressed Mortality File, Underlying Cause of Death. http://wonder.cdc.gov. The complete web-link pathway from the CDC WONDER Home Page is: à Mortality underlying cause of death à Mortality for 1999 2001 with ICD 10 codes For 2002 data: National Center for Health Statistics (NCHS). 2004. Deaths Final Data 2002. National Vital Statistics vol 53 no. 5 http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf Regional Mortality: Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled through use of CDC WONDER. Maps were created for this same data. See attached file, Calculating data for GIS mortality maps and regional trends.doc, for more information on the calculation of rates. Data file for maps can be found in file MapDataSummaries.xls.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The data can be accessed up to the county level through the electronic data warehouse for CDC at http://wonder.cdc.gov. Individual level data are not available due to confidentiality issues.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. Virtually all deaths from the 50 states, including District of Columbia, submit mortality data to the NVSS at NCHS. The recommended certificate of death is posted at http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf. The documentation for the mortality data set is http://wonder.cdc.gov/wonder/help/mort.html.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

See answer to T3Q1

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Not applicable

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Not applicable

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not applicable

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The mortality data on the Compressed Mortality File at http://wonder.cdc.gov/mortSQL.html are based on records for all deaths occurring in the fifty states and the District of Columbia. Deaths to foreign residents are excluded. Deaths to residents who died abroad are not included on this file. The difference in overall the COPD mortality rate for 1999 quoted in ROE03 (45.8 per 100,000) versus the rate quoted in this updated reported (44.5 per 100,000) is that the rate in ROE03 was based on 1990 Census projections and the rate has since been adjusted for 2000 standard population. COPD mortality rates are based on under-lying cause-of-death as entered on a death certificate by a physician. Some individuals may have had competing causes of death. When more than one cause or condition is entered by the physician, the underlying cause is determined by the sequence of conditions on the certificate, provisions of the ICD, and associated selection rules and modifications. (CDC WONDER database) The 2002 mortality rates were not yet available in CDC WONDER database at the time of this indicator write-up. The age-adjusted mortality rates were obtained through National Center for Health Statistics publication. Mortality rates reported by NCHS differ slightly from those reported by CDC WONDER. NCHS uses U.S. Census Bureau population estimates for all age groups; CDC WONDER uses birth certificate data for the Under 1 Year age group and uses U.S. Census Bureau population estimates for all other age groups. The International Classification of Diseases 9th Revision (ICD 9) codes are used to specify underlying cause of death for years 1979 - 1998. Beginning in 1999, cause of death is specified with the International Classification of Diseases 10th Revision (ICD 10) codes. The two revisions differ substantially, and to prevent confusion about the significance of any specific disease code, data queries are separate. Regional data: Mortality data are not available for the U.S. territories in CDC WONDER. Thus, Regions 2 and 9 are calculated to include only States. Note that for the years 1979, 1981-1989, and 2001, if the user selects a WONDER query for the United States with data grouped by state, or selects a WONDER query for a specific state, WONDER reports state population figures that do not add up to the national population reported by WONDER. This is because the two different sets of populations come from different U.S. Census population estimates. (For all other years, these two sets of population data are the same.)

Data set name(s): Indicator Maps
Cancer Mortality by EPA Region
Chronic Obstructive Pulmonary Disease (COPD) by EPA Region

Data set date(s): 1999-2001

Data source: CDC. WONDER Compressed Mortality 1999–2001 with ICD-10 Codes. http://wonder.cdc.gov/mortICD10J.html.

Data description: Mortality rates are for the U.S. population over the combined years of 1999, 2000, and 2001 (rates per 100,000 population, age-adjusted to the 2000 U.S. standard population). Underlying data were compiled from the WONDER system by age group and by state. Age-adjusted regional mortality rates for the period 1999-2001 were generated using the procedure described in "Calculation of Age-Adjusted Regional Mortality Rates Using State Data from CDC WONDER" (attached).

The mortality rates for each indicator were broken down into equal quartiles

ICD Codes:
Cancer: ICD-10 codes C00 – C97.
COPD: ICD-10 codes J40 – J47.

Supporting data files (represent a subset of the 1979-2001 regional trend data):
MapDataSummary.xls (see attached)

Calculation of Age-Adjusted Regional Mortality Rates Using State Data from CDC WONDER

Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled as detailed below. (Mortality data for 2002 and later are not yet available through CDC WONDER.)

Identifying relevant data

- For each mortality indicator (e.g., cancer, cardiovascular disease, asthma) was reviewed based on EPA's 2003 Draft Report on the Environment and the National Center for Health Statistics (NCHS) report that discusses ICD (International Classification of Diseases) to obtain the ICD codes that describe each of these indicators. Due to a revision of the ICD system in 1999, we obtained ICD-9 codes for the years 1979-1998 and ICD-10 codes for the years 1999-2001.

Downloading and organizing the data

- Mortality data was accessed through CDC's WONDER database (http://wonder.cdc.gov/).

- We downloaded a file for each year that regional mortality indicators were requested (1979-2001) and saved these data into separate sheets in Microsoft Excel (one workbook for each indicator). Both raw and compiled data are presented in each of these Excel workbooks. For example, '1999D' is the sheet with the raw data for the year 1999 and '1999' is the sheet with the calculations for that year.

- The calculation worksheet is organized as follows:

    - The first table arranges the raw data by state and age group. For each age group and state, two numbers are presented: the mortality cases and the associated population.

    - The second table (Regional Breakdown) groups the mortality cases and populations for the 50 states plus Washington, D.C., into the ten EPA regions, to obtain the total cases and total population for each region, by age group. (For a map of the EPA regions, refer to http://www.epa.gov/epahome/whereyou-live.htm.)

    - The third table (Regional Breakdown [combine certain groups]) merges two sets of age groups with each other (5-9 years with 10-14 years; 15-19 years with 20-24 years) to match the age-adjustment methodology used to calculate age-adjusted mortality rates in CDC WONDER (see below).

    - The fourth table on the worksheet (Regional Breakdown [Computation of Age-Adjusted Rate Components]) presents the basic steps of calculating age-adjusted mortality rates for each region (see below).

    - The final table on the Excel sheet (Regional Summary) lists the age-adjusted rates for each region and for the entire US; these values are compiled into the summary sheet

that covers all regions for all years for an indicator, accompanied by a trend chart that graphically depicts the regional data.

Calculating age-adjusted regional rates

The steps followed in calculating age-adjusted regional rates are detailed below, followed by a sample calculation.

Step 1
Using the following equation, the *crude death (or mortality) rate* is obtained by dividing the mortality cases ($Cases_i$) by the population for that age group ($Population_i$), then by multiplying by 100,000 (to get the cases per 100,000). This is done for each age group within each region. (The "i" subscript is included to indicate that this calculation is performed for several age groups, i.e. $CrudeRate_{<1\ year}$, $CrudeRate_{1\text{-}4\ years}$, etc.)

$$CrudeRate_i = \frac{Cases_i}{Population_i} \times 100{,}000$$

Step 2
For each age group, the weighted age-adjusted factor is calculated, using 2000 U.S. standard population factors provided by NCHS (See Table 1 below). The age-specific crude death rate is multiplied by that age group's standard population for the year 2000 ($2000\ Population_i$), and then divided by the total standard population for the year 2000 ($2000\ Population_{total}$). (For details on the standard population, see "Age-Adjustment of Death Rates" on the web page http://wonder.cdc.gov/wonder/help/mort.html[1]).

$$WeightedFactor = CrudeRate \times \frac{2000\,Population_i}{2000\,Population_{total}}$$

Table 1. United States Standard Population*

Age	Number
Under I year	13,818
1-4 years	55,317
5-14 years	145,565
15-24 years	138,646
25-34 years	135,573
35-44 years	162,613
45-54 years	134,834
55-64 years	87,247
65-74 years	66,037
75-84 years	44,842
85 years and over	15,508
All ages	1,000,000

* Based on year 2000 projected population

[1] The source cited by CDC WONDER for the age-adjustment data is the following NCHS report: *Anderson RN, Rosenberg HM. Age standardization of death rates: Implementation of the year 2000 standard. National Vital Statistics Reports; Vol 47 No 3. Hyattsville, Maryland. National Center for Health Statistics. 1998.*

Step 3

The age-adjusted mortality rate is then obtained by adding together the individual weighted factors for each age group:

$$AgeAdjustedRate = \sum_i WeightedFactor_i$$

Sample Calculation

Table 2 (below) shows the output of a sample calculation of the age-adjusted mortality rate for cancer (across all age groups) in EPA Region 9 in 1982. (Note that we have presented this in a format that is not used in the Excel workbook, in order to illustrate the calculations for a single region. However, all of the steps and calculations are identical.)

For each age group, the number of mortality cases is the sum of the mortality cases for Arizona, California, Hawaii, and Nevada, for that age group in that year; the population is the sum of the populations of these same four states for that age group in that year. For example, for the 35-44 years age group, the number of cancer mortalities for these states are 112 (Arizona), 1,413 (California), 53 (Hawaii), and 55 (Nevada), with the sum equaling 1,633. Similarly, the population is the sum of the respective states 338,654 (Arizona), 3,152,885 (California), 124,743 (Hawaii), and 120,463 (Nevada), which equals 3,736,745. The crude rate (43.70) for this age group is therefore equal to the total number of mortality cases (1,633) divided by the total population (3,736,745), multiplied by 100,000.

Table 1. Cancer Mortality, All Age Groups, EPA Region 9, 1982.

Age Group (Years)	Mortality Cases	Year 1982 Population	Crude Death Rate	2000 Std. Population	Weighted Factor
<1 year	32	515,809	6.20	13,818	0.09
1- 4 years	108	1,824,635	5.92	55,317	0.33
5- 9 years	114	1,977,487	N/A		
10-14 years	94	2,188,828	N/A		
5-14 years	208	4,166,315	4.99	145,565	0.73
15-19 years	139	2,432,939	N/A		
20-24 years	180	2,884,175	N/A		
15-24 years	319	5,317,114	6.00	138,646	0.83
25-34 years	694	5,551,792	12.50	135,573	1.69
35-44 years	1,633	3,736,745	43.70	162,613	7.11
45-54 years	4,662	2,793,603	166.88	134,834	22.50
55-64 years	11,283	2,679,802	421.04	87,247	36.73
65-74 years	15,423	1,876,606	821.86	66,037	54.27
75-84 years	11,397	912,865	1248.49	44,842	55.98
85+ years	4,424	269,593	1640.99	15,508	25.45
Unknown	27	0	N/A	0	0
Total	*50,210*	*29,644,879*	*N/A*	*1,000,000*	N/A
Age-Adjusted Mortality Rate					**205.7**

As described above, the Weighted Factor is the Crude Death Rate multiplied by the 2000 Standard Population for that age group and divided by the total Standard Population (the total of the age-group populations). For example, the weighted factor for the 35-44 years age group is the crude rate (43.70) times the 2000 population for that group (162,613), divided by the total 2000 Standard Population (1,000,000), which equals 7.11. The 1982 Region 9 age-adjusted mortality rate, 205.7, is the sum of the weighted factors of all age groups.

Notes:

- For the 5-14 and 15-24 years categories it is necessary to merge two sets of age ranges to match the age-adjustment grouping used within WONDER.

- For mortality indicators that were also compiled for children (ages 0-19 years), we only used the data for the age groups 0-1, 1-4, 5-9, 10-14, and 15-19 years, and then we age-adjusted these data using a set of age-adjustment factors that only cover to age 19 years.

- For the file that compiles birth defect mortality rates, the only data used from CDC WONDER are for the <1 year age group, so the crude rate equals the age-adjusted rate.

- Although data was queried for individual states to compile regional data, we did this by querying data for the entire United States from the CDC WONDER system, and specifying that the data be grouped by age and by year. Due to a quirk of CDC WONDER, if the user selects a single state for a query (instead of the entire United States), the population data are taken from a different data source: there are small discrepancies between these numbers and so the state-specific query should not be used to verify the compiled data.

Indicator: Cardiovascular Disease Mortality (078)

The broad category of cardiovascular disease (CVD) includes any disease involving the heart and blood vessels. Coronary heart disease (CHD) and cerebrovascular disease, commonly known as stroke, are the major cardiovascular diseases (American Heart Association, 2003). Since 1900, cardiovascular disease has been the leading cause of death in the United States every year except 1918 (American Heart Association, 2003). The U.S. age-adjusted mortality rate for CVD reached a peak in 1950 (CDC, 1999). Between 1950 and 1999, the age-adjusted mortality rate for CVD declined 60 percent.

The major risk factors for CVD include tobacco use, high blood pressure, high blood cholesterol, diabetes, physical inactivity, and poor nutrition (CDC, 2004). Environmental factors (such as air pollution) may also contribute to overall CVD mortality. Environmental factors may play a role in CVD mortality independent of other risk factors, however, susceptible populations such as the elderly, smokers, and other high-risk populations may be most impacted. For example, chronic exposure to ambient airborne particulate matter has been shown in studies to be associated with increased hospitalizations and mortality among older individuals, largely due to cardiopulmonary and cardiovascular disease (EPA, 2004).

This indicator reflects the occurrence of cardiovascular disease deaths in the United States as recorded in the National Vital Statistics System (NVSS). Virtually all deaths are registered with the NVSS nationwide, and the cause of death is determined and recorded by a physician, medical examiner, or coroner. The temporal coverage of the data is from 1933 to present and data are collected from all 50 States and the District of Columbia.

What the Data Show

Figures 078-1, 078-2, and 078-3 present the overall trends in CVD, CHD and stroke mortality for the 10 EPA Regions and the Nation for the time periods 1979-1998 and 1999-2001. In 1998, the national age-adjusted CVD mortality rate was 352.0 per 100,000 compared to a rate of 541.0 per 100,000 in 1980 (Figure 078-1). This decline appears to continue after 1999 with the rate dropping from 349.3 per 100,000 in 1999 to 317.4 per 100,000 in 2002. Both CHD and stroke mortality rates have been declining in the United States. The age-adjusted CHD mortality rate ranged from 345.2 per 100,000 in 1980 to 197.1 per 100,000 in 1998. For stroke mortality the age-adjusted rate ranged from 97.6 per 100,000 in 1979 to 59.3 per 100,000 in 1998. The age-adjusted mortality rate (2000 U.S. Standard Population) for CHD and stroke in 2002 was 170.8 and 56.2 per 100,000, respectively, compared to 194.6 and 61.6 per 100,000, respectively, in 1999 (Figure 078-2, and Figure 078-3).

Like the national rates, the age adjusted CVD mortality rates (2000 U.S. Standard Population) have been decreasing over time in each of the 10 EPA Regions from 1979 to 1998. In 1979, rates in the 10 Regions ranged from 477.1 (Region 10) to 566.0 (Region 3) per 100,000 and in 1998 from 295.0 (Region 8) to 368.3 (Region 6) per 100,000. The decreasing trend in CVD mortality rates appears to continue during the period 1999-2001 (Figure 078-1).

Both CHD and stroke have been declining over time in the 10 EPA Regions. In 1979, CHD and stroke age-adjusted mortality rates (2000 U.S. Standard Population) ranged from 285.6 (Region 10) to 401.9 (Region 2) per 100,000 and 80.3 (Region 2) to 111.4 (Region 4) per 100,000, respectively. In 1998, CHD and stroke mortality rates ranged 145.6 (Region 8) to 233.2 (Region 2) per 100,000 and 43.2 (Region 2) to 68.5 per (Region 10) 100,000, respectively (Figures 078-2 and 078-3). The declining trends in CHD and stroke also appear to continue in the 1999-2001 period.

Differences exist in CVD mortality rates among gender, racial and age groups. In 2001, those aged 65 and older had the highest CVD, CHD and stroke mortality (2,188.9, 1,186.3, and 406.1 per 100,000, respectively) compared to younger age groups (e.g., in 2001, the age-adjusted CVD, CHD, and stroke mortality rates for those 45-64 years of age were 187.2, 111.1, 24.1 per 100,000, respectively). Notable differences in CVD and CHD mortality rates exist between males and females, but not for stroke mortality. CHD mortality among men in 2001 was 228.5 per 100,000 compared to 139.9 per 100,000 for women. In 2001, black males had the highest CVD mortality rate at 505.3 per 100,000 compared to white males (381.1 per 100,000), black females (372.4 per 100,000) and white females (270.8 per 100,000).

Indicator Limitations

- CVD mortality rates are based on under-lying cause-of-death as entered on a death certificate by a physician. Some individuals may have had competing causes of death. "When more than one cause or condition is entered by the physician, the underlying cause is determined by the sequence of conditions on the certificate, provisions of the ICD, and associated selection rules and modifications" (CDC WONDER). Consequently, some misclassification of reported mortality might occur in individuals with competing causes of death.

- The difference in overall CHD and stroke mortality rate for 1999 quoted in ROE03 (195.6 per 100,000 and 61.4 per 100,000, respectively) versus the rate quoted in this updated reported (194.6 per 100,000 and 61.6 per 100,000, respectively) is that the rate in ROE03 was based on 1990 Census projections and the rate has since been adjusted for 2000 standard population.

- For the years 1979, 1981-1989, and 2001, if the user selects a CDC WONDER query for the United States with data grouped by state, or selects a WONDER query for a specific state, CDC WONDER reports state population figures that do not add up to the national population reported by CDC WONDER. This is because the two different sets of populations come from different U.S. Census population estimates. (For all other years, these two sets of population data are the same.)

- The International Classification of Diseases 9th Revision (ICD-9) codes were used to specify underlying cause of death for years 1979 - 1998. Beginning in 1999, cause of death is specified with the International Classification of Diseases 10th Revision (ICD-10) codes. The two revisions differ substantially, and to prevent confusion about the significance of any specific disease code, data queries are separate.

Data Sources

CDC. CDC WONDER. Compressed Mortality File, Underlying Cause of Death. http://wonder.cdc.gov.
The complete web-link pathway from the CDC WONDER Home Page is:
→ Mortality—underlying cause of death → Mortality for 1999–2001 with ICD 10 codes.
Note: ICD-9 codes 390-434,436-448; ICD-10codes I00–I78 are listed as major cardiovascular diseases
Note: ICD-9 codes 410-414, 429.2; ICD-10 codes I20–I25 are listed as ischaemic heart diseases
Note: ICD-9 codes 430-434, 436-438; ICD-10 codes I60–I69 are listed as cerebrovascular diseases

The raw numbers for each state were downloaded from the CDC WONDER mortality database (http://wonder.cdc.gov). The raw numbers for each state within a region were combined and age adjusted rates (2000 U.S. Standard Population) were calculated.

NCHS. Deaths: Final Data for 2002. National Vital Statistics Reports. 53(5). October 12, 2004. Available at: http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf.

References

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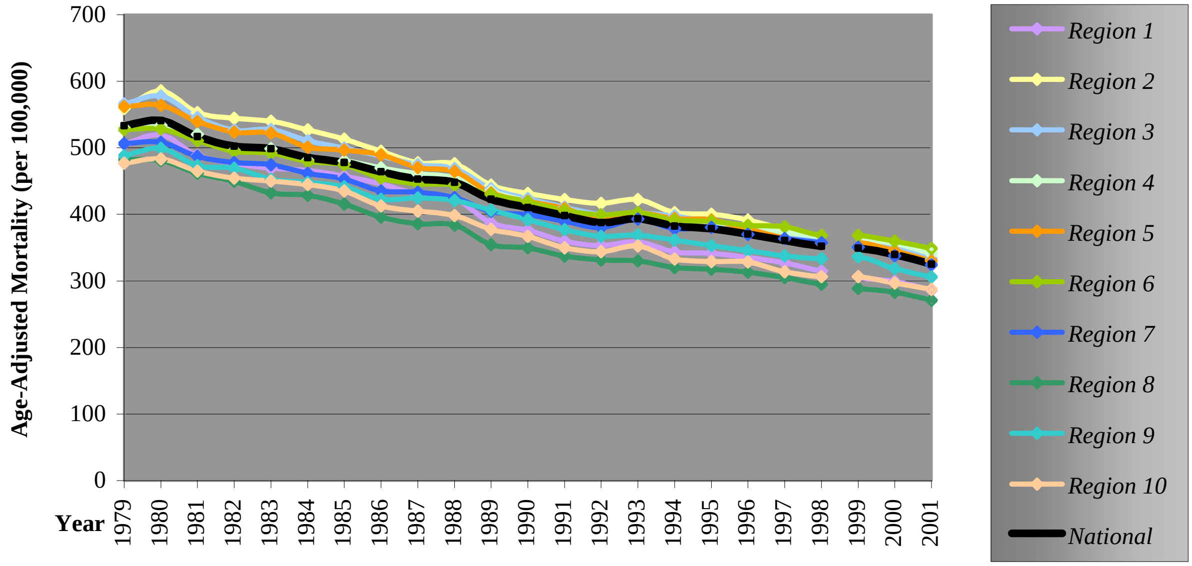
Environmental Protection Agency. 2004. Particular Matter (PM) Research. Accessed February 2, 2005. http://www.epa.gov/pmresearch/pm_grant/04_necessity.html

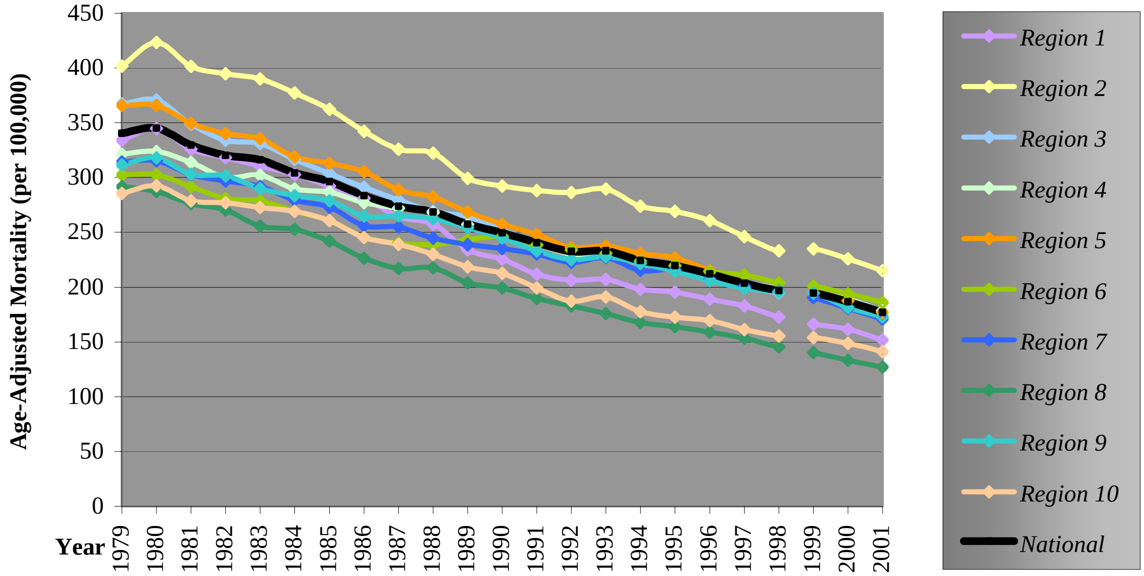
Graphics

Figure 078-1. Age Adjusted U.S. Cardiovascular Disease (CVD) Mortality Rates, 10 EPA Regions, 1979-2001*



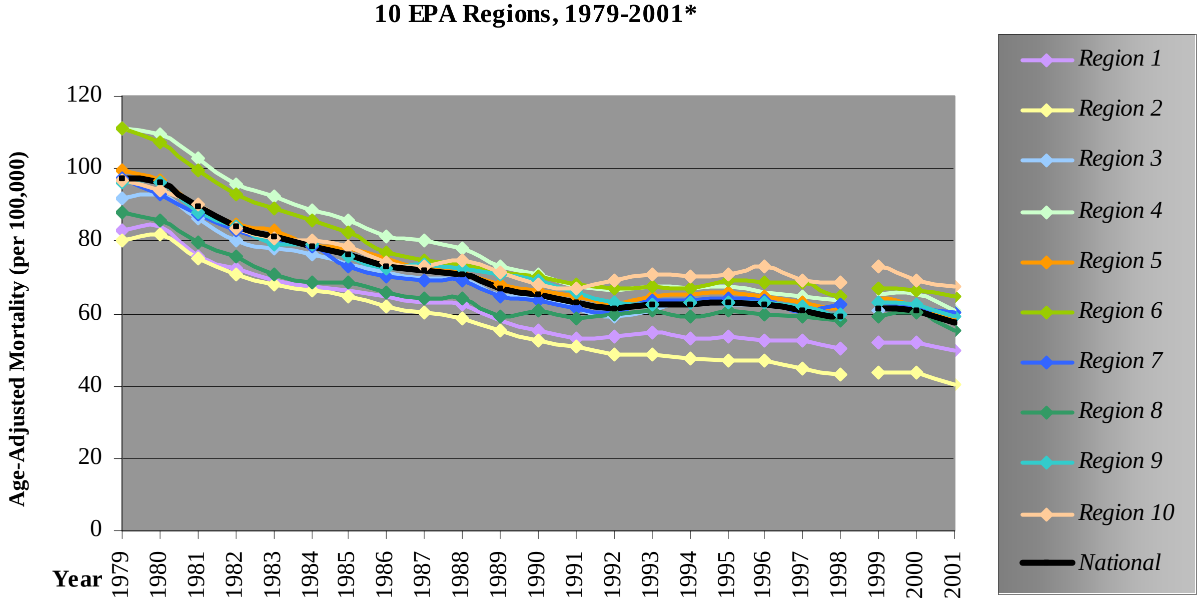
** - Due to differences in the ICD system used for classifying mortalities, data from 1979-1998 should not be directly compared to data from 1999-2001.*
I CD-9 CODES: 390-434, 436-448 (1979-1998); ICD-10 CODES: I00-I78 (1999-2001)

Figure 078-2. Age Adjusted U.S. Coronary Heart Disease (CHD) Mortality Rates, 10 EPA Regions, 1979-2001*



** - Due to differences in the ICD system used for classifying mortalities, data from 1979-1998 should not be directly compared to data from 1999-2001.*
I CD-9 CODES: 410-414, 429.2 (1979-1998); ICD-10 CODES: I20-I25 (I999-2001)

Figure 078-3. Age Adjusted U.S. Stroke Mortality Rates, 10 EPA Regions, 1979-2001*



**- Due to differences in the ICD system used for classifying mortalities, data from 1979-1998 should not be directly compared to data from 1999-2001.*
ICD-9 CODES: 430-434, 436-438 (1979-1998); ICD-10 CODES: I60-I69 (1999-2001)

R.O.E. Indicator QA/QC

Data Set Name: CVD MORTALITY
Indicator Number: 078 (89107)
Data Set Source: CDC, NCHS
Data Collection Date: ongoing
Data Collection Frequency: yearly
Data Set Description: CVD Mortality
Primary ROE Question: What are the trends in human disease and conditions for which environmental pollutants are thought to be to risk factors including across population subgroups and geographic regions?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The National Vital Statistics System (NVSS) is the oldest and most successful example of inter-governmental data sharing in Public Health and the shared relationships, standards, and procedures form the mechanism by which NCHS collects and disseminates the Nation's official vital statistics. The methodology for collecting vital statistics is standardized and outlined in Model State Vital Statistics Act and Regulations Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf)

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The National Vital Statistics System is responsible for the Nation s official vital statistics. These vital statistics are provided through State-operated registration systems. Standard forms for the collection of data and model procedures for the uniform registration of the events are developed and recommended for State use through cooperative activities of the States and the NCHS (http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf). U.S. Standard Death Certificates are revised periodically. Most state certificates conform closely in content and arrangement to the standard certificate recommended by NCHS and all certificates contain a minimum data set specified by NCHS. Demographic information on the death certificate is provided by the funeral director based on information supplied by an informant. A physician, medical examiner, or coroner provides medical certification of cause of death.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The data collected by NVSS are routinely referenced and used in epidemiological studies. Regional Mortality: Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled through use of CDC WONDER. See attached file, age-adjusted regional rates.doc , for more information on the calculation of rates.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Virtually all deaths are registered with the NVSS nationwide. The temporal coverage of the data is from 1933 to present. Data are collected from all 50 States including the District of Columbia.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The data set has nationwide death reporting, including sensitive populations.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Not applicable

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The sampling and quality assurance information can be found in Model State Vital Statistics Act and Regulations Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf). Documentation is also available at http://wonder.cdc.gov/wonder/help/mort.html Data source for Table HH2: CDC. CDC WONDER. Compressed Mortality File, Underlying Cause of Death. http://wonder.cdc.gov. The complete web-link pathway from the CDC WONDER Home Page is: à Mortality underlying cause of death à Mortality for 1999 2001 with ICD 10 codes For 2002 data: National Center for Health Statistics (NCHS). 2004. Deaths Final Data 2002. National Vital Statistics vol 53 no. 5 http://www.cdc.gov/nchs/data/nvsr/nvsr53/nvsr53_05.pdf Regional Mortality: Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled through use of CDC WONDER. See attached file, age-adjusted regional rates.doc , for more information on the calculation of rates.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The data can be accessed up to the county level through the electronic data warehouse for CDC at http://wonder.cdc.gov. Individual level data are not available due to confidentiality issues.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. Virtually all deaths from the 50 states, including District of Columbia, submit mortality data to the NVSS at NCHS. The recommended certificate of death is posted at http://www.cdc.gov/nchs/data/dvs/DEATH11-03final-ACC.pdf. The documentation for the mortality data set is http://wonder.cdc.gov/wonder/help/mort.html.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

See answer to T3Q1

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Not applicable

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Not applicable

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not applicable

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The mortality data on the Compressed Mortality File at http://wonder.cdc.gov/mortSQL.html are based on records for all deaths occurring in the fifty states and the District of Columbia. Deaths to foreign residents are excluded. Deaths to residents who died abroad are not included on this file. The difference in overall CHD and stroke mortality rate for 1999 quoted in ROE03 (195.6 per 100,000 and 61.4 per 100,000, respectively) versus the rate quoted in this updated reported (194.6 per 100,000 and 61.6 per 100,000, respectively) is that the rate in ROE03 was based on 1990 Census projections and the rate has since been adjusted for 2000 standard population. Cardiovascular mortality rates are based on under-lying cause-of-death as entered on a death certificate by a physician. Some individuals may have had competing causes of death. When more than one cause or condition is entered by the physician, the underlying cause is determined by the sequence of conditions on the certificate, provisions of the ICD, and associated selection rules and modifications. (CDC WONDER database) The 2002 mortality rates were not yet available in CDC WONDER database at the time of this indicator write-up. The age-adjusted mortality rates were obtained through National Center for Health Statistics publication. For purposes of comparison, it should be noted that mortality rates reported by NCHS reports differ slightly from those rates reported by CDC WONDER. NCHS uses U.S. Census Bureau population estimates for all age groups; CDC WONDER uses birth certificate data for the Under 1 Year age group and uses U.S. Census Bureau population estimates for all other age groups. The International Classification of Diseases 9th Revision (ICD 9) codes are used to specify underlying cause of death for years 1979 - 1998. Beginning in 1999, cause of death is specified with the International Classification of Diseases 10th Revision (ICD 10) codes. The two revisions differ substantially, and to prevent confusion about the significance of any specific disease code, data queries are separate. Regional data: Mortality data are not available for the U.S. territories in CDC WONDER. Thus, Regions 2 and 9 are calculated to include only States. Note that for the years 1979, 1981-1989, and 2001, if the user selects a WONDER query for the United States with data grouped by state, or selects a WONDER query for a specific state, WONDER reports state population figures that do not add up to the national population reported by WONDER. This is because the two different sets of populations come from different U.S. Census population estimates. (For all other years, these two sets of population data are the same.)

Calculation of Age-Adjusted Regional Mortality Rates Using State Data from CDC WONDER

Mortality rates age-adjusted for the 2000 U.S. standard population (rates per 100,000) for the years 1979 through 2001 were compiled as detailed below. (Mortality data for 2002 and later are not yet available through CDC WONDER.)

Identifying relevant data

- Each mortality indicator (e.g., cancer, cardiovascular disease, asthma) was reviewed based on EPA's 2003 Draft Report on the Environment and a National Center for Health Statistics (NCHS) report that discusses ICD (International Classification of Diseases) to obtain the ICD codes that describe each of these indicators. Due to a revision of the ICD system in 1999, ICD-9 codes were obtained for the years 1979-1998 and ICD-10 codes for the years 1999-2001.

Downloading and organizing the data

- Mortality data were accessed through CDC's WONDER database (http://wonder.cdc.gov/).

- We downloaded a file for each year that regional mortality indicators were requested (1979-2001) and saved these data into separate sheets in Microsoft Excel (one workbook for each indicator). Both raw and compiled data are presented in each of these Excel workbooks. For example, '1999D' is the sheet with the raw data for the year 1999 and '1999' is the sheet with the calculations for that year.

- The calculation worksheet is organized as follows:

    - The first table arranges the raw data by state and age group. For each age group and state, two numbers are presented: the mortality cases and the associated population.

    - The second table (Regional Breakdown) groups the mortality cases and populations for the 50 states plus Washington, D.C., into the ten EPA regions, to obtain the total cases and total population for each region, by age group. (For a map of the EPA regions, refer to http://www.epa.gov/epahome/whereyou-live.htm.)

    - The third table (Regional Breakdown [combine certain groups]) merges two sets of age groups with each other (5-9 years with 10-14 years; 15-19 years with 20-24 years) to match the age-adjustment methodology used to calculate age-adjusted mortality rates in CDC WONDER (see below).

    - The fourth table on the worksheet (Regional Breakdown [Computation of Age-Adjusted Rate Components]) presents the basic steps of calculating age-adjusted mortality rates for each region (see below).

    - The final table on the Excel sheet (Regional Summary) lists the age-adjusted rates for each region and for the entire US; these values are compiled into the summary sheet that covers all regions for all years for an indicator, accompanied by a trend chart that graphically depicts the regional data.

Calculating age-adjusted regional rates

The steps followed in calculating age-adjusted regional rates are detailed below, followed by a sample calculation.

Step 1

Using the following equation, the *crude death (or mortality) rate* is obtained by dividing the mortality cases ($Cases_i$) by the population for that age group ($Population_i$), then by multiplying by 100,000 (to get the cases per 100,000). This is done for each age group within each region. (The "i" subscript is included to indicate that this calculation is performed for several age groups, i.e. $CrudeRate_{<1\ year}$, $CrudeRate_{1\text{-}4\ years}$, etc.)

$$CrudeRate_i = \frac{Cases_i}{Population_i} \times 100{,}000$$

Step 2

For each age group, the weighted age-adjusted factor is calculated, using 2000 U.S. standard population factors provided by NCHS (See Table 1 below). The age-specific crude death rate is multiplied by that age group's standard population for the year 2000 ($2000\ Population_i$), and then divided by the total standard population for the year 2000 ($2000\ Population_{total}$). (For details on the standard population, see "Age-Adjustment of Death Rates" on the web page http://wonder.cdc.gov/wonder/help/mort.html[1]).

$$WeightedFactor = CrudeRate \times \frac{2000 Population_i}{2000 Population_{total}}$$

Table 1. United States Standard Population*

Age	**Number**
Under I year	13,818
1-4 years	55,317
5-14 years	145,565
15-24 years	138,646
25-34 years	135,573
35-44 years	162,613
45-54 years	134,834
55-64 years	87,247
65-74 years	66,037
75-84 years	44,842
85 years and over	15,508
All ages	1,000,000

* Based on year 2000 projected population

Step 3

The age-adjusted mortality rate is then obtained by adding together the individual weighted factors for each age group:

$$AgeAdjustedRate = \sum_i WeightedFactor_i$$

Sample Calculation

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[1] The source cited by CDC WONDER for the age-adjustment data is the following NCHS report: *Anderson RN, Rosenberg HM. Age standardization of death rates: Implementation of the year 2000 standard. National Vital Statistics Reports; Vol 47 No 3. Hyattsville, Maryland. National Center for Health Statistics. 1998.*

Table 2 (below) shows the output of a sample calculation of the age-adjusted mortality rate for cancer (across all age groups) in EPA Region 9 in 1982. (Note that we have presented this in a format that is not used in the Excel workbook, in order to illustrate the calculations for a single region. However, all of the steps and calculations are identical.)

For each age group, the number of mortality cases is the sum of the mortality cases for Arizona, California, Hawaii, and Nevada, for that age group in that year; the population is the sum of the populations of these same four states for that age group in that year. For example, for the 35-44 years age group, the number of cancer mortalities for these states are 112 (Arizona), 1,413 (California), 53 (Hawaii), and 55 (Nevada), with the sum equaling 1,633. Similarly, the population is the sum of the respective states 338,654 (Arizona), 3,152,885 (California), 124,743 (Hawaii), and 120,463 (Nevada), which equals 3,736,745. The crude rate (43.70) for this age group is therefore equal to the total number of mortality cases (1,633) divided by the total population (3,736,745), multiplied by 100,000.

Table 2. Cancer Mortality, All Age Groups, EPA Region 9, 1982.

Age Group (Years)	Mortality Cases	Year 1982 Population	Crude Death Rate	2000 Std. Population	Weighted Factor
<1 year	32	515,809	6.20	13,818	0.09
1- 4 years	108	1,824,635	5.92	55,317	0.33
5- 9 years	114	1,977,487	N/A		
10-14 years	94	2,188,828	N/A		
5-14 years	208	4,166,315	4.99	145,565	0.73
15-19 years	139	2,432,939	N/A		
20-24 years	180	2,884,175	N/A		
15-24 years	319	5,317,114	6.00	138,646	0.83
25-34 years	694	5,551,792	12.50	135,573	1.69
35-44 years	1,633	3,736,745	43.70	162,613	7.11
45-54 years	4,662	2,793,603	166.88	134,834	22.50
55-64 years	11,283	2,679,802	421.04	87,247	36.73
65-74 years	15,423	1,876,606	821.86	66,037	54.27
75-84 years	11,397	912,865	1248.49	44,842	55.98
85+ years	4,424	269,593	1640.99	15,508	25.45
Unknown	27	0	N/A	0	0
Total	*50,210*	*29,644,879*	*N/A*	*1,000,000*	N/A
Age-Adjusted Mortality Rate					**205.7**

As described above, the Weighted Factor is the Crude Death Rate multiplied by the 2000 Standard Population for that age group and divided by the total Standard Population (the total of the age-group populations). For example, the weighted factor for the 35-44 years age group is the crude rate (43.70) times the 2000 population for that group (162,613), divided by the total 2000 Standard Population (1,000,000), which equals 7.11. The 1982 Region 9 age-adjusted mortality rate, 205.7, is the sum of the weighted factors of all age groups.

Notes:

- For the 5-14 and 15-24 years categories it is necessary to merge two sets of age ranges to match the age-adjustment grouping used within WONDER.

- For mortality indicators that were also compiled for children (ages 0-19 years), we only used the data for the age groups 0-1, 1-4, 5-9, 10-14, and 15-19 years, and then we age-adjusted these data using a set of age-adjustment factors that only cover to age 19 years.

- For the file that compiles birth defect mortality rates, the only data used from CDC WONDER are for the <1 year age group, so the crude rate equals the age-adjusted rate.

- Although data were queried for individual states to compile regional data, we did this by querying data for the entire United States from the CDC WONDER system, and specifying that the data be grouped by age and by year. Due to a quirk of CDC WONDER, if the user selects a single state for a query (instead of the entire United States), the population data are taken from a different data source: there are small discrepancies between these numbers and so the state-specific query should not be used to verify these compiled data.

Indicator: Infectious Gastrointestinal and Arthropod-Borne Disease Prevalence (083-089)

The two broad infectious disease categories included here are those whose appearance and spread may be influenced to some extent by environmental conditions and change. First, seven notifiable gastrointestinal diseases caused by microorganisms are discussed below including: cholera, cryptosporidiosis, *Escherichia coli* (*E. Coli*) O157:H7, Hepatitis A, salmonellosis, shigellosis, and typhoid fever. The major environmental source of gastrointestinal illness is water or food that is contaminated with pathogenic microorganisms. The primary means of transmission for these seven diseases is through ingestion of contaminated food/water or through contact and accidental ingestion of fecal matter (CDC, 2005).

Next, three arthropod-borne diseases are detailed including: Lyme disease (transmission of Borrelia burgdorferi by ticks), Rocky Mountain Spotted fever (transmission of Rickettsia rickettsii by ticks), and West Nile virus (transmitted by mosquitoes).Certain ticks and mosquitoes (arthropods) can carry bacteria and viruses that cause disease in humans. The arthropods acquire the bacteria or viruses when they bite an infected mammal or bird. In recent years, both Lyme disease and West Nile virus have spread across the United States (CDC, 2004). Some studies indicate that spread of vector-borne disease may be influenced by land use and/or other environmental change (CDC, 2004).

This indicator reflects occurrence of the ten aforementioned notifiable diseases as reported by health departments to the National Notifiable Diseases Surveillance System. Data is collected by all 50 states, five territories, New York City, and the District of Columbia, based on a list of recommended Nationally Notifiable Infectious Diseases, and compiled nationally. The temporal coverage of the data varies by disease.

What the Data Show

Figure 083-089GI presents the number of reported cases for each of the seven notifiable gastrointestinal diseases from 1997-2003. Very few cases of cholera were reported yearly with only two cases reported in 2003. Like cholera, typhoid fever has a relatively low prevalence. In 2003, 356 cases of typhoid fever were reported, comparable to the number of reported cases in years past. Hepatitis A has continued to decline, where in 1999 17,047 cases were reported compared to 7,653 cases in 2003. No notable trends are revealed for cryptosporidiosis, *E. Coli* O157:H7, salmonellosis, and shigellosis, but under-reporting has probably occurred because of milder cases not being diagnosed or reported.

Figure 083-089Arthropod presents the number of reported cases for three arthropod-borne diseases. Surveillance for Lyme disease was initiated by the Centers for Disease Control (CDC) in 1982 (CDC 1993). Lyme disease is the most commonly reported arthropod-borne disease in the United States with 21,273 cases reported in 2003, a decrease from the record number reported in 2002 (23,763 cases). CDC began surveillance of Rocky Mountain Spotted fever in 1970. From 1999 to 2002 a steady increase in the number of reported cases of Rocky Mountain spotted fever occurred. However a slight decrease in the number of cases were reported in 2003 (1,091 cases) compared to 2002 (1,104 cases). Cases of West Nile virus were first documented in the United States in 1999 (CDC, 2000). A total of 80 cases were reported in 1999 (62 cases) and 2000 (18 cases). West Nile virus became nationally reportable in 2002, and the number of reported cases rose from 2,840 in 2002 to 2,866 in 2003.

Indicator Limitations

- State epidemiologists report cases of notifiable diseases to CDC and policies for reporting can vary by disease or reporting jurisdiction.
- Reporting nationally notifiable diseases to CDC is voluntary. The degree of completeness of data reporting is influenced by many factors such as the diagnostic facilities available, the control

measures in effect, public awareness of a specific disease, and the interests, resources, and priorities of state and local officials responsible for disease control and public health surveillance.
- Factors such as changes in case definitions for public health surveillance, introduction of new diagnostic tests, or discovery of new disease entities can cause changes in disease reporting that are independent of the true incidence of disease (CDC, 2004).

Data Sources

Centers for Disease Control and Prevention (CDC). Summary of Notifiable Diseases—United States, Web-link for overview page: http://www.cdc.gov/epo/dphsi/annsum/index.htm.

CDC. 2001. Summary of Notifiable Diseases—United States, 1999. Volume 48:53. April 6, 2001. http://www.cdc.gov/mmwr/PDF/wk/mm4853.pdf. See Table 1.

CDC. 2002. Summary of Notifiable Diseases—United States, 2000. Volume 49:53. June 14, 2002. http://www.cdc.gov/mmwr/PDF/wk/mm4953.pdf. See Table 1.

CDC. 2003. Summary of Notifiable Diseases—United States, 2001. Volume 50:53. May 2, 2003. http://www.cdc.gov/mmwr/PDF/wk/mm5053.pdf. See Table 1.

CDC. 2004a. Summary of Notifiable Diseases—United States, 2002. Volume 51:53. April 30, 2004. http://www.cdc.gov/mmwr/PDF/wk/mm5153.pdf. See Table 1.

CDC. 2004b. Final 2003 Report of Notifiable Diseases. Volume 53:30. August 6, 2004. http://www.cdc.gov/mmwr/PDF/wk/mm5330.pdf. See Table 2.

References

Centers for Disease Control and Prevention (CDC). 1993. MMWR Weekly. Volume 42:18. May 14, 1993. http://www.cdc.gov/mmwr/preview/mmwrhtml/00020506.htm.

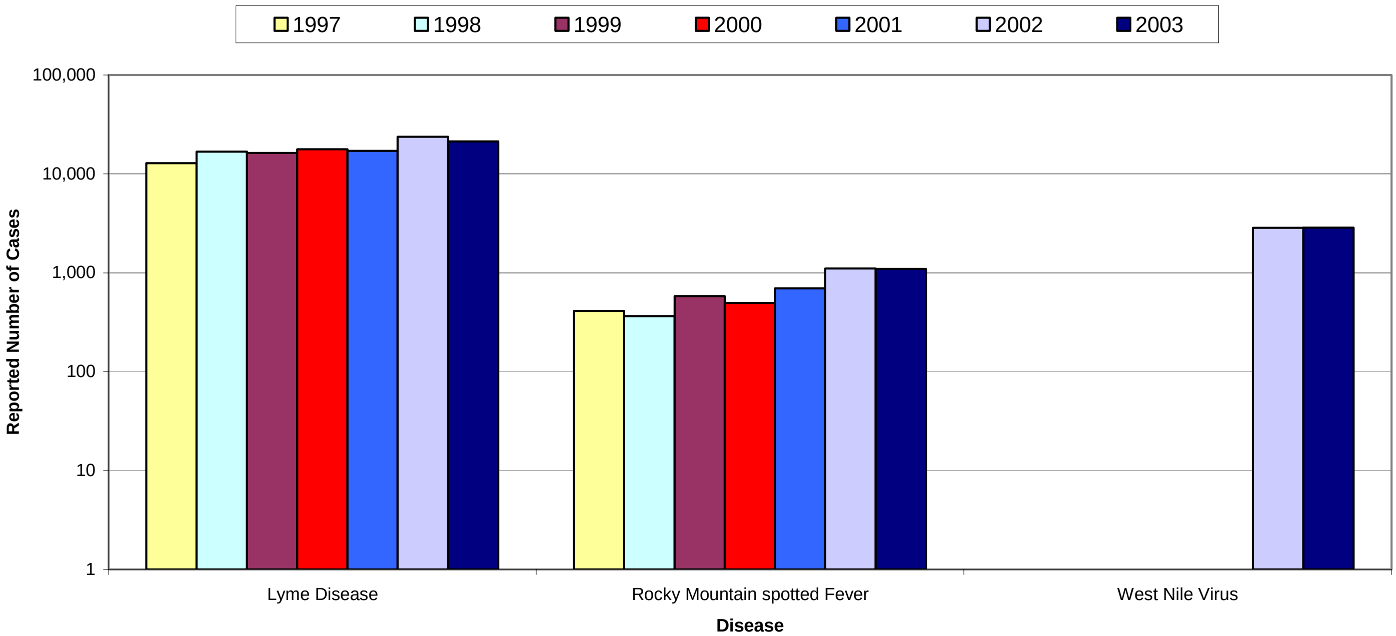
Centers for Disease Control and Prevention (CDC). 2000. Update: West Nile virus activity – Eastern United States, 2000. Morbidity and Mortality Weekly Report 49 (46):1044-47.

Centers for Disease Control and Prevention (CDC). 2004. Summary of Notifiable Diseases—United States, 2002. Volume 51:53. April 30, 2004. http://www.cdc.gov/mmwr/PDF/wk/mm5153.pdf See Table 1.

Centers for Disease Control and Prevention (CDC). 2005. Foodborne Illness – Frequently Asked Questions (Accessed April 11, 2005) http://www.cdc.gov/ncidod/dbmd/diseaseinfo/foodborneinfections_g.htm#howdiagnosed

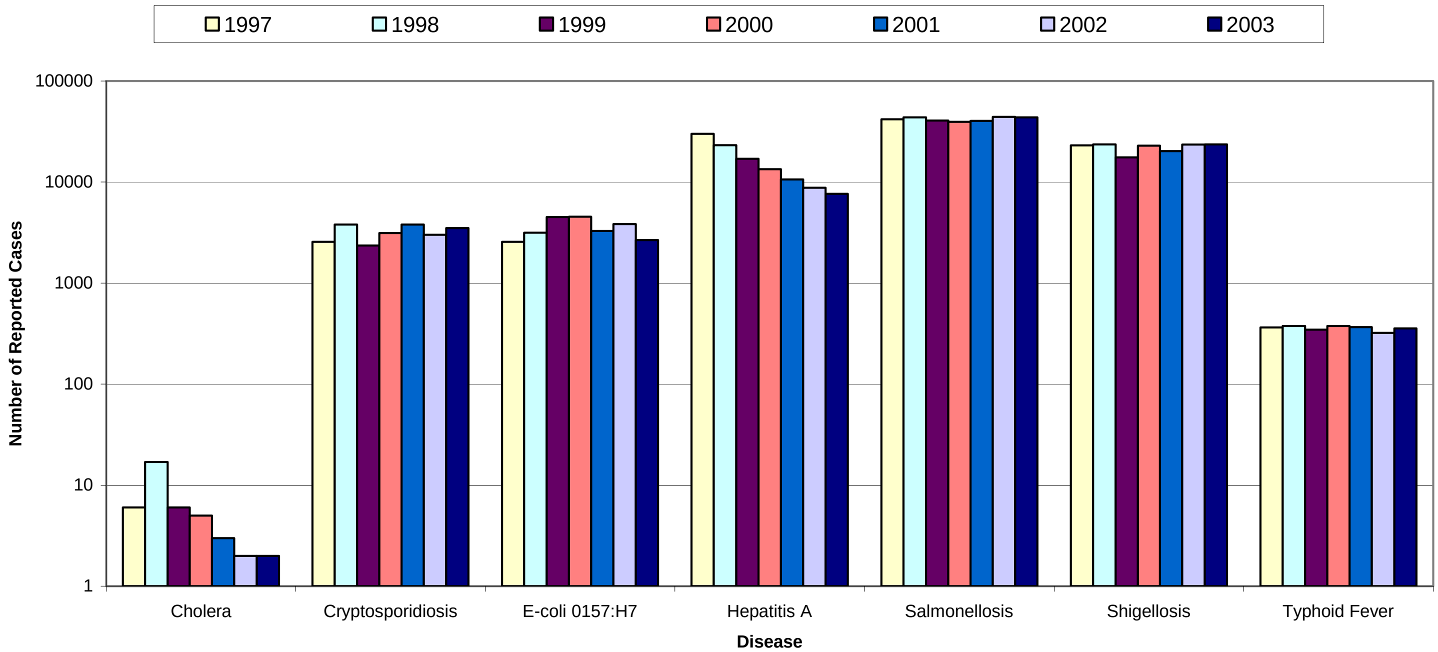
Graphics

Figure 083-089Arthropod: Prevalence of Reported Arthropod-borne Diseases in the United States, 1997—2003



Source:
CDC. 2002. Summary of Notifiable Diseases—United States, 2000. Volume 49:53. June 14, 2002. http://www.cdc.gov/mmwr/PDF/wk/mm4953.pdf. See Table 8 (1997-2000).
CDC. 2003. Summary of Notifiable Diseases—United States, 2001. Volume 50:53. May 2, 2003. http://www.cdc.gov/mmwr/PDF/wk/mm5053.pdf. See Table 1.
CDC. 2004. Summary of Notifiable Diseases—United States, 2002. Volume 51:53. April 30, 2004. http://www.cdc.gov/mmwr/PDF/wk/mm5153.pdf. See Table 1.
CDC. 2004. Final 2003 Report of Notifiable Diseases. Volume 53:30. August 6, 2004. http://www.cdc.gov/mmwr/PDF/wk/mm5330.pdf. See Table 2.

Figure 083-089GI: Prevalence of Reported Gasrointestinal Diseases in the United States, 1997—2003



Source:
CDC. 2002. Summary of Notifiable Diseases—United States, 2000. Volume 49:53. June 14, 2002.
http://www.cdc.gov/mmwr/PDF/wk/mm4953.pdf. See Table 8 (1997-2000).
CDC. 2003. Summary of Notifiable Diseases—United States, 2001. Volume 50:53. May 2, 2003.
http://www.cdc.gov/mmwr/PDF/wk/mm5053.pdf. See Table 1.
CDC. 2004. Summary of Notifiable Diseases—United States, 2002. Volume 51:53. April 30, 2004.
http://www.cdc.gov/mmwr/PDF/wk/mm5153.pdf. See Table 1.
CDC. 2004. Final 2003 Report of Notifiable Diseases. Volume 53:30. August 6, 2004.
http://www.cdc.gov/mmwr/PDF/wk/mm5330.pdf. See Table 2.

R.O.E. Indicator QA/QC

Data Set Name: INFECTIOUS GASTROINTESTINAL AND ARTHROPOD-BORNE DISEASE PREVALENCE
Indicator Number: 083 (89115)
Data Set Source: CDC
Data Collection Date: ongoing
Data Collection Frequency: yearly
Data Set Description: Infectious Gastrointestinal and Arthropod-Borne Disease Prevalence (combines former 083, 084, 085, 086, 087, 088, 089)
Primary ROE Question: What are the trends in human disease and conditions for which environmental pollutants are thought to be to risk factors including across population subgroups and geographic regions?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

The Epidemiology Program Office (EPO) of CDC, in partnership with the Council of State and Territorial Epidemiologists (CSTE), operates the National Notifiable Diseases Surveillance System. The purpose of this system is primarily to provide weekly provisional information on the occurrence of diseases defined as notifiable by CSTE. The system also provides summary data on an annual basis. State epidemiologists report cases of notifiable diseases to EPO, and EPO tabulates and publishes these data in the Morbidity and Mortality Weekly Report (MMWR) and the Summary of Notifiable Diseases, United States (entitled Annual Summary before 1985). Notifiable disease surveillance is conducted by public health practitioners at local, State, and national levels to support disease prevention and control activities. Notifiable disease reports are received from health departments in the 50 States, five territories, New York City, and the District of Columbia.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

In the United States, requirements for reporting diseases are mandated by state laws or regulations, and the list of reportable diseases in each state differs. In October 1990, in collaboration with the Council of State and Territorial Epidemiologists, CDC published a report entitled Case Definitions for Public Health Surveillance, which, for the first time, provided uniform criteria for reporting cases. The 1990 Report was revised and published in 1997 to provide updated uniform criteria for state health department personnel to use when reporting notifiable diseases to CDC. The 1997 updates were published in a report entitled Case Definitions for Infectious Conditions Under Public Health Surveillance (ftp://ftp.cdc.gov/pub/Publications/mmwr/rr/rr4610.pdf).

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. Data collected is published weekly in the CDC s Morbidity and Mortality Weekly Report (MMWR)

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Data is collected at the state level, based on a list of recommended Nationally Notifiable Infectious Diseases, and compiled nationally. The temporal coverage of the data is from 1997-2003.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

This is national data; sensitive populations are included to the extent that they are seen, reported or treated by a reporting official.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Not applicable

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Reporting is performed by state health departments, which submit data to CDC through an electronic system described at http://www.cdc.gov/epo/dphsi/netss.htm. Additional documentation is available at ftp://ftp.cdc.gov/pub/Publications/mmwr/rr/rr4610.pdf. Table HH2 data source: Source: Centers for Disease Control and Prevention (CDC). Summary of Notifiable Diseases United States, Web-link for overview page: http://www.cdc.gov/epo/dphsi/annsum/index.htm. CDC. 2001. Summary of Notifiable Diseases United States, 1999. Volume 48:53. April 6, 2001. http://www.cdc.gov/mmwr/PDF/wk/mm4853.pdf. See Table 1. CDC. 2002. Summary of Notifiable Diseases United States, 2000. Volume 49:53. June 14, 2002. http://www.cdc.gov/mmwr/PDF/wk/mm4953.pdf. See Table 1. CDC. 2003. Summary of Notifiable Diseases United States, 2001. Volume 50:53. May 2, 2003. http://www.cdc.gov/mmwr/PDF/wk/mm5053.pdf. See Table 1. CDC. 2004. Summary of Notifiable Diseases United States, 2002. Volume 51:53. April 30, 2004. http://www.cdc.gov/mmwr/PDF/wk/mm5153.pdf. See Table 1. CDC. 2004. Final 2003 Report of Notifiable Diseases. Volume 53:30. August 6, 2004. http://www.cdc.gov/mmwr/PDF/wk/mm5330.pdf. See Table 2.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Weekly summaries of the data are published in the CDC s Morbidity and Mortality Weekly Report (http://www.cdc.gov/mmwr/). Annual summaries are available at http://www.cdc.gov/epo/dphsi/annsum/index.htm.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

See T3Q1

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Quality assurance information, as well as case definitions of the infectious diseases reported, is available at http://www.cdc.gov/epo/dphsi/casedef/index.htm.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Not applicable

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Not applicable

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not applicable

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Policies for reporting notifiable disease cases can vary by disease or reporting jurisdiction, depending on case status classification (i.e., confirmed, probable, or suspect). CSTE and CDC annually review the status of national infectious disease surveillance and recommend additions or deletions to the list of nationally notifiable diseases based on the need to respond to emerging priorities. However, reporting nationally notifiable diseases to CDC is voluntary. Reporting is currently mandated by law or regulation only at the local and State level. Therefore, the list of diseases that are considered notifiable varies slightly by State. The degree of completeness of data reporting also is influenced by the diagnostic facilities available; the control measures in effect; public awareness of a specific disease; and the interests, resources, and priorities of State and local officials responsible for disease control and public health surveillance. Finally, factors such as changes in case definitions for public health surveillance, introduction of new diagnostic tests, or discovery of new disease entities can cause changes in disease reporting that are independent of the true incidence of disease. The degree of completeness of data reporting also is influenced by the diagnostic facilities available; the control measures in effect; public awareness of a specific disease; and the interests, resources, and priorities of State and local officials responsible for disease control and public health surveillance. Finally, factors such as changes in case definitions for public health surveillance, introduction of new diagnostic tests, or discovery of new disease entities can cause changes in disease reporting that are independent of the true incidence of disease.

Indicator: Low Birthweight (091)

“Low birthweight” (LBW) is typically defined as any infant weighing <2,500 grams at birth. Weight is a critical health measure because low birthweight children are more prone to death and disability than their counterparts. Another important natality indicator is “very low birthweight” (VLBW), which is typically defined as any infant weighing <1,500 grams at birth.

Environmental exposures have been implicated as a risk factor for low birthweight (e.g., maternal smoking, maternal exposure to lead, DES, occupational exposures) (Kiely et al. 1994). However, the etiology of term-LBW (born 37+ weeks gestation) infants and preterm-LBW (born <37 weeks gestation) infants differs in that for term-LBW infants, most underlying causes (e.g., maternal smoking, weight at conception, and gestational weight gain) have been identified, where as for preterm-LBW infants, the etiology largely remains unexplained (CDC, 1994).

This indicator presents the percentage of LBW and VLBW infants born in the U.S. , based on natality data reported to the National Vital Statistics System. The NVSS registers virtually all deaths and births nationwide with data coverage from 1933 to present and from all 50 States and the District of Columbia.

What the Data Show

Figures 091-1 and 091-2 present the percentage of LBW and VLBW infants for the U.S. and each of the 10 EPA Regions for the years 1995-2001. The percentage of infants defined as LBW ranged from 7.3% in 1995 to 7.7% by 2001. The percentage of infants defined as VLBW was very stable and accounted for between 1.4% (1995, 1996, 1997, 2000, and 2001) and 1.5% (1998 and 1999) of all live births. In 2001, the percentage of LBW infants generally ranged from a high of 8.9% to a low of 5.8% for each of the EPA regions. From 1995 to 2001, the overall trend within each region increased slightly in the percentage of low birthweight infants. However, trends in the occurrence of very low birthweight infants have been relatively stable; varying less than 0.1% to 0.2% for each of the 10 EPA Regions.

Black women were generally twice as likely to have LBW infant and almost three times as likely to have VLBW infants between 1991 and 2000 compared to White and Hispanic women. This trend continued in 2001 and 2002. The percentage of LBW infants born among Black mothers was 12.9% (2001) and 13.3% (2002), compared to 6.7% (2001) and 6.8% (2002) among White women and 6.5% (2001 and 2002) among Hispanic women. The percentage of VLBW infants among Black women was 3.0% (2001) and 3.1% (2002), compared with 1.2% (2001 and 2002) among White women and 1.1% (2001) and 1.2% (2002) among Hispanic women

Differences in the percentage of LBW and VLBW infants among maternal age categories are apparent, especially at the extremes (i.e., younger mothers and older mothers). In 2002, the percentage of LBW infants born to mothers aged ≤19, 20-34, and 35+ years was 9.6%, 7.3%, and 9.0%, respectively. The percentage of VLBW infants for the same maternal age groups was 1.8%, 1.4%, and 1.7%, respectively.

Indicator Limitations

- Complete reporting of natality indicators such as LBW and VBLW may vary due to differences in the reporting requirements established by each state. It is possible that in some states the number of low birthweight babies may be under reported.

- Natality data are not available for the U.S. territories in CDC WONDER. Thus, Regions 2 and 9 are calculated to include only States.

Data Source

CDC. CDC WONDER: Natality Data Request. http://wonder.cdc.gov/nataJ.html

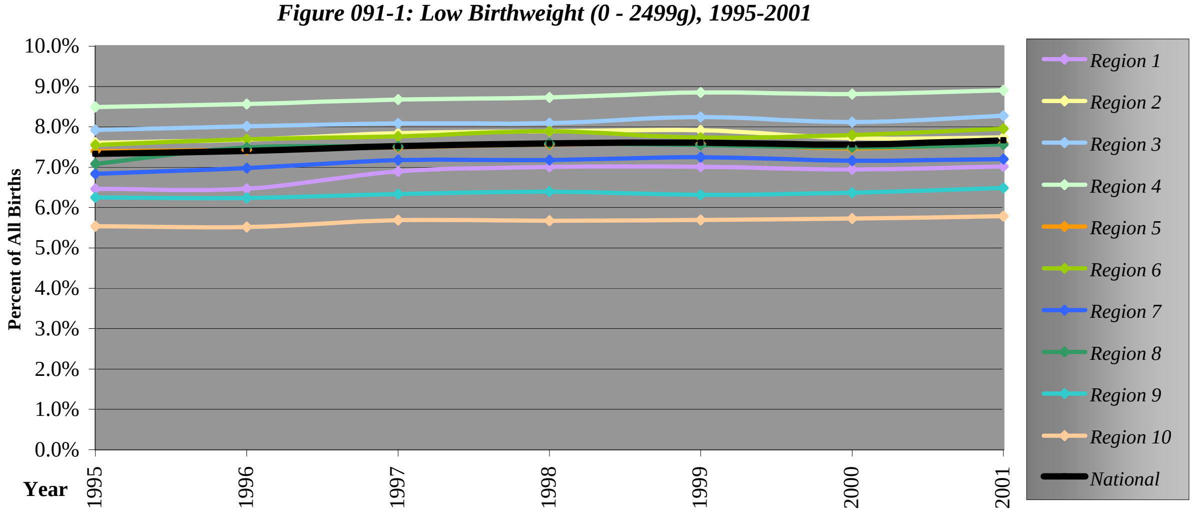
References

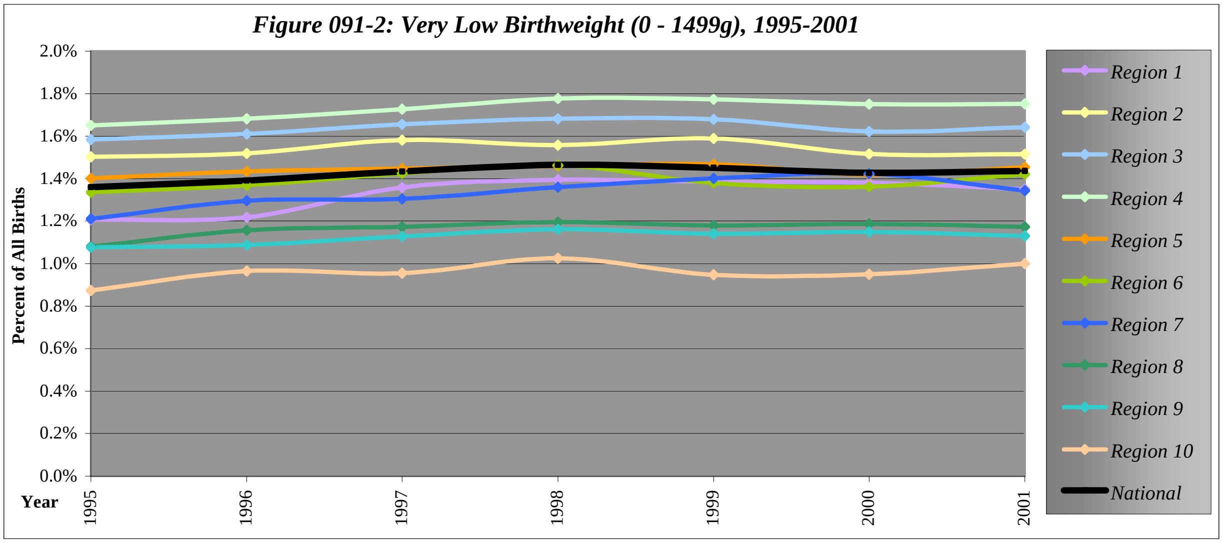
Center for Disease Control (CDC). 1994. Increasing Incidence of Low Birthweight -- United States, 1981-1991. MMWR 43:335-339. Accessed February 2, 2005. http://www.cdc.gov/mmwr/preview/mmwrhtml/00030918.htm

Kiely JS, Brett KM, Yu S, and Rowley DL. 1994. Low Birthweight and Intrauterine Growth Retardation. eds. Wilcox LS and Marks JS.In. From Data to Action CDC's Public Health Surveillance for Women, Infants, and Children CDC's Maternal & Child Health Monograph 1994. Center for Disease Control: Atlanta, GA.

Graphics

Figure 091-1: Low Birthweight (0 - 2499g), 1995-2001





R.O.E. Indicator QA/QC

Data Set Name: LOW BIRTHWEIGHT
Indicator Number: 091 (89091)
Data Set Source: CDC, NCHS
Data Collection Date: ongoing
Data Collection Frequency: yearly
Data Set Description: Low Birthweight
Primary ROE Question: What are the trends in human disease and conditions for which environmental pollutants are thought to be to risk factors including across population subgroups and geographic regions?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The National Vital Statistics System (NVSS) is the oldest and most successful example of inter-governmental data sharing in Public Health and the shared relationships, standards, and procedures form the mechanism by which NCHS collects and disseminates the Nation's official vital statistics. The methodology for collecting vital statistics is standardized and outlined in Model State Vital Statistics Act and Regulations Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf).

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The National Vital Statistics System is responsible for the Nation’s official vital statistics. These vital statistics are provided through State-operated registration systems. Standard forms for the collection of data and model procedures for the uniform registration of the events are developed and recommended for State use through cooperative activities of the States and the NCHS (http://www.cdc.gov/nchs/data/dvs/birth11-03final-ACC.pdf). U.S. Standard Birth Certificates are revised periodically. Most state certificates conform closely in content and arrangement to the standard certificate recommended by NCHS and all certificates contain a minimum data set specified by NCHS. One section of the Standard Birth Certificate is reserved for birth weight. The mother provides demographic information on the birth certificate, such as race and ethnicity, at the time of birth. Medical and health information is based on hospital record.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The data collected by NVSS are routinely referenced and used in epidemiological studies. Regional data: The raw numbers for each state were downloaded from the CDC WONDER natality database (http://wonder.cdc.gov/nataJ.html). The raw numbers for each state within a region were combined and percentages for each region calculated.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Virtually all births are registered with the NVSS nationwide. The temporal coverage of the data is from 1933 to present. Data are collected from all 50 States including the District of Columbia.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The data set has nationwide birth reporting, including sensitive populations.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Not applicable

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The sampling and quality assurance information can be found in Model State Vital Statistics Act and Regulations Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf). Documentation is also available at http://wonder.cdc.gov/wonder/help/nata.html Data source for Table HH3: CDC. CDC WONDER: Natality Data Request. http://wonder.cdc.gov/nataJ.html

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The data can be accessed up to the county level through the electronic data warehouse for CDC at http://wonder.cdc.gov/nataJ.html. Individual level data are not available due to confidentiality issues.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. Virtually all births from the 50 states, including District of Columbia, submit birth data to the NVSS at NCHS. The recommended birth certificate is posted at http://www.cdc.gov/nchs/data/dvs/birth11-03final-ACC.pdf. The documentation for the birth set is at http://wonder.cdc.gov/wonder/help/nata.html.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

See answer to T3Q1

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Not applicable

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Not applicable

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not applicable

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Regional data: Natality data are not available for the U.S. territories in CDC WONDER. Thus, Regions 2 and 9 are calculated to include only States.

Generation of Regional Natality Rates

Data set name(s): Indicator Graphs
Low Birth Weight by EPA Region
Very Low Birth Weight by EPA Region
Preterm Delivery by EPA Region

Data set date(s): 1995-2001 (data available at time of query)

Data source: CDC. WONDER Natality file1995–2001.
http://wonder.cdc.gov/nataJ.html

Data description:
Natality indicators are defined as:

- Low Birth Weight (0-2,499 grams)
- Very Low Birth Weight (0-1,499 grams)
- Preterm Delivery (0-36 weeks gestation)

Downloading and organizing the data:

- Natality data were accessed through CDC's WONDER database (http://wonder.cdc.gov/).

- We downloaded a raw data file containing the following data fields: year of birth; state of maternal residence; count of all births; count of "low birth weight" births (0-2,499 grams); count of "very low birth weight" births (0-1,499 grams); and count of "preterm delivery" births (0-36 weeks).

- The regional data file was produced by aggregating natality data for the 50 states and the District of Columbia into the ten EPA regions to obtain the total number of births and natality indicator counts for each region, by year. No natality data were available for U.S. territories. (For a map of the EPA regions, refer to http://www.epa.gov/epahome/whereyou-live.htm.)

- An Excel worksheet was produced for each natality indicator displaying either, the percentage of births that were defined as low birth weight, very low birth weight, or preterm delivery, by EPA region for the years 1995 – 2001. All cases for a given indicator (e.g., very low birth weight) are summed by year within each region.

- No adjustments (e.g., calculating age-adjusted rates) to the raw data were required for the natality dataset.

- Rates are expressed as percentages and calculated by dividing the number of observations in each of the regions (e.g., low birth weight babies) by the total number of births in the corresponding regions and multiplying by 100.

Indicator: Preterm Delivery (212)

Preterm delivery is defined as delivery prior to 37 weeks of gestation (a typical pregnancy lasts 40 weeks). The shorter the gestational age of an infant, the more likely (s)he is to suffer adverse effects. Preterm birth along with low birthweight is the second leading cause of infant death, and is associated with nearly half of all neurological birth defects (Martin et al., 2003).

Maternal high risk conditions (e.g., infertility problems, vaginal spotting, inadequate maternal weight gain), maternal previous history, socioeconomic status, smoking, alcohol consumption before third trimester, and multiple gestation pregnancy are major risk factors for preterm delivery. Environmental contaminants (e.g., lead) continue to be studied to better understand the likely associations with preterm delivery (Blackmore and Rowley, 1994).

This indicator presents the proportion of U.S. infants born prior to 37 weeks of gestation, based on natality data reported to the National Vital Statistics System. The NVSS registers virtually all deaths and births nationwide with data coverage from 1933 to present and from all 50 States and the District of Columbia.

What the Data Show

The proportion of infants defined as preterm has risen 14% since 1990 (Martin, et al. 2003). Figure 212 presents preterm delivery percentages for the U.S. and each of the 10 EPA Regions for the years 1995-2001. A general increase has been observed from 1995 (10.9%) to 2001 (11.8%). The rate in 2002 was 11.9% (Martin et al., 2003). Moderately preterm births (infants born 32-36 weeks gestation) account for the bulk of the rise for 2001–2002; the percent of infants born very preterm (less than 32 weeks) was essentially unchanged at 1.96% in 2002 and 1.95% in 2001(Martin et al., 2003).

Like the national data, the number of preterm deliveries has increased over time for each of the 10 EPA Regions from 1995 to 2001 (Figure 212). In 1995, the number of preterm deliveries across the 10 EPA Regions ranged from 8.6 % (Region 10) to 12.4% (Region 4). In 2001, the number of preterm deliveries across the EPA Regions ranged from 9.8% (Region 10) to 13.5% (Region 4).

Preterm delivery has been observed to be higher among Black mothers compared to White and Hispanic mothers. Between 1999-2002, preterm delivery among Black mothers ranged from a low of 17.1% (2000) to 17.4% (1999, 2001, 2002). During that same time period, preterm delivery among White mothers ranged from 10.5% (2000) to 11.0% (2002) and Hispanic mothers ranged from 11.0% (2000) to 11.4% (2002) (Martin et al., 2003).

Indicator Limitations

- “The primary measure used to determine the gestational age of the newborn is the interval between the first day of the mother’s last normal menstrual period (LMP) and the date of birth.” This measurement is subject to error, including imperfect maternal recall or misidentification of the LMP because of postconception bleeding, delayed ovulation, or intervening early miscarriage These data are edited for LMP-based gestational ages, which are clearly inconsistent with the infant’s plurality and birthweight, but reporting problems for this item persist and may occur more frequently among some subpopulations and among births with shorter gestations (Martin et al., 2003).

- Preterm delivery data were extracted from the CDC WONDER database. Slight differences in percentages were obtained compared to reports by Martin et al. (2003). The source of these differences in unknown.

- Natality data are not available for the U.S. territories in CDC WONDER. Thus, Regions 2 and 9 are calculated to include only States.

Data Source

CDC. CDC WONDER: Natality Data Request. http://wonder.cdc.gov/nataJ.html

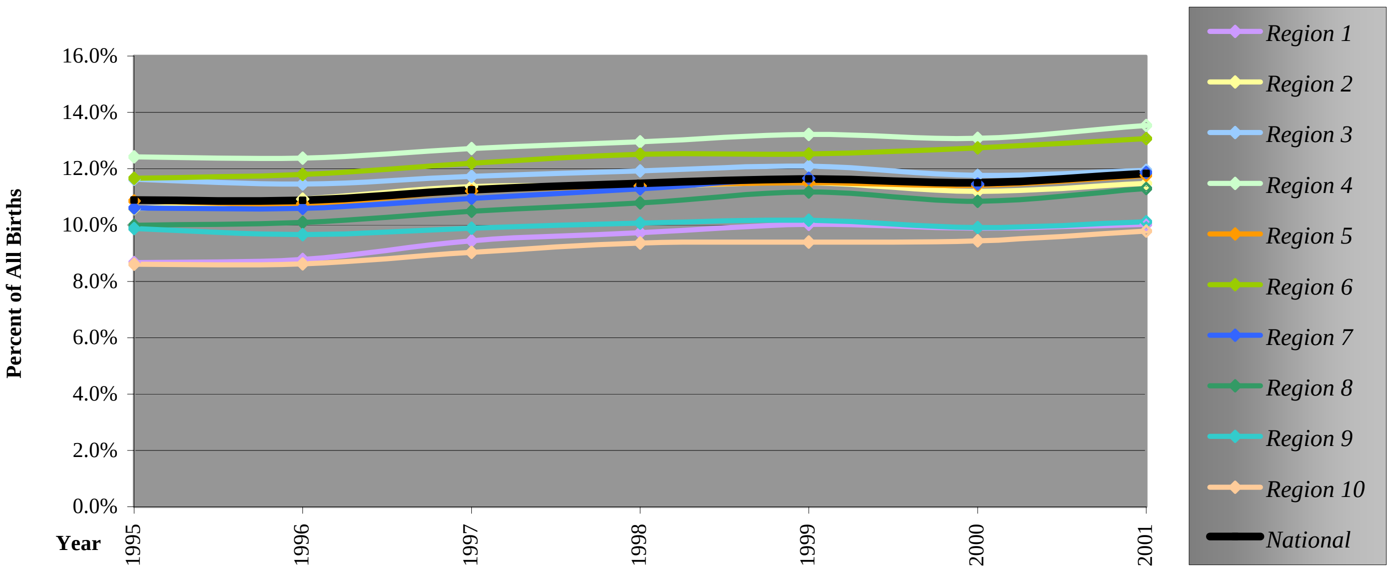
References

Blackmore CA, Rowley DL. 1994. Preterm Birth. eds. Wilcox LS and Marks JS.In. From Data to Action CDC's Public Health Surveillance for Women, Infants, and Children CDC's Maternal & Child Health Monograph 1994. Center for Disease Control: Atlanta, GA.

Martin JA, Hamilton BE, Sutton PD, Ventura SJ, Menacker F, and Munson ML. 2003. "Births: Final Data for 2002." *National Vital Statistics Reports*, 52(10) Hyattsville, Maryland: National Center for Health Statistics. Last accessed: November 22, 2004. http://www.cdc.gov/nchs/data/nvsr/nvsr52/nvsr52_10.pdf

Graphics

Figure 212. Percentage of Preterm Delivery (<37 weeks gestations), total U.S. and 10 EPA Regions, 1995-2001



R.O.E. Indicator QA/QC

Data Set Name: PRETERM DELIVERY
Indicator Number: 212 (89087)
Data Set Source: CDC, NCHS
Data Collection Date: ongoing
Data Collection Frequency: yearly
Data Set Description: Preterm Delivery
Primary ROE Question: What are the trends in human disease and conditions for which environmental pollutants are thought to be to risk factors including across population subgroups and geographic regions?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The National Vital Statistics System (NVSS) is the oldest and most successful example of inter-governmental data sharing in Public Health and the shared relationships, standards, and procedures form the mechanism by which NCHS collects and disseminates the Nation's official vital statistics. The methodology for collecting vital statistics is standardized and outlined in Model State Vital Statistics Act and Regulations Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf). Preterm delivery is defined as <37 completed weeks of gestation, and is measured in frequency and rate.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The National Vital Statistics System is responsible for the Nation s official vital statistics. These vital statistics are provided through State-operated registration systems. Standard forms for the collection of data and model procedures for the uniform registration of the events are developed and recommended for State use through cooperative activities of the States and the NCHS (http://www.cdc.gov/nchs/data/dvs/birth11-03final-ACC.pdf). U.S. Standard Birth Certificates are revised periodically. Most state certificates conform closely in content and arrangement to the standard certificate recommended by NCHS and all certificates contain a minimum data set specified by NCHS. One section of the Standard Birth Certificate is reserved for gestational age. The mother provides demographic information on the birth certificate, such as race and ethnicity, at the time of birth. Medical and health information is based on hospital record.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The data collected by NVSS are routinely referenced and used in epidemiological studies. Regional data: The raw numbers for each state were downloaded from the CDC WONDER natality database (http://wonder.cdc.gov/nataJ.html). The raw numbers for each state within a region were combined and percentages for each region calculated.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Virtually all births are registered with the NVSS nationwide. The temporal coverage of the data is from 1933 to present. Data are collected from all 50 States including the District of Columbia.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The data set has nationwide birth reporting, including sensitive populations.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Not applicable

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The sampling and quality assurance information can be found in Model State Vital Statistics Act and Regulations Revised April 1995, DHHS publication (PHS) 95-1115 (http://www.cdc.gov/nchs/data/misc/mvsact92aacc.pdf). Documentation is also available at http://wonder.cdc.gov/wonder/help/nata.html Data source for Table HH3: CDC. CDC WONDER: Natality Data Request. http://wonder.cdc.gov/nataJ.html

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The data can be accessed up to the county level through the electronic data warehouse for CDC at http://wonder.cdc.gov/nataJ.html. Individual level data are not available due to confidentiality issues.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. Virtually all births from the 50 states, including District of Columbia, submit birth data to the NVSS at NCHS. The recommended birth certificate is posted at http://www.cdc.gov/nchs/data/dvs/birth11-03final-ACC.pdf. The documentation for the birth set is at http://wonder.cdc.gov/wonder/help/nata.html.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

See answer to T3Q1

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Not applicable

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Not applicable

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not applicable

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The primary measure used to determine the gestational age of the newborn is the interval between the first day of the mother's last normal menstrual period (LMP) and the date of birth (Martin et al., 2003). This measurement is subject to error, including imperfect maternal recall or misidentification of the LMP because of postconception bleeding, delayed ovulation, or intervening early miscarriage. These data are edited for LMP-based gestational ages, which are clearly inconsistent with the infant's plurality and birthweight, but reporting problems for this item persist and may occur more frequently among some subpopulations and among births with shorter gestations. Regional Data: Natality data are not available for the U.S. territories in CDC WONDER. Thus, Regions 2 and 9 are calculated to include only States.

Generation of Regional Natality Rates

Data set name(s): Indicator Graphs
Low Birth Weight by EPA Region
Very Low Birth Weight by EPA Region
Preterm Delivery by EPA Region

Data set date(s): 1995-2001 (data available at time of query)

Data source: CDC. WONDER Natality file1995–2001.
http://wonder.cdc.gov/nataJ.html

Data description:
Natality indicators are defined as:
Low Birth Weight (0-2,499 grams)
Very Low Birth Weight (0-1,499 grams)
Preterm Delivery (0-36 weeks gestation)

Downloading and organizing the data:

Natality data were accessed through CDC's WONDER database (http://wonder.cdc.gov/).

We downloaded a raw data file containing the following data fields: year of birth; state of maternal residence; count of all births; count of "low birth weight" births (0-2,499 grams); count of "very low birth weight" births (0-1,499 grams); and count of "preterm delivery" births (0-36 weeks).

The regional data file was produced by aggregating natality data for the 50 states and the District of Columbia into the ten EPA regions to obtain the total number of births and natality indicator counts for each region, by year. No natality data were available for U.S. territories. (For a map of the EPA regions, refer to http://www.epa.gov/epahome/whereyou-live.htm.)

An Excel worksheet was produced for each natality indicator displaying either, the percentage of births that were defined as low birth weight, very low birth weight, or preterm delivery, by EPA region for the years 1995 – 2001. All cases for a given indicator (e.g., very low birth weight) are summed by year within each region.

No adjustments (e.g., calculating age-adjusted rates) to the raw data were required for the natality dataset.

Rates are expressed as percentages and calculated by dividing the number of observations in each of the regions (e.g., low birth weight babies) by the total number of births in the corresponding regions and multiplying by 100.

Indicator: Blood Lead Level and Childhood Blood Lead (098 and 105)

Lead is a naturally occurring metal found in small amounts in rock and soil. Lead has been used industrially in the production of gasoline, ceramic products, paints, and solder. While lead arising from the combustion of leaded gasoline was a major source of exposure in past decades, today lead based paint and lead-contaminated dust from paint are the primary sources of lead exposure in the home. Lead levels can be measured in blood or urine.

Lead is a neurotoxic metal that affects areas of the brain that regulate behavior and nerve cell developments (NRC, 1993). Its adverse effects range from subtle responses to overt toxicity, depending on how much lead is taken into the body and the age and health status of the person (CDC, 1991). Lead is one of the few pollutants for which biomonitoring and health effect data are sufficient to clearly evaluate environmental management efforts to reduce lead in the environment.

Infants, children, and fetuses are more vulnerable to the effects of lead because the blood-brain barrier is not fully developed (Nadakavukaren, 2000). Thus, a smaller amount of lead will have a greater effect in children than in adults. In addition, ingested lead is more readily absorbed into a child's bloodstream, while adults absorb only 10%. Because of lead's adverse effects on cognitive development, CDC has defined an elevated blood lead level as equal to or greater than 10 micrograms/deciliter (µg/dL) for children under 6 years of age (CDC, 2003).

This indicator is based on data collected by the National Health and Nutrition Examination Survey (NHANES). NHANES is a series of surveys conducted by CDC's National Center for Health Statistics (NCHS) that is designed to collect data on the health and nutritional status of the civilian, non-institutionalized U.S. population using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey; biomonitoring for certain environmental chemicals also was implemented. These data are presented here as a baseline with the intent of reporting trends in the future.

What the Data Show

The overall geometric mean for blood lead levels among all participants aged 1 year and older from NHANES 1999-2000 was 1.7 µg/dL (Table 098_105Lead). Adults aged 20 years and older had a geometric mean lead level of 1.8 µg/dL. Males and females had a geometric mean lead level of 2.0 µg/dL and 1.4 µg/dL, respectively. For non-Hispanic African-Americans, Mexican Americans, and non-Hispanic Whites the geometric mean lead levels were 1.9, 1.8, and 1.6µg/dL, respectively.

Of all groups, children aged 1-5 years had the highest geometric mean lead level at 2.2 µg/dL. Children aged 6-11 years and teenagers aged 12-19 years geometric mean lead levels were 1.5 and 1.1 µg/dL, respectively.

Indicator Limitations

- NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 2 years of data in NHANES 1999-2000, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representativeness of coverage.

- The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2000 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses.

- For NHANES 1999-2000, the first stage of selection was the PSU-level. The PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 NHANES sample is selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates.

- NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999 and 2000, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported.

- The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value.

- The measurement of lead or any other environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.

Data Source

Centers for Disease Control and Prevention. Second National Report on Human Exposure to Environmental Chemicals. January 2003. (Last Accessed November 21, 2004) http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

References

Centers for Disease Control and Prevention (CDC). 1991. Preventing lead poisoning in young children. U.S. Department of Health and Human Services, Public Health Service. (Last Accessed November 21, 2004) http://aepo-xdv-www.epo.cdc.gov/wonder/prevguid/p0000029/p0000029.asp

Centers for Disease Control and Prevention (CDC). 2003. Second National Report on Human Exposure to Environmental Chemicals. (Last Accessed November 21, 2004) http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

Nadakavukaren A. 2000. Our Global Environment: A Health Perspective, Fifth Edition. Prospect Heights, IL: Waveland Press, Inc.

National Research Council. 1993. Measuring Lead Exposure in Infants, Children, and Other Sensitive Populations. Washington, DC: National Academies Press.

Graphics

Table 098_105Lead. Geometric mean and selected percentiles of total blood lead concentrations (in µg/dL) for the United States population, aged one year and older, by select demographic groups, National Health and Nutrition Examination Survey (NHANES), 1999-2000.

	Sample Size	Geometric Mean	10th	25th	50th	75th	90th
Total, Age 1 year and older	7,970	1.7	0.8	1.0	1.6	2.4	3.8
Sex							
Male	3,913	2.0	0.8	1.3	1.8	2.9	4.4
Female	4,057	1.4	0.6	0.8	1.3	1.9	3.0
Race Ethnicity*							
Black, non-Hispanic	1,842	1.9	0.7	1.1	1.7	2.8	4.2
Mexican American	2,743	1.8	0.8	1.2	1.8	2.7	4.2
White, non-Hispanic	2,715	1.6	0.6	1.0	1.6	2.4	3.6
Age Group							
1-5 years	723	2.2	1.0	1.4	2.2	3.3	4.8
6-11 years	905	1.5	0.7	0.9	1.3	2.0	3.3
12-19 years	2,135	1.1	0.4	0.8	1.0	1.4	2.3
20+ years	4,207	1.8	0.7	1.0	1.7	2.5	3.9

*Other racial/ethnic groups are included in the Total only

Source: Centers for Disease Control and Prevention. Second National Report on Human Exposure to Environmental Chemicals. January 2003. (Accessed November 21, 2004) http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

R.O.E. Indicator QA/QC

Data Set Name: BLOOD LEAD LEVEL
Indicator Number: 098 (89122)
Data Set Source: NHANES 1999-2000
Data Collection Date: ongoing
Data Collection Frequency: 2 yr cycle
Data Set Description: Blood Lead Level (including childhood blood lead - combines 098 & 105)
Primary ROE Question: What are the trends in biomeasures of exposure to common environmental pollutants including across population subgroups and geographic regions?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. Blood samples were collected and processed in accordance with the methods indicated in the NHANES Specimen Collection and Laboratory/Medical Technologists Procedures Manual (LPM). See: http://www.cdc.gov/nchs/data/nhanes/blood.pdf http://www.cdc.gov/nchs/data/nhanes/LAB1-6.pdf Cadmium and lead were simultaneously measured in whole blood. Cadmium and lead quantification is based on the measurement of light absorbed at 228.8 nm and 283.3 nm, respectively, by ground state atoms of cadmium and lead from either an electrodeless discharge lamp (EDL) or hollow cathode lamp (HCL) source. Human blood (patient or study) samples, bovine blood quality control pools, and aqueous standards are diluted with a matrix modifier (nitric acid, Triton X-100, and ammonium phosphate). The cadmium and lead contents are determined on a Perkin-Elmer Model SIMAA 6000 simultaneous multi-element atomic absorption spectrometer with Zeeman Background correction. See: http://www.cdc.gov/nchs/data/nhanes/frequency/lab06_doc.pdf The units used for this indicator were ¼g/dL. http://www.cdc.gov/nchs/data/nhanes/frequency/varlab.pdf

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. NHANES is designed to provide statistically representative national averages. Starting with NHANES 1999, the survey is conducted annually. All participants aged 1 year or older in NHANES 1999-2000 were measured for blood lead. The measurements produced by NHANES for this indicator were used in the "Second National Report on Human Exposure to Environmental Chemicals" published by the National Center for Environmental Health in 2003. http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Not applicable. The indicator is a direct measure of lead in blood.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

This indicator is based on a national probability-based sampling design and is deemed of sufficient quality for generalization to the nation. The samples for 1999-2000 were used for this analysis. Quality assurance measures were in place. Beginning in 1999, NHANES became a continuous and annual survey. The sampling plan for each year follows a complex, stratified, multistage, probability-cluster design to select a representative sample of the civilian, noninstitutionalized population. Every year, approximately 7,000 individuals, of all ages, are interviewed in their homes; of these, approximately 5,000 complete the health examination component of the survey. The survey sample size for NHANES 1999-2000 is 9,965 (http://www.cdc.gov/nchs/data/nhanes/gendoc.pdf).

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The current sampling design includes oversampling of African Americans, Mexican Americans, adolescents (12-19 year olds), older Americans (60 years of age and older), and pregnant women to produce more reliable estimates for these groups.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator simply provides information that exposure to lead has occurred. Blood lead measurement is the preferred method (over urinary measurements) of evaluating lead exposure and its health effects in people. Blood lead levels (BLLs) are contributed to by both recent intake and an equilibration with stored lead in other tissues, whereas urine lead levels result from only recent exposures. The U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) requires monitoring of blood lead and reduction of exposure to lead when worker BLLs are higher than 40 ¼g/dL of whole blood. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that BLLs in workers not exceed 30 ¼g/dL. The Deutsche Forschungsgemeinschaft provides a Biological Tolerance Level of 40 ¼g/dL for workers. The World Health Organization has a level of concern of 20 ¼g/dL. The CDC recommends that children's levels not exceed 10 ¼g/dL. As reported in "Second National Report on Human Exposure to Environmental Chemicals" published by the National Center for Environmental Health in 2003. http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf The measurement of lead or any other environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Documentation for NHANES 1999-2000 is found on NCHS/CDC website at the following URL: http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files The following provides more specific examples: The Addendum to the NHANES III for the 1999-2000 dataset clearly outlines the 1999-2000 sampling design and recommends analytic procedures. http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf The "Second National Report on Human Exposure to Environmental Chemicals" published by the National Center for Environmental Health in 2003 more generally describes the NHANES 1999-2000 sampling plan. http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf Laboratory measurement information: http://www.cdc.gov/nchs/data/nhanes/frequency/lab06_doc.pdf And the "Weighting Notes" posted on the NHANES website also offer helpful advice. http://www.cdc.gov/nchs/data/nhanes/frequency/weights%20to%20usev6.pdf

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

For the most part, Individual level data are available, but data access limitations do exist for some variables due to confidentiality issues.
http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The Addendum to the NHANES III for the 1999-2000 dataset clearly outlines the 1999-2000 sampling design and recommends analytic procedures.
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf
http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The quality assurance plans for NHANES 1999-2000 are available from the Division of Data Dissemination, NCHS, 6525 Belcrest Rd. Hyattsville, MD, 20782-2003. Tel. 301-458-4636. Internet: http://www.cdc.gov/nchs/about/quality.htm

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The NHANES 1999-2004 survey is designed to be annually nationally representative of the U.S. citizen, non-institutionalized population. (see page 11 of the addendum linked below)
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. (see pages 11-19 of the addendum linked below)
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 2 years of data in NHANES 1999-2000, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representative of coverage. The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2000 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses. For NHANES 1999-2000, the first stage of selection was the PSU-level. The PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 NHANES sample is selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates. NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999 and 2000, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported. The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value. For more information, see the addendum to NHANES III linked below: http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

As subsequent years are added to this survey, estimates will become more stable. However, with the laboratory data, there is no guarantee that an environmental chemical will be measured from year to year. Lead was measured in the 2001-2002 cycle and the current 2003-2004 cycle. Effort will be made to include in this report any published updates. http://www.cdc.gov/exposurereport/pdf/third_report_chemicals.pdf Serum lead was measured in all people in the survey year aged one year and older. The measurement of lead or any other environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.

Indicator: Blood Mercury Level and Childhood Blood Mercury (100 and 106)

Mercury is a naturally occurring metal that is widespread and persistent in the environment. It is found in elemental form and in various organic compounds and complexes. Methylmercury (an organic form) can accumulate in the food chain in aquatic systems and lead to high concentrations in predatory fish. Consumption of contaminated fish is the major source of human exposure to methylmercury in the United States (NRC, 2000).

The human health effects of mercury are diverse and depend on the forms of mercury encountered and the severity and length of exposure. Fetuses and children may be more susceptible to mercury than adults, with concern for the occurrence of developmental and neurological health effects (NRC, 2000). Prenatal exposures interfere with the growth and migration of neurons and have the potential to cause irreversible damage to the developing central nervous system. Blood mercury levels below 5.8 µg/L (the EPA Reference dose) are assumed to be without appreciable harm (CDC, 2004).

This indicator quantifies the blood mercury levels (includes organic and inorganic) among U.S. women aged 16–49 years and children aged 1–5 years, using data from the 1999-2002 National Health and Nutrition Examination Survey (NHANES). NHANES is a series of surveys conducted by CDC's National Center for Health Statistics (NCHS) that is designed to collect data on the health and nutritional status of the civilian, non-institutionalized U.S. population using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. These data are presented here as a baseline with the intent of reporting trends in the future.

What the Data Show

For 1999–2002, the overall geometric mean for total blood mercury levels among women aged 16–49 years was 0.92 µg/L and among children aged 1–5 years it was 0.33 µg/L (Table 100_106Mercury). When the means are stratified across three racial/ethnic groups, Black, non-Hispanic women aged 16–49 have the highest levels (1.18 µg/L), followed by White, non-Hispanics (0.87 µg/L) and Mexican Americans (0.74 µg/L) Among children, Black, non-Hispanics have the highest geometric mean (0.50 µg/L), followed by Mexican Americans (0.35 µg/L) and White, non-Hispanics (0.29 µg/L) (CDC, 2004).

The percentage of women aged 16–49 years with blood mercury levels greater than or equal to 5.8 µg/L was 5.7% for 1999-2002 (CDC, 2004). White, non-Hispanic women (5.8%) were most likely to have levels above the Reference dose followed by Black, non-Hispanics (4.8%) and Mexican Americans (1.7%). Because so few children had levels ≥ 5.8 µg/L, a statistically reliable percentage could not be calculated.

Indicator Limitations

- NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 4 years of data in NHANES 1999-2000 and 2001-2002, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representative of coverage.

    - The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2002 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses.

  - For NHANES 1999-2000 and 2001-2002, the first stage of selection was the PSU-level. The PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 and 2001-2002 NHANES samples are selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates.

  - NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999, 2000, 2001, and 2002, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported.

  - The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value.

- The National Center for Health Statistics advises users of these data that the most reliable estimates of current exposure are obtained when the 1999–2002 data are analyzed together

- The measurement of mercury or any other environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.

Data Sources

Centers for Disease Control and Prevention. 2004. Blood Mercury Levels in Young Children and Childbearing-Aged Women – United States, 1999-2002. MMWR 53:1018-1020 (Last Accessed December 2, 2004) http://www.cdc.gov/mmwr/PDF/wk/mm5343.pdf

References

Centers for Disease Control and Prevention (CDC). 2004. Blood Mercury Levels in Young Children and Childbearing-Aged Women – United States, 1999-2002. MMWR 53:1018-1020 (Last Accessed December 2, 2004) http://www.cdc.gov/mmwr/PDF/wk/mm5343.pdf

National Research Council (NRC). 2000. Toxicological Effects of Methylmercury. Washington, DC: National Academies Press.

Graphics

Table 100_106Mercury. Geometric mean and selected percentiles of blood mercury concentrations (in µg/L) for women aged 16 to 49 years and children (males and females) aged 1-5 years in the United States population, National Health and Nutrition Examination Survey (NHANES), 1999-2002

	Sample Size	Geometric Mean	10^{th}	25^{th}	50^{th}	75^{th}	90^{th}
Women aged 16-49 years	3,637	0.92	0.17	0.40	0.86	1.81	3.89
Race Ethnicity							
Black, non-Hispanic	794	1.18	0.30	0.60	1.15	2.12	3.89
Mexican American	1,106	0.74	0.17	0.34	0.73	1.27	2.38
White, non-Hispanic	1,377	0.87	0.15	0.37	0.81	1.69	3.73
Children Aged 1-5 years	1,577	0.33	0.07	0.10	0.26	0.61	1.29
Race Ethnicity							
Black, non-Hispanic	424	0.50	0.10	0.22	0.47	0.88	1.54
Mexican American	526	0.35	0.08	0.13	0.28	0.63	1.36
White, non-Hispanic	447	0.29	0.07	0.09	0.20	0.49	1.15

Source: Centers for Disease Control and Prevention. 2004. Blood Mercury Levels in Young Children and Childbearing-Aged Women – United States, 1999-2002. MMWR 53:1018-1020. November 5, 2004. http://www.cdc.gov/mmwr/PDF/wk/mm5343.pdf

R.O.E. Indicator QA/QC

Data Set Name: BLOOD MERCURY LEVEL
Indicator Number: 100 (89096)
Data Set Source: CDC - NHANES
Data Collection Date: ongoing
Data Collection Frequency: 2 year cycles
Data Set Description: Blood Mercury Level (including childhood blood mercury - combines 100 & 106)
Primary ROE Question: What are the trends in biomeasures of exposure to common environmental pollutants including across population subgroups and geographic regions?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. Blood samples were collected and processed in accordance with the methods indicated in the NHANES Specimen Collection and Laboratory/Medical Technologists Procedures Manual (LPM). See: http://www.cdc.gov/nchs/data/nhanes/blood.pdf http://www.cdc.gov/nchs/data/nhanes/LAB1-6.pdf Total mercury in whole blood was measured by flow injection cold vapor atomic absorption analysis with on-line microwave digestion, based on the method by T. Buo and J. Bassner. Decomposition of organic mercury compounds in blood occurs mainly while the sample (mixed with bromate-bromide reagent and hydrochloric acid) flows through the digestion coil in the microwave. Further decomposition of organic mercury is achieved by on-line addition of potassium permanganate. The total (organic + inorganic) mercuric mercury released is reduced to mercury vapor by sodium tetrahydroborate. The mercury vapor is measured by the spectrometer at 253.7 nm. Inorganic mercury in whole blood is measured by using stannous chloride as reductant without employing microwave digestion system. Mercury vapor (reduced from inorganic mercury compounds) is measured via the same quartz cell at 253.7 nm. The difference in the total reduced mercury (by sodium tetrahydroborate) and inorganic reduced mercury (by stannous chloride) is taken to represent organic mercury in whole blood. See: http://www.cdc.gov/nchs/data/nhanes/frequency/lab06_doc.pdf The units used for this indicator were ¼g/L. http://www.cdc.gov/nchs/data/nhanes/frequency/varlab.pdf

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. NHANES is designed to provide statistically representative national averages. Starting with NHANES 1999, the survey is conducted annually. Blood mercury levels were measured in a subsample of participants in NHANES 1999-2002 aged 1-5 years and in females aged 16-49 years. Subsamples were randomly selected within the specified age ranges to be a representative sample of the U.S. population. The measurement of total blood mercury included both the inorganic and organic forms.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Not applicable.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

This indicator is based on a national probability-based sampling design and is deemed of sufficient quality for generalization to the nation. The samples for 1999-2002 were used for this analysis. Quality assurance measures were in place. Beginning in 1999, NHANES became a continuous and annual survey. The sampling plan for each year follows a complex, stratified, multistage, probability-cluster design to select a representative sample of the civilian, noninstitutionalized population. Every year, approximately 7,000 individuals, of all ages, are interviewed in their homes; of these, approximately 5,000 complete the health examination component of the survey. The survey sample size for NHANES 1999-2000 is 9,965 (http://www.cdc.gov/nchs/data/nhanes/gendoc.pdf).

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The current sampling design includes oversampling of African Americans, Mexican Americans, adolescents (12-19 year olds), older Americans (60 years of age and older), and pregnant women to produce more reliable estimates for these groups.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator simply provides information that exposure to mercury has occurred. The American Conference of Governmental Industrial Hygienists recommends that the blood inorganic mercury of workers not exceed 15 ¼g/L. As reported in “Second National Report on Human Exposure to Environmental Chemicals” published by the National Center for Environmental Health in 2003 (http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf), the measurement of mercury or any other environmental chemical in a person’s blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Source: Centers for Disease Control and Prevention. 2004. Blood Mercury Levels in Young Children and Childbearing-Aged Women United States, 1999-2002. MMWR 53:1018-1020 (Accessed December 2, 2004) http://www.cdc.gov/mmwr/PDF/wk/mm5343.pdf Additional Documentation can be found on CDC's NHANES website. For instance: Documentation for NHANES 1999-2000 is found on NCHS/CDC website at the following URL: http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files The following provides more specific examples: The Addendum to the NHANES III for the 1999-2000 dataset clearly outlines the 1999-2000 sampling design and recommends analytic procedures. http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf The Second National Report on Human Exposure to Environmental Chemicals published by the National Center for Environmental Health in 2003 more generally describes the NHANES 1999-2000 sampling plan. http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf Laboratory measurement information: http://www.cdc.gov/nchs/data/nhanes/frequency/lab06_doc.pdf The NHANES 1999-2000 subsampling webpage clearly describes the subsampling methods used and how subsampled data should be analyzed http://www.cdc.gov/nchs/about/major/nhanes/subsample.htm as do the Weighting Notes posted on the NHANES website http://www.cdc.gov/nchs/data/nhanes/frequency/weights%20to%20usev6.pdf

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

For the most part, Individual level data are available, but data access limitations do exist for some variables due to confidentiality issues.
http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The Addendum to the NHANES III for the 1999-2002 dataset clearly outlines the 1999-2002 sampling design and recommends analytic procedures.
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf
http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The quality assurance plans for NHANES 1999-2002 are available from the Division of Data Dissemination, NCHS, 6525 Belcrest Rd. Hyattsville, MD, 20782-2003. Tel. 301-458-4636. Internet: http://www.cdc.gov/nchs/about/quality.htm

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The NHANES 1999-2002 survey is designed to be annually nationally representative of the U.S. citizen, non-institutionalized population. (see page 11 of the addendum linked below)
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. (see pages 11-19 of the addendum linked below)
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 4 years of data in NHANES 1999-2000 and 2001-2002, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representative of coverage. The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2002 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses. For

NHANES 1999-2000 and 2001-2002, the first stage of selection was the PSU-level. The PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 and 2001-2002 NHANES samples are selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates. NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999, 2000, 2001, and 2002, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported. The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value. http://www.cdc.gov/nchs/about/major/nhanes/subsample.htm

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Although the annual NHANES is nationally representative, it is not possible to produce environmental exposure estimates by geographic region. Because the number of geographic sites sampled each year is small and because environmental exposure measures may vary geographically, national estimates based on one year of data may be highly variable. Caution is needed when comparing blood mercury data between 1999-2000 and 2001-2002. Each time period (1999-2000 and 2001-2002) represents only two years of data. Changes in estimates between the two time periods do not necessarily reflect a trend. At least two more years of data are needed (e.g., 2003-2004) to better evaluate possible trends (CDC, 2004). Blood mercury levels were measured in all women aged 16-49 years and children aged 1-5 years. The measurement of mercury or any other environmental chemical in a person s blood or urine does not by itself mean that the chemical has caused or will cause harmful effects. As subsequent years are added to this survey, estimates will become more stable. However, with the laboratory data, there is no guarantee that an environmental chemical will be measured from year to year.

Indicator: Blood Cadmium Level (101)

Elemental cadmium is a metal that is usually found in nature combined with other elements such as oxygen, chlorine, or sulfur. Cadmium enters the environment from the weathering of rocks and minerals that contain cadmium. Exposure to cadmium can occur in occupations such as mining or electroplating, where cadmium is produced or used. Cadmium exposure can also occur from exposure to cigarette smoke (CDC, 2003).

Cadmium and its compounds are toxic to humans and animals. Once absorbed into the human body, cadmium can accumulate in the kidneys and remain in the body for decades. Chronic exposure to cadmium may result in serious kidney damage. Osteomalacia, a bone disorder similar to rickets, is also associated with long-term ingestion of cadmium. Acute airborne exposure, as occurs from welding on cadmium-alloy metals, can result in swelling (edema) and scarring (fibrosis) of the lungs (CDC, 2003).

This indicator reflects blood cadmium concentrations in µg/L for the United States population, aged one year and older, as measured in the 1999-2000 National Health and Nutrition Examination Survey (NHANES). NHANES is a series of surveys conducted by CDC's National Center for Health Statistics (NCHS) that is designed to collect data on the health and nutritional status of the civilian, non-institutionalized U.S. population using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey; biomonitoring for certain environmental chemicals also was implemented. These data are presented here as a baseline with the intent of reporting trends in the future.

What the Data Show

Table 101Cadmium presents the geometric means for blood cadmium among participants aged 1 year and older from NHANES 1999-2000. The overall geometric mean was 0.4 µg/L. The blood cadmium measurements were similar among males and females as well as among the racial or ethnic groups sampled. The overall geometric mean among participants aged 20 years or older was slightly higher (0.5 µg/L) than the geometric mean among the 12–19 year age group (0.3 µg/L). Approximately one-half of all participants under the age of 12 had non-detectable blood cadmium concentrations.

Indicator Limitations

- NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 2 years of data in NHANES 1999-2000, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representativeness of coverage.

    - The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2000 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses.

- For NHANES 1999-2000, the first stage of selection was the PSU-level. The PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 NHANES sample is selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates.

- NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999 and 2000, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported.

- The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value.

- The measurement of cadmium or any other environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.

Data Sources

Centers for Disease Control and Prevention (CDC). 2003. Second National Report on Human Exposure to Environmental Chemicals. (Accessed November 21, 2004)
http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

References

Centers for Disease Control and Prevention (CDC). 2003. Second National Report on Human Exposure to Environmental Chemicals. (Accessed November 21, 2004)
http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

Graphics

Table 101Cadmium. Geometric mean and selected percentiles of blood cadmium concentrations (in µg/L) for the United States population, aged one year and older, by select demographic groups, National Health and Nutrition Examination Survey (NHANES), 1999-2000.

	Sample Size	Geometric Mean	10th	25th	50th	75th	90th
Total, Age 1 year and older	7,970	0.4	<LOD	<LOD	0.3	0.6	1.0
Sex							
Male	3,913	0.4	<LOD	<LOD	0.4	0.6	1.0
Female	4,057	0.4	<LOD	<LOD	0.3	0.6	1.0
Race Ethnicity*							
Black, non-Hispanic	1,842	0.4	<LOD	<LOD	0.3	0.6	1.0
Mexican American	2,743	0.4	<LOD	<LOD	0.4	0.4	0.7
White, non-Hispanic	2,715	0.4	<LOD	<LOD	0.4	0.5	1.0
Age Group							
1-5 years	723	NC	<LOD	<LOD	<LOD	0.3	0.3
6-11 years	905	NC	<LOD	<LOD	<LOD	0.3	0.4
12-19 years	2,135	0.3	<LOD	<LOD	0.3	0.3	0.8
20+ years	4,207	0.5	<LOD	<LOD	0.4	0.6	1.0

*Other racial/ethnic groups are included in the Total only

NC = Not Calculated — The proportion of results below the limit of detection was too high to provide a valid result

<LOD= Less than the limit of detection of the analytical method.

Source: Centers for Disease Control and Prevention. Second National Report on Human Exposure to Environmental Chemicals. January 2003. (Accessed November 21, 2004) http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

R.O.E. Indicator QA/QC

Data Set Name: BLOOD CADMIUM LEVEL
Indicator Number: 101 (89100)
Data Set Source: CDC- NHANES
Data Collection Date: ongoing
Data Collection Frequency: 2 year cycle
Data Set Description: Blood Cadmium Level
Primary ROE Question: What are the trends in biomeasures of exposure to common environmental pollutants including across population subgroups and geographic regions?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Blood samples were collected and processed in accordance with the methods indicated in the NHANES Specimen Collection and Laboratory/Medical Technologists Procedures Manual (LPM). See: http://www.cdc.gov/nchs/data/nhanes/blood.pdf http://www.cdc.gov/nchs/data/nhanes/LAB1-6.pdf Cadmium and lead were simultaneously measured in whole blood. Cadmium and lead quantification is based on the measurement of light absorbed at 228.8 nm and 283.3 nm, respectively, by ground state atoms of cadmium and lead from either an electrodeless discharge lamp (EDL) or hollow cathode lamp (HCL) source. Human blood (patient or study) samples, bovine blood quality control pools, and aqueous standards are diluted with a matrix modifier (nitric acid, Triton X-100, and ammonium phosphate). The cadmium and lead contents are determined on a Perkin-Elmer Model SIMAA 6000 simultaneous multi-element atomic absorption spectrometer with Zeeman Background correction. See: http://www.cdc.gov/nchs/data/nhanes/frequency/lab06_doc.pdf The units used for this indicator were ¼g/L. http://www.cdc.gov/nchs/data/nhanes/frequency/varlab.pdf

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. NHANES is designed to provide statistically representative national averages. Starting with NHANES 1999, the survey is conducted annually. All participants aged 1 year or older in NHANES 1999-2000 were measured for blood cadmium. The measurements produced by NHANES for this indicator were used in the “Second National Report on Human Exposure to Environmental Chemicals” published by the National Center for Environmental Health in 2003. http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Not applicable.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

This indicator is based on a national probability-based sampling design and is deemed of sufficient quality for generalization to the nation. The samples for 1999-2000 were used for this analysis. Quality assurance measures were in place. Beginning in 1999, NHANES became a continuous and annual survey. The sampling plan for each year follows a complex, stratified, multistage, probability-cluster design to select a representative sample of the civilian, noninstitutionalized population. The 1999 NHANES was conducted in 12 counties across the U.S. From these locations, 5,325 people were selected to participate in the survey. Of these, 3,812 (71%) participated in the examination component. Data collection ended in 2000.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The current sampling design includes oversampling of African Americans, Mexican Americans, adolescents (12-19 year olds), older Americans (60 years of age and older), and pregnant women to produce more reliable estimates for these groups.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator simply provides information that exposure to cadmium has occurred. The measurement of cadmium or any other environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects. OSHA (1998) has developed criteria for evaluating occupational exposures. These occupational criteria are to be used to assess chronic workplace exposure. The criterion for blood cadmium is 5 ug/L. Occupational criteria are provided for comparisons only, not to imply a safety level for general population exposure. As reported in "Second National Report on Human Exposure to Environmental Chemicals" published by the National Center for Environmental Health in 2003. http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Documentation for NHANES 1999-2000 is found on NCHS/CDC website at the following URL: http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files The following provides more specific examples: The Addendum to the NHANES III for the 1999-2000 dataset clearly outlines the 1999-2000 sampling design and recommends analytic procedures. http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf The "Second National Report on Human Exposure to Environmental Chemicals" published by the National Center for Environmental Health in 2003 more generally describes the NHANES 1999-2000 sampling plan. http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf Laboratory measurement information: http://www.cdc.gov/nchs/data/nhanes/frequency/lab06_doc.pdf And the "Weighting Notes" posted on the NHANES website also offer helpful advice. http://www.cdc.gov/nchs/data/nhanes/frequency/weights%20to%20usev6.pdf

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

For the most part, Individual level data are available, but data access limitations do exist for some variables due to confidentiality issues. http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The Addendum to the NHANES III for the 1999-2000 dataset clearly outlines the 1999-2000 sampling design and recommends analytic procedures.
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf
http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The quality assurance plans for NHANES 1999-2000 are available from the Division of Data Dissemination, NCHS, 6525 Belcrest Rd. Hyattsville, MD, 20782-2003. Tel. 301-458-4636. Internet: http://www.cdc.gov/nchs/about/quality.htm

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The NHANES 1999-2004 survey is designed to be annually nationally representative of the U.S. citizen, non-institutionalized population. (see page 11 of the addendum linked below)
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. (see pages 11-19 of the addendum linked below)
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 2 years of data in NHANES 1999-2000, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representative of coverage. The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2000 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses. For NHANES 1999-2000, the first stage of selection was the PSU-level. The PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 NHANES sample is selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates. NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999 and 2000, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported. The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value. For more information, see the addendum to NHANES III linked below: http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

As subsequent years are added to this survey, estimates will become more stable. However, with the laboratory data, there is no guarantee that an environmental chemical will be measured from year to year. Although the annual NHANES is nationally representative, it is not possible to produce environmental exposure estimates by geographic region. Because the number of geographic sites sampled each year is small and because environmental exposure measures may vary geographically, national estimates based on one year of data may be highly variable. Serum cadmium was measured in all people aged one year and older. The measurement of cadmium or any other environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects

Indicator: Blood Persistent Organic Pollutants (POPs) Level (336)

Persistent organic pollutants (POPs) are manmade organic chemicals that remain in the environment for years or decades. Some POPs are toxic; others are not. Toxic POPs are of special concern because they often remain toxic for decades or longer. The more persistent a toxic chemical is, the greater the probability for human exposure over time. Because they circulate globally long after their release into the environment, POPs released in one part of the world are often detected in regions far from the original source (EPA, 2004a).

One of the major sources of POPs exposure among the general population is food. Food contamination begins with contaminated soil and/or plants but is of greatest concern to humans as the POPs move up the food chain into animals. Because POPs are stored, especially in fat, they accumulate and increase in concentration with each trophic level. Therefore, foods such as dairy products, eggs, animal fats, and some types of fish are more likely to contain greater concentrations of POPs than fruits, vegetables, and grains. POPs have been linked to adverse health effects such as cancer, nervous system damage, reproductive disorders, and disruption of the immune system in both human and animals (EPA, 2004a).

This indicator presents data from CDC's National Health and Nutrition Examination Survey (NHANES) 1999-2000. NHANES is a series of surveys conducted by CDC's National Center for Health Statistics (NCHS) that is designed to collect data on the health and nutritional status of the civilian, non-institutionalized U.S. population using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey; biomonitoring for certain environmental chemicals also was implemented. These data are presented here as a baseline with the intent of reporting trends in the future. Blood serum levels of POPs or their metabolites are presented for NHANES participants age 12 years or older. This indicator includes the following three broad classes of POPs:

- Organochlorine pesticides
- Polychlorinated dibenzo-p-dioxins (dioxins) and polychlorinated dibenzo-p-furans (furans)
- Polychlorinated biphenyls (PCBs)

Organochlorine pesticides were first introduced in the 1940s. Because of their environmental persistence, EPA banned most uses of these chemicals during the 1970s and 1980s. However, many other countries still produce and/or use organochlorines. These fat-soluble chemicals are most commonly absorbed through fatty foods. This indicator includes five organochlorine pesticides that were measured in NHANES 1999-2000; data on three others (aldrin, dieldrin, and endrin) will be available with the release of results from NHANES 2001-2002 (CDC, 2005). Acute exposure to high concentrations of organochlorine pesticides has demonstrated effects to the central nervous system (Reigart and Roberts, 1999),

- **Chlordane and heptachlor**. EPA banned these pesticides in 1988. Within the body, chlordane is metabolized to oxychlordane and *trans*-nonachlor, and heptachlor is metabolized to heptachlor epoxide. (CDC, 2003). Chlordane was commonly used against termites and on some agricultural crops and heptachlor was used primarily against soil insects and termites (Ritter et al.).
- **DDT**. Dichlorodiphenyltrichlorethane, or DDT, was banned in the United States in 1973 but is still produced in other countries, where it is used primarily to control mosquitoes. In the body or the environment, DDT breaks down to DDE (dichlorodiphenyldichloroethylene), a more persistent chemical. DDT or DDE in the human body may reflect either a relatively recent exposure or cumulative past exposures (CDC, 2003).

- **Hexachlorobenzene** (HCB) was commonly used as a pesticide until 1965. HCB was also used in the past as a fungicide to protect wheat seeds, and for a variety of industrial purposes, including rubber, aluminum, dye production and wood preservation (EPA, 2004b). EPA canceled registered use in 1984; however, HCB is still formed as a by-product during manufacturing of other chemicals and pesticides (EPA, 2004b).
- **Mirex** has not been produced or used in the United States since 1978. It was used primarily in the southern United States to control fire ants. The primary source of exposure is dietary, most often through consumption of fish (EPA, 2004c).

Dioxins and furans are similar classes of chlorinated aromatic chemicals, usually generated as pollutants or by-products. In the environment, dioxins and furans occur as a mixture of about 20 compounds (termed "congeners"). Half-lives of these congeners range from roughly 3 to 19 years (CDC, 2003). Human exposure occurs primarily through food; other sources of exposure include industrial accidents, burning of PCBs contaminated with dioxins and furans, burning of many plastics such as PVC, and spraying or unintended releases of contaminated herbicides such as Agent Orange. The detection of dioxins and furans in human serum can reflect either recent or past exposures (CDC, 2003).

Human health effects associated with dioxins and furans are wide-ranging. The effects of individual congeners are difficult to determine since most people are exposed to mixtures of several congeners. However, overall health effects include liver disorders, fetal injury, porphyria (a condition resulting in abnormal metabolic function), elevated lipid levels, chloracne, hormonal changes, neurologic damage, and immunogenic changes. The dioxin congener TCDD (2,3,7,8-tetrachlorodibenzo-*p*-dioxin) is the most toxic form of dioxin and it is classified as a known human carcinogen (IARC, 1997). The half-life of TCDD is estimated to be around 7 years (CDC, 2003).

Polychlorinated biphenyls (PCBs) are chlorinated aromatic hydrocarbons used in a variety of industries as electrical insulating and heat exchange fluids. PCBs are composed of mixtures of up to 209 different chlorinated congeners. United States production of PCBs peaked in the early 1970s; PCBs were banned in 1979. Sources of exposure for the general population include releases from waste sites and fires involving transformers, ingestion of foods contaminated by PCBs, and migration from packaging materials. PCBs typically accumulate in fatty tissues (ATSDR, 2000).

The detection of PCBs in human serum can reflect either recent or past exposures. PCBs with higher degrees of chlorination persist in the human body from several months to years after exposure. Coplanar and mono-ortho substituted PCBs exhibit health effects similar to dioxins. The human health effects of PCBs include changes in liver function, elevated lipids, and gastrointestinal cancers (CDC, 2003).

What the Data Show

Organochlorine pesticides. Table 336Organochlorine presents the geometric means for serum concentrations, lipid adjusted, for the selected organochlorine pesticide metabolites. The overall geometric mean for DDE (metabolite for DDT) was 260 ng/g of lipid. The geometric mean for *trans*-nonachlor (metabolite for chlordane) was 18.3 ng/g of lipid. Metabolites for heptachlor, HCB, and mirex were not measured with sufficient frequency above the limit of detection to calculate a geometric mean.

Geometric mean serum concentrations of *p, p'*-DDE were compared among demographic groups after adjustment for the covariates of race/ethnicity, age, and gender. The 12-19 year age group had less than half the serum DDE level of the 20 years-and-older age group (CDC, 2003). The adjusted geometric mean level in Mexican Americans was 653 ng/g, about three times higher than levels in non-Hispanic Whites and two times higher than non-Hispanic Blacks. It is unknown whether differences in geometric mean serum DDE concentrations between ages or races/ethnicities represent differences in exposure, body size relationships, or metabolism (CDC, 2003).

Dioxins and furans. Human serum lipid-based levels of overall dioxins and furans have decreased by an estimated 80% since the 1980s and the low NHANES 1999-2000 values support that estimation (CDC, 2003). Within the 12 years-and-older subsample of NHANES 1999-2000, none of the six dioxin or nine furan congeners measured in blood serum were measured with sufficient frequency above the limit of detection to calculate a geometric mean. TCDD had a detection rate of 0.7% (CDC, 2003). Five dioxin and four furan congeners had a detection rate above 5%. The more highly chlorinated dioxin and furan congeners were the main contributors to the human body burden (CDC, 2003).

PCBs. Within the NHANES 1999-2000 subsample, none of the 28 PCB congeners were measured in blood serum with sufficient frequency above the limit of detection to calculate a geometric mean. The frequency of detection of the eight mono-ortho substituted PCBs ranged from 2 to 47% (CDC, 2003). Coplanar PCB congeners 169 and 126, which exhibit dioxin-like toxicity, had a detection rate above 5% (CDC, 2003).

Indicator Limitations

- NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 2 years of data in NHANES 1999-2000, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representative of coverage.
    - The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2000 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses.
    - For NHANES 1999-2000, the first stage of selection was the primary sampling unit (PSU) level. PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 NHANES sample is selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates.
    - NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999 and 2000, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported.
    - The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value.
- The measurement of an environmental chemical in a person’s blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.
- Generally recognized guidelines for serum levels of organochlorine pesticides and dioxin, furan, and PCB congeners have not yet been established.

Data Sources

Centers for Disease Control and Prevention. 2003. Second National Report on Human Exposure to Environmental Chemicals. (Accessed November 21, 2004) http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

References

ATSDR. 2000. Toxicological profile for Polychlorinated Biphenyls (PCBs). U.S. Department of Health and Human Services. Public Health Service. Agency for Toxic Substances and Disease Registry. November 2000.

Centers for Disease Control and Prevention (CDC). 2003. Second National Report on Human Exposure to Environmental Chemicals. (Accessed November 21, 2004) http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

Centers for Disease Control and Prevention (CDC). 2005. Chemicals for Inclusion for the Third Report. (Last Accessed January 24, 2005) http://www.cdc.gov/exposurereport/pdf/third_report_chemicals.pdf

International Agency for Research on Cancer (IARC). 1997. Polychlorinated dibenzo-para-dioxins and polychlorinated dibenzofurans. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Vol. 69. Lyon, France.

Reigart JR, Roberts JR. Recognition and Management of Pesticide Poisonings. (1999) Prepared for U.S. Environmental Protection Agency (Accessed April 11, 2005) http://www.epa.gov/pesticides/safety/healthcare/handbook/contents.htm

Ritter L, Solomon KR, Forget J, Stemeroff M, O'Leary C. (date not available) Persistent Organic Pollutants. The international Programme on Chemical Safety (IPCS) within the framework of the Inter-Organization Programme for the Sound Management of Chemicals (IOMC) http://www.chem.unep.ch/pops/ritter/en/ritteren.pdf

U.S. Environmental Protection Agency (EPA). 2004a. Pesticides: Regulating Pesticides – Persistent Organic Pollutants (POPs). Last updated August 2004. (Accessed December 7, 2004) http://www.epa.gov/oppfead1/international/pops.htm

U.S. Environmental Protection Agency (EPA). 2004b. Hexachlorobenzene. Last updated December 2004. (Accessed December 07, 2004) http://www.epa.gov/opptintr/pbt/hexa.htm

U.S. Environmental Protection Agency (EPA). 2004c. Mirex. Last updated December 2004. (Accessed December 07, 2004) http://www.epa.gov/opptintr/pbt/mirex.htm

Graphics

Table 336Organochlorine. Geometric mean and selected percentiles of selected serum organochlorine pesticide metabolites, lipid adjusted levels (ng/g)* for the United States population, aged 12 years and older, National Health and Nutrition Examination Survey (NHANES), 1999-2000

	Sample Size	Geometric Mean	10^{th}	25^{th}	50^{th}	75^{th}	90^{th}
Chlordane							
Oxychlordane	1661	NC	<LOD	<LOD	<LOD	20.6	34.4
trans-Nonachlor	1933	18.3	<LOD	<LOD	17.8	31.9	55.1
Heptachlor							
Heptachlor Epoxide	1589	NC	<LOD	<LOD	<LOD	<LOD	15.3
DDT/DDE							
p, p'-DDE	1964	260	74.4	114	226	537	1150
p, p'-DDT	1679	NC	<LOD	<LOD	<LOD	<LOD	<LOD
o, p'-DDT	1669	NC	<LOD	<LOD	<LOD	<LOD	<LOD
Hexachlorobenzene	1702	NC	<LOD	<LOD	<LOD	<LOD	<LOD
Mirex	1853	NC	<LOD	<LOD	<LOD	<LOD	<LOD

* ng/g = nanograms/gram of lipid or parts-per-billion on a lipid weight basis
<LOD= Less than the limit of detection of the analytical method.
NC= Not calculated – Proportion of results below limit of detection was too high to provide a valid result.
Source: Centers for Disease Control and Prevention. Second National Report on Human Exposure to Environmental Chemicals. January 2003. (Accessed November 21, 2004) http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

R.O.E. Indicator QA/QC

Data Set Name: BLOOD POPS LEVEL
Indicator Number: 336 (90063)
Data Set Source: CDC, NHANES
Data Collection Date: ongoing
Data Collection Frequency: 2 year cycle
Data Set Description: Blood POPs Level
Primary ROE Question: What are the trends in biomeasures of exposure to common environmental pollutants including across population subgroups and geographic regions?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. Blood samples were collected and processed in accordance with the methods indicated in the NHANES Specimen Collection and Laboratory/Medical Technologists Procedures Manual (LPM). See: http://www.cdc.gov/nchs/data/nhanes/blood.pdf
http://www.cdc.gov/nchs/data/nhanes/LAB1-6.pdf

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. NHANES is designed to provide statistically representative national averages. Starting with NHANES 1999, the survey is conducted annually. A subsample of participants aged 12 years and older in NHANES 1999-2000 were measured for blood levels of the persistent organic pollutant chemicals. Subsamples were randomly selected within the specified age range to be a representative sample of the U.S. population. The measurements produced by NHANES for this indicator were used in the Second National Report on Human Exposure to Environmental Chemicals published by the National Center for Environmental Health in 2003.
http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Not applicable

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

This indicator is based on a national probability-based sampling design and is deemed of sufficient quality for generalization to the nation. The samples for 1999-2000 were used for this analysis. Quality assurance measures were in place. Beginning in 1999, NHANES became a continuous and annual survey. The sampling plan for each year follows a complex, stratified, multistage, probability-cluster design to select a representative sample of the civilian, noninstitutionalized population. Every year, approximately 7,000 individuals, of all ages, are interviewed in their homes; of these, approximately 5,000 complete the health examination component of the survey. The survey sample size for NHANES 1999-2000 is 9,965 (http://www.cdc.gov/nchs/data/nhanes/gendoc.pdf).

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The current sampling design includes oversampling of African Americans, Mexican Americans, adolescents (12-19 year olds), older Americans (60 years of age and older), and pregnant women to produce more reliable estimates for these groups.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator simply provides information that exposure to a selected persistent organic pollutant has occurred. Generally recognized guidelines for serum levels of POPs have not been established. The measurement of an environmental chemical in a person s blood or urine does not by itself mean that the chemical has caused or will cause harmful effects. More research is needed to identify at which POPs constitute a health concern. As reported in Second National Report on Human Exposure to Environmental Chemicals published by the National Center for Environmental Health in 2003. http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Documentation for NHANES 1999-2000 is found on NCHS/CDC website at the following URL: http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files The following provides more specific examples: The Addendum to the NHANES III for the 1999-2000 dataset clearly outlines the 1999-2000 sampling design and recommends analytic procedures. http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf The Second National Report on Human Exposure to Environmental Chemicals published by the National Center for Environmental Health in 2003 more generally describes the NHANES 1999-2000 sampling plan. http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf The NHANES 1999-2000 subsampling webpage clearly describes the subsampling methods used and how subsampled data should be analyzed http://www.cdc.gov/nchs/about/major/nhanes/subsample.htm as do the Weighting Notes posted on the NHANES website http://www.cdc.gov/nchs/data/nhanes/frequency/weights%20to%20usev6.pdf

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

For the most part, Individual level data are available, but data access limitations do exist for some variables due to confidentiality issues. http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The Addendum to the NHANES III for the 1999-2000 dataset clearly outlines the 1999-2000 sampling design and recommends analytic procedures.
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf
http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The quality assurance plans for NHANES 1999-2000 are available from the Division of Data Dissemination, NCHS, 6525 Belcrest Rd. Hyattsville, MD, 20782-2003. Tel. 301-458-4636. Internet: http://www.cdc.gov/nchs/about/quality.htm

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The NHANES 1999-2004 survey is designed to be annually nationally representative of the U.S. citizen, non-institutionalized population. (see page 11 of the addendum linked below) http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. (see pages 11-19 of the addendum linked below)
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 2 years of data in NHANES 1999-2000, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representative of coverage. The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2000 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses. For NHANES 1999-2000, the first stage of selection was the PSU-level. The PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 NHANES sample is selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates. NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999 and 2000, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported. The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value.
http://www.cdc.gov/nchs/about/major/nhanes/subsample.htm)

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

As subsequent years are added to this survey, estimates will become more stable. However, with the laboratory data, there is no guarantee that an environmental chemical will be measured from year to year. It is unknown whether differences between ages, genders, or races/ethnicities represent differences in exposure, body-size relationships, or metabolism. Generally recognized guidelines for serum levels of these chemicals have not been established. Measurement of these chemicals in the blood can reflect either a relatively recent exposure or a cumulative past exposure over time because of the persistent nature of these chemicals. The measurement of an environmental chemical in a person s blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.

Indicator: Phthalate Exposure (347)

Phthalates are industrial chemicals added to many consumer products such as food packaging, plastics (plastic bags, garden hoses, recreational toys, medical tubing, plastic clothes, etc.), adhesives, detergents, personal-care products (such as soap, shampoo, nail polish, et.), and many others. Exposure can occur through food that has been in contact with phthalate containing packaging as well as direct contact with products that contain phthalates. The health effects of phthalates in humans have not been well studied (CDC, 2003). Acute high dose exposure to Di (2-ethylhexyl) phthalate may be associated with mild gastrointestinal disturbances, nausea and vertigo (EPA, 2005). Chronic exposure may be associated with damage to the liver and testes, cancer, and adverse reproductive effects.

This indicator is based on data collected by the National Health and Nutrition Examination Survey (NHANES). NHANES is a series of surveys conducted by CDC's National Center for Health Statistics (NCHS) that is designed to collect data on the health and nutritional status of the civilian, non-institutionalized U.S. population using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey; biomonitoring for certain environmental chemicals also was implemented. These data are presented here as a baseline with the intent of reporting trends in the future.

What the Data Show

Table 347Phthalate presents the geometric means for urinary concentrations and creatinine-adjusted urinary concentrations of seven selected metabolites of phthalates among a subsample of participants aged six years and older from NHANES 1999-2000. Mono-ethyl phthalate (metabolite for diethyl phthalate, an industrial solvent used in many products including those containing fragrances), mono-butyl phthalate (metabolite for dibutyl phthalate, an industrial solvent used in cosmetics, printing inks, insecticides), mono-benzyl phthalate (metabolite for benzylbutyl phthalate, an industrial solvent used in adhesives, vinyl flooring, and car care products), and mono-2-ethylhexyl phthalate (metabolite for di-2-ethylhexyl phthalate, used to produce flexible plastics) had geometric means of 179 µg/L, 24.6 µg/L, 15.3 µg/L, and 3.4 µg/L, respectively. Mono-cyclohexyl phthalate, mono-n-octyl phthalate, and mono-isononyl phthalate were not measured with sufficient frequency above the limit of detection to calculate a geometric mean.

The geometric mean levels for mono-ethyl phthalate, mono-butyl phthalate, mono-benzyl phthalate, and mon-2-ethylhexyl phthalate among specified demographic subgroups were compared after adjustment for the covariates of race/ethnicity, age, gender, and urinary creatinine. For those aged 6-11 years compared to the older age groups (12-19 years and 20+ years), urinary mono-ethyl phthalate levels were found to be lower, but urinary mono-butyl, mono-benzyl, and mono-2-ethylhexl phthalates were higher (CDC, 2003). Females tended to have a higher level than males for mono-ethyl, mono-butyl, and mono-benzyl phthalates. Non-Hispanic blacks had higher levels of mono-ethyl phthalate than non-Hispanic whites or Mexican Americans.

Indicator Limitations

- NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 2 years of data in NHANES 1999-2000, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representative of coverage.

- The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2000 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses.

- For NHANES 1999-2000, the first stage of selection was the PSU-level. The PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 NHANES sample is selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates.

- NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999 and 2000, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported.

- The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value.

- Differences in the excretion of various phthalates may be due to differences in either exposure or toxicokinetics. The low detection rates for some of the long alkyl chain phthalates metabolites may be due to significantly less metabolism to the monoester metabolite.

- It is unknown whether differences between ages, genders, or races/ethnicities represent differences in exposure, body-size relationships, or metabolism.

- Generally recognized guidelines for urinary levels of these phthalate metabolites have not been established.

- The measurement of an environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.

Data Sources

Centers for Disease Control and Prevention. 2003. Second National Report on Human Exposure to Environmental Chemicals. (Accessed November 21, 2004)
http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

References

Centers for Disease Control and Prevention. 2003. Second National Report on Human Exposure to Environmental Chemicals. (Accessed November 21, 2004)
http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

Environmental Protection Agency. 2005. Consumer Factsheet on : Di(2-ethylhexyl) phthalate. (Accessed March 21, 2005). http://www.epa.gov/safewater/dwh/c-soc/phthalat.html

Graphics

Table 347Phthalate. Geometric mean and selected percentiles of selected phthalate metabolite urine concentrations and creatinine-adjusted levels for the United States population, aged 6 years and older, National Health and Nutrition Examination Survey (NHANES), 1999-2000

	Sample Size	Geometric Mean	10th	25th	50th	75th	90th
Mono-ethyl phthalate							
µg/L of urine	2536	179.0	28.9	61.4	164.0	450.0	1260.0
µg/g of creatinine*	2536	163.0	33.0	64.7	141.0	360.0	898.0
Mono-butyl phthalate							
µg/L of urine	2541	24.6	5.7	12.6	26.0	51.6	98.6
µg/g of creatinine*	2541	22.4	7.7	12.8	21.9	38.9	68.3
Mono-benzyl phthalate							
µg/L of urine	2541	15.3	2.8	6.9	17.0	35.3	67.1
µg/g of creatinine*	2541	14.0	4.4	7.6	13.3	25.1	50.1
Mono-cyclohexyl phthalate							
µg/L of urine	2541	NC	<LOD	<LOD	<LOD	<LOD	<LOD
µg/g of creatinine*	2541	NC	<LOD	<LOD	<LOD	<LOD	<LOD
Mono-2-ethylhexyl phthalate							
µg/L of urine	2541	3.4	<LOD	1.2	3.2	7.6	14.8
µg/g of creatinine*	2541	3.1	<LOD	1.5	3.1	5.9	10.8
Mono-n-octyl phthalate							
µg/L of urine	2541	NC	<LOD	<LOD	<LOD	<LOD	1.6
µg/g of creatinine*	2541	NC	<LOD	<LOD	<LOD	<LOD	2.4

Mono-isononyl phthalate							
µg/L of urine	2541	NC	<LOD	<LOD	<LOD	<LOD	<LOD
µg/g of creatinine*	2541	NC	<LOD	<LOD	<LOD	<LOD	<LOD

* µg per gram of creatinine in urine
<LOD= Less than the limit of detection of the analytical method.
NC= Not calculated – Proportion of results below limit of detection was too high to provide a valid result.
Source: Centers for Disease Control and Prevention. Second National Report on Human Exposure to Environmental Chemicals. January 2003. (Accessed November 21, 2004) http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

R.O.E. Indicator QA/QC

Data Set Name: PHTHALATE EXPOSURE
Indicator Number: 347 (89743)
Data Set Source: CDC, NHANES
Data Collection Date: ongoing
Data Collection Frequency: 2 year cycle
Data Set Description: Phthalate exposure
Primary ROE Question: What are the trends in biomeasures of exposure to common environmental pollutants including across population subgroups and geographic regions?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Urine samples were collected and processed in accordance with the methods indicated in the NHANES Specimen Collection and Laboratory/Medical Technologists Procedures Manual (LPM). See: http://www.cdc.gov/nchs/data/nhanes/blood.pdf
http://www.cdc.gov/nchs/data/nhanes/LAB1-6.pdf

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. NHANES is designed to provide statistically representative national averages. Starting with NHANES 1999, the survey is conducted annually. A subsample of participants aged six years and older in NHANES 1999-2000 were measured for urine levels of the phthalate metabolites. Subsamples were randomly selected within the specified age range to be a representative sample of the U.S. population. The measurements produced by NHANES for this indicator were used in the “Second National Report on Human Exposure to Environmental Chemicals” published by the National Center for Environmental Health in 2003.
http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Not applicable

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

This indicator is based on a national probability-based sampling design and is deemed of sufficient quality for generalization to the nation. The samples for 1999-2000 were used for this analysis. Quality assurance measures were in place. Beginning in 1999, NHANES became a continuous and annual survey. The sampling plan for each year follows a complex, stratified, multistage, probability-cluster design to select a representative sample of the civilian, noninstitutionalized population. The 1999 NHANES was conducted in 12 counties across the U.S. From these locations, 5,325 people were selected to participate in the survey. Of these, 3,812 (71%) participated in the examination component. Data collection ended in 2000.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?
The current sampling design includes oversampling of African Americans, Mexican Americans, adolescents (12-19 year olds), older Americans (60 years of age and older), and pregnant women to produce more reliable estimates for these groups.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator simply provides information that exposure to a phthalate metabolite has occurred. Generally recognized guidelines for urinary levels of these phthalate metabolites have not been established. Measurements of urinary phthalate metabolites provide an estimate of exposure to various classes of phthalates. Furthermore, finding a measurable amount of one or more metabolites in urine does not by itself mean that the chemical has caused or will cause harmful effects. More research is needed to identify at which levels urinary phthalate metabolites constitute a health concern. As reported in “Second National Report on Human Exposure to Environmental Chemicals” published by the National Center for Environmental Health in 2003. http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Documentation for NHANES 1999-2000 is found on NCHS/CDC website at the following URL: http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files The following provides more specific examples: The Addendum to the NHANES III for the 1999-2000 dataset clearly outlines the 1999-2000 sampling design and recommends analytic procedures. http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf The “Second National Report on Human Exposure to Environmental Chemicals” published by the National Center for Environmental Health in 2003 more generally describes the NHANES 1999-2000 sampling plan. http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf The NHANES 1999-2000 subsampling webpage clearly describes the subsampling methods used and how subsampled data should be analyzed http://www.cdc.gov/nchs/about/major/nhanes/subsample.htm as do the “Weighting Notes”posted on the NHANES website http://www.cdc.gov/nchs/data/nhanes/frequency/weights%20to%20usev6.pdf

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

For the most part, Individual level data are available, but data access limitations do exist for some variables due to confidentiality issues.
http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The Addendum to the NHANES III for the 1999-2000 dataset clearly outlines the 1999-2000 sampling design and recommends analytic procedures.
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf
http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The quality assurance plans for NHANES 1999-2000 are available from the Division of Data Dissemination, NCHS, 6525 Belcrest Rd. Hyattsville, MD, 20782-2003. Tel. 301-458-4636. Internet: http://www.cdc.gov/nchs/about/quality.htm

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The NHANES 1999-2004 survey is designed to be annually nationally representative of the U.S. citizen, non-institutionalized population. (see page 11 of the addendum linked below)
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. (see pages 11-19 of the addendum linked below)
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 2 years of data in NHANES 1999-2000, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representative of coverage. The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2000 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses. For NHANES 1999-2000, the first stage of selection was the PSU-level. The PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were

combined with geographically contiguous counties to form a PSU. The 1999-2000 NHANES sample is selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates. NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999 and 2000, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported. The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value
http://www.cdc.gov/nchs/about/major/nhanes/subsample.htm

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

As subsequent years are added to this survey, estimates will become more stable. However, with the laboratory data, there is no guarantee that an environmental chemical will be measured from year to year. It is unknown whether differences between ages, genders, or races/ethnicities represent differences in exposure, body-size relationships, or metabolism. Differences in the excretion of various phthalates may be due to differences in either exposure or toxicokinetics. The low detection rates for some of the long alkyl chain phthalates metabolites may be due to significantly less metabolism to the monoester metabolite. The measurement of an environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.

Indicator: Urinary Pesticide/Herbicide Level (104)

More than one billion pounds of pesticides and herbicides are used in the United States each year to control weeds, insects, and other organisms that threaten or undermine human activities (Aspelin, 2003). Some of these compounds can be harmful to humans if ingested, inhaled, or otherwise contacted in sufficient quantities. The primary routes of exposure for the general population are ingestion of a treated food source and contact with applications in or near residential sites. Herbicide exposure may also result from contaminated water. Those who manufacture, formulate, and/or apply these chemicals may also be occupationally exposed.

This indicator reports the results of human biomonitoring for three classes of non-persistent pesticides and three classes of herbicides, which can be measured through metabolites that result from the chemical breakdown of the pesticide/herbicide within the body. Measurement of non-persistent pesticide/herbicide metabolites in urine typically reflects recent exposure (i.e., in the last few days) due to the short time these metabolites remain within the body (CDC, 2003).

The three classes of pesticides covered by this indicator are Carbamates, Organophosphates (OPs), and Pyrethroids. All three groups are neurotoxicants that act by overstimulating the nervous system of exposed organisms. Symptoms of exposure to pesticides in these classes may include muscle weakness or paralysis, difficulty breathing, difficulty concentrating, impaired coordination, and memory loss (CDC , 2003).

The three herbicide classes discussed here have all been designated by EPA as restricted use products, meaning the products are only to be used by certified applicators or under the supervision of such an applicator (EPA, 2003). The herbicide groups are: chlorphenoxy acids, triazines, and chloroacetamides. Symptoms of acute high dose exposure to these herbicides may include skin and mucosal irritation as well as burning sensations in the nasopharynx and chest if inhaled (Reigart and Roberts, 1999).

This indicator presents pesticide and herbicide urinary metabolite data colleced as part of CDC's National Health and Nutrition Examination Survey (NHANES). NHANES is a series of surveys conducted by CDC's National Center for Health Statistics (NCHS) that is designed to collect data on the health and nutritional status of the civilian, non-institutionalized U.S. population using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey; biomonitoring for certain environmental chemicals also was implemented. These data are presented here as a baseline with the intent of reporting trends in the future. Carbamates, organophosphates, and herbicides were measured as part of NHANES 1999-2000; pyrethroid data were collected in NHANES 2001-2002. This indicator presents data for a subsample of survey participants ages 6 to 59 years; the sample size for each chemical was between 1,800 and 2,000 individuals. NHANES also measured levels of a class of persistent pesticides, the organochlorine pesticides, which are not discussed here but can be found under the Indicator “Blood POPs Level” (POPs = Persistent Organic Pollutants).

What the Data Show

Carbamates. Table 104-1Carbamate presents the geometric means for unadjusted and creatinine-adjusted urinary concentrations of the carbamate pesticide metabolites. Of the three metabolites presented, only 1-naphthol was detected with sufficient frequency to calculate a measurable geometric mean which was 1.70 µg/L and 1.52 µg/g (creatinine-adjusted).

Organophosphates. NHANES 1999-2000 measured urinary concentrations of dialkyl phosphates, which are the primary metabolites of many organophosphate compounds. Table 104-2Organophospate presents the geometric means for urinary concentrations and creatinine-adjusted urinary concentrations of these metabolites. Only two of the six urinary dialkyl phosphates presented (dimethylthiophosphate and diethylphosphate) were measured with sufficient frequency above the limit of detection to calculate a geometric mean. The geometric means for those metabolites were 1.82 µg/L (1.64 µg/g creatinine) and 1.03 µg/L (0.92 µg/g creatinine), respectively.

Pyrethroids. *This is a placeholder for the data that will be released as part of the Third National Report on Human Exposure to Environmental Chemicals from CDC. Pyrethroids were collected in NHANES 2001-2002. Release of this report is pending, but should be out before release ROE06.*

Herbicides. None of the direct metabolites of the three primary classes of herbicide were detected in urine with sufficient frequency above the limit of detection to calculate a geometric mean. The metabolites 2,4,5-trichlorophenoxyacetic acid and atrazine mercapturate were detected in only 1.2% and 3.3%, respectively, of the subsample (CDC, 2003). The minor metabolite 2,4-dichlorophenol had a geometric mean of 1.1 µg/L measured in urine; however, this metabolite can also be a result of metabolism of several other chemicals or a byproduct in the manufacture of chemicals.

Indicator Limitations

- NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 2 years of data in NHANES 1999-2000, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representative of coverage.
    - The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2000 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses.
    - For NHANES 1999-2000, the first stage of selection was the primary sampling unit (PSU) level. PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 NHANES sample is selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates.
    - NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999 and 2000, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported.
    - The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value.
- The measurement of an environmental chemical in a person's blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.
- Generally recognized guidelines for urinary levels of carbamate, organophophate, herbicide, and pyrethroid metabolites have not yet been established.
- Some metabolites may result from sources other than pesticide exposure. For example, 1-naphthol in the urine may reflect multiple sources of exposure, and is therefore not just an indicator of carbamate pesticide exposure.

Data Sources

Centers for Disease Control and Prevention. 2003. Second National Report on Human Exposure to Environmental Chemicals. (Accessed November 21, 2004) http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

Centers for Disease Control and Prevention. *Results from NHANES 2001-2002 (anticipated release prior to publication of ROE'06)*

References

Aspelin AL. 2003. Pesticide Usage in the United States: Trends During the 20th Century. Raleigh, NC: Center for Integrated Pest Management, North Carolina State University. February 2003. http://www.pestmanagement.info/pesticide_history/index.pdf.

Centers for Disease Control and Prevention. 2003. Second National Report on Human Exposure to Environmental Chemicals. (Accessed November 21, 2004) http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

Environmental Protection Agency. 2003. Restricted Use Products (RUP) Report. (Accessed March 10, 2005) http://www.epa.gov/opprd001/rup/

Reigart JR, Roberts JR. Recognition and Management of Pesticide Poisonings. (1999) Prepared for U.S. Environmental Protection Agency (Accessed April 11, 2005) http://www.epa.gov/pesticides/safety/healthcare/handbook/contents.htm

Graphics

Table 104-1Carbamate. Geometric mean and selected percentiles for unadjusted and creatinine-adjusted urinary concentrations of selected carbamate metabolites among a subsample of participants aged 6-59 years from National Health and Nutrition Examination Survey (NHANES), 1999-2000

	Sample Size	Geometric Mean	10th	25th	50th	75th	90th
1-Naphthol							
µg/L of urine	1998	1.70	<LOD	<LOD	1.22	2.72	6.20
µg/g of creatinine*	1998	1.52	<LOD	<LOD	1.25	3.00	6.80
2-Isopropoxyphenol							
µg/L of urine	1917	NC	<LOD	<LOD	<LOD	<LOD	<LOD
µg/g of creatinine*	1917	NC	<LOD	<LOD	<LOD	<LOD	<LOD
Carbofuranphenol							
µg/L of urine	1994	NC	<LOD	<LOD	<LOD	<LOD	<LOD
µg/g of creatinine*	1994	NC	<LOD	<LOD	<LOD	<LOD	<LOD

* µg per gram of creatinine in urine
<LOD= Less than the limit of detection of the analytical method.
NC= Not calculated – Proportion of results below limit of detection was too high to provide a valid result.
Source: Centers for Disease Control and Prevention. Second National Report on Human Exposure to Environmental Chemicals. January 2003. (Accessed November 21, 2004) http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

Table 104-2Organophosphate. Geometric mean and selected percentiles for unadjusted and creatinine-adjusted urinary concentrations of selected organophosphate metabolites for the United States population, aged 6-59 years, National Health and Nutrition Examination Survey (NHANES), 1999-2000

	Sample Size	Geometric Mean	10th	25th	50th	75th	90th
Dimethylphophate							
µg/L of urine	1949	NC	<LOD	<LOD	0.74	2.80	7.90
µg/g of creatinine*	1949	NC	<LOD	<LOD	0.81	2.93	8.46
Dimethylthiophosphate							
µg/L of urine	1948	1.82	<LOD	<LOD	2.70	10.0	38.0
µg/g of creatinine*	1948	1.64	<LOD	<LOD	2.12	9.57	32.0
Dimethyldithiophophate							
µg/L of urine	1949	NC	<LOD	<LOD	<LOD	2.30	12.0
µg/g of creatinine*	1949	NC	<LOD	<LOD	<LOD	1.86	10.1
Diethylphosphate							
µg/L of urine	1949	1.03	<LOD	<LOD	1.20	3.10	7.50
µg/g of creatinine*	1949	0.92	<LOD	<LOD	0.93	2.73	7.94
Diethylthiophosphate							
µg/L of urine	1949	NC	<LOD	<LOD	0.49	0.76	1.3
µg/g of creatinine*	1949	NC	<LOD	<LOD	0.25	0.71	1.7
Diethyldithiophosphate							
µg/L of urine	1949	NC	<LOD	<LOD	0.08	0.20	0.47
µg/g of creatinine*	1949	NC	<LOD	<LOD	0.07	0.20	0.55

* µg per gram of creatinine in urine

<LOD= Less than the limit of detection of the analytical method.

NC= Not calculated – Proportion of results below limit of detection was too high to provide a valid result.

Source: Centers for Disease Control and Prevention. Second National Report on Human Exposure to Environmental Chemicals. January 2003 (Accessed November 21, 2004) http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

R.O.E. Indicator QA/QC

Data Set Name: URINARY PESTICIDE/HERBICIDE LEVEL
Indicator Number: 104 (89119)
Data Set Source: CDC, NHANES
Data Collection Date: ongoing
Data Collection Frequency: 2 year cycle
Data Set Description: Urinary Pesticide/Herbicide level Note: Pesticides that are considered Persistent Organic Pollutants (POPs) will be found in the POPs section.
Primary ROE Question: What are the trends in biomeasures of exposure to common environmental pollutants including across population subgroups and geographic regions?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. Urine samples were collected and processed in accordance with the methods indicated in the NHANES Specimen Collection and Laboratory/Medical Technologists Procedures Manual (LPM). See: http://www.cdc.gov/nchs/data/nhanes/blood.pdf http://www.cdc.gov/nchs/data/nhanes/LAB1-6.pdf See http://www.cdc.gov/nchs/data/nhanes/frequency/l26ppdoc.pdf for the description of laboratory procedures for pesticide measurement.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. NHANES is designed to provide statistically representative national averages. Starting with NHANES 1999, the survey is conducted annually. A subsample of participants aged 6-59 years in NHANES 1999-2000 were measured for urine levels of the pesticide metabolites. Subsamples were randomly selected within the specified age range to be a representative sample of the U.S. population. The measurements produced by NHANES for this indicator were used in the Second National Report on Human Exposure to Environmental Chemicals published by the National Center for Environmental Health in 2003.
http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Not applicable

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

This indicator is based on a national probability-based sampling design and is deemed of sufficient quality for generalization to the nation. The samples for 1999-2000 were used for this analysis. Quality assurance measures were in place. Beginning in 1999, NHANES became a continuous and annual survey. The sampling plan for each year follows a complex, stratified, multistage, probability-cluster design to select a representative sample of the civilian, noninstitutionalized population. Every year, approximately 7,000 individuals, of all ages, are interviewed in their homes; of these, approximately 5,000 complete the health examination component of the survey. The survey sample size for NHANES 1999-2000 is 9,965 (http://www.cdc.gov/nchs/data/nhanes/gendoc.pdf).

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The current sampling design includes oversampling of African Americans, Mexican Americans, adolescents (12-19 year olds), older Americans (60 years of age and older), and pregnant women to produce more reliable estimates for these groups.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator simply provides information that exposure to a pesticide has occurred. Generally recognized guidelines for urinary levels of these pesticide metabolites have not been established. Measurements of urinary pesticide metabolites provide an estimate of exposure to various classes of pesticides; however, without additional information, linking these metabolites to specific pesticides is not possible. Furthermore, finding a measurable amount of one or more metabolites in urine does not by itself mean that the chemical has caused or will cause harmful effects. More research is needed to identify at which levels urinary pesticide metabolites constitute a health concern. As reported in Second National Report on Human Exposure to Environmental Chemicals published by the National Center for Environmental Health in 2003. http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Documentation for NHANES 1999-2000 is found on NCHS/CDC website at the following URL: http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files The following provides more specific examples: The Addendum to the NHANES III for the 1999-2000 dataset clearly outlines the 1999-2000 sampling design and recommends analytic procedures. http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf The Second National Report on Human Exposure to Environmental Chemicals published by the National Center for Environmental Health in 2003 more generally describes the NHANES 1999-2000 sampling plan. http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf The NHANES 1999-2000 subsampling webpage clearly describes the subsampling methods used and how subsampled data should be analyzed http://www.cdc.gov/nchs/about/major/nhanes/subsample.htm as do the Weighting Notes posted on the NHANES website http://www.cdc.gov/nchs/data/nhanes/frequency/weights%20to%20usev6.pdf

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

For the most part, Individual level data are available, but data access limitations do exist for some variables due to confidentiality issues. http://www.cdc.gov/nchs/about/major/nhanes/nhanes99_00.htm#Laboratory%20Files

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The Addendum to the NHANES III for the 1999-2000 dataset clearly outlines the 1999-2000 sampling design and recommends analytic procedures.

http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf
http://www.cdc.gov/nchs/data/nhanes/nhanes3/nh3gui.pdf

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The quality assurance plans for NHANES 1999-2000 are available from the Division of Data Dissemination, NCHS, 6525 Belcrest Rd. Hyattsville, MD, 20782-2003. Tel. 301-458-4636. Internet: http://www.cdc.gov/nchs/about/quality.htm

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The NHANES 1999-2004 survey is designed to be annually nationally representative of the U.S. citizen, non-institutionalized population. (see page 11 of the addendum linked below)
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. (see pages 11-19 of the addendum linked below)
http://www.cdc.gov/nchs/data/nhanes/guidelines1.pdf

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

NHANES selects a representative sample of the civilian, non-institutionalized population in the United States using a complex, stratified, multistage, probability-cluster design. Beginning in 1999, NHANES became a continuous and annual national survey. With only 2 years of data in NHANES 1999-2000, instead of the 6-years for NHANES III (1988-1994), some differences exist that may limit the underlying data with respect to completeness or representative of coverage. The sample size is smaller and the number of geographic units in the sample is more limited. The current 1999-2000 NHANES survey is nationally representative but it is subject to the limits of increased sampling error due to (1) the smaller number of individuals sampled in the annual sample and (2) the smaller number of Primary Sampling Units (PSUs) [see description below] available for each annual sample. Therefore, the sample size for any 1-year period is relatively small, possibly resulting in large variability for U.S. population estimates, especially those for narrowly defined demographic groups or other specific subgroup analyses. For NHANES 1999-2000, the first stage of selection was the PSU-level. The PSUs were defined as single counties. For a few PSUs, the county population was too small and those counties were combined with geographically contiguous counties to form a PSU. The 1999-2000 NHANES sample is selected from a relatively small number of PSUs compared to NHANES III. With a small number of PSUs, variance estimates that account for the complex design may be relatively unstable, a factor which introduces a higher level of uncertainty in the annual estimates. NHANES is designed to increase precision by combining data across calendar years. Because of the relatively small sample size in 1999 and 2000, analytical data for just one or two survey participants may be weighted heavily and greatly influence the mean value reported. The number of geographic sites sampled each year is small and environmental exposures may vary geographically; thus producing environmental exposure estimates by geographic region using the NHANES data set is of limited value.
http://www.cdc.gov/nchs/about/major/nhanes/subsample.htm

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

As subsequent years are added to this survey, estimates will become more stable. However, with the laboratory data, there is no guarantee that an environmental chemical will be measured from year to year. The measurement of an environmental chemical in a person s blood or urine does not by itself mean that the chemical has caused or will cause harmful effects.

Charge to the Peer Reviewers: Ecological Condition and Other Relevant Indicators for the U.S. Environmental Protection Agency's 2007 *Report on the Environment* Technical Document May 20, 2005

The U.S. Environmental Protection Agency (EPA) has asked that independent peer reviewers critically review the indicators that the Agency proposes to use for its 2007 *Report on the Environment*—Technical Document (ROE07 TD). The purpose of this peer review is to ensure that the proposed indicators are appropriate, adequate, and useful for evaluating ecological conditions in general; useful for answering the questions posed in ROE07; meet technical requirements (including the indicator definition and criteria); are properly documented; and are scientifically sound. Separate peer reviews will be conducted for the indicators proposed for each of the five main chapters in the ROE07. This charge provides background and instructions for peer review of the *ecological condition* indicators. It includes the following sections and attachments:

- Section 1: Background information on ROE07 TD
- Section 2: Indicator definition and criteria
- Section 3: Charge and materials for the individual pre-workshop review
- Section 4: The peer review meeting
- Attachment 1: Questions and Proposed Indicators for the ROE07 Technical Document
- Attachment 2: Comment Sheet for Group 1 Indicators
- Attachment 3: Comment Sheet for Group 2 Indicators
- Attachment 4: Comment Sheet for General Questions for Group 1 and 2 Indicators
- Attachment 5: Comment Sheet for Group 3A Indicators
- Attachment 6: Comment Sheet for Group 3B Indicator
- Attachment 7: List of and EPA Rationale for Withdrawn ROE03 Indicators (will be posted by 6/10/05)
- Attachment 8: Indicator Materials for Review (included as subsequent sections of this binder).

Section 1: Background

In 2003, EPA published its first draft *Report on the Environment* (ROE03). ROE03 is a set of two question-driven reports comprising:

- A Technical Document (TD), which provides the scientific foundation for the ROE.
- A shorter Public Document that distills information in the TD for a non-technical audience.

These two reports were intended to identify and present the best available national-level indicators to help answer broad questions about the state of the nation's environment in five topic areas (chapters): air, water, land, human health, and ecological condition. In addition to reporting what we know, the ROE03 was also intended to point out where current data and understanding fall short of fully answering the questions in terms of delivering national, consistent, comprehensive data about the state of the nation's air, water, land, human health, and ecological condition. The ROE03 also presented some contextual information from other scientific sources in order to provide background and explain indicator data gaps.

EPA's Administrator has requested that the generation of Reports on the Environment be continued into the future. Current plans are for future reports to be developed on an approximately 3-year reporting cycle. To support the next anticipated ROE release in 2007, EPA has compiled a set of proposed indicators to help answer the questions posed for the 2007 Technical Document. EPA proposes reporting on both national-level indicators, national-level indicators that are provided at the scale of EPA regions, as well as several region-level indicators. As with ROE03, the questions are organized into five topic areas: air, water, land, human health, and ecological condition. There will be a separate chapter in the ROE07 Technical Document for each topic area. Each chapter will describe the set of questions for the topic area and the indicators that answer those questions.

Many of the indicators proposed for ROE07 were presented in ROE03, but some are new and others have new data sources. In addition, after refining the indicator definition and criteria (see boxes on the following pages), and applying both more consistently to the proposed indicator list, EPA recommends that some indicators from ROE03 not be presented in 2007.

To ensure that the indicators presented in the ROE07 TD are supported by data that are technically sound, meet the established indicator definition and criteria, and help answer the questions posed in the ROE, EPA has contracted with ERG to organize an independent peer review of the proposed ROE07 indicators.

Reviewers for the ecological condition indicators are charged with four tasks:

1) Assess whether the proposed ecological indicators are appropriate, adequate, and useful for evaluating ecological conditions (i.e., for establishing an overall picture of ecological conditions).

2) Evaluate the proposed indicators with respect to their importance in terms of their ability to respond to the question.

3) Evaluate the proposed ecological condition and related indicators and their underlying data with respect to the ROE indicator definition and criteria presented below.

4) Identify any additional ***national-level*** ecological condition indicators that currently exist which meet the ROE indicator definition and criteria, help to answer one of the ROE questions, and for which data are readily available such that text and graphics describing the indicator could be developed within a short time frame (approximately 6 weeks).

Section 2: Indicator Definition and Criteria

Each indicator in ROE07 should conform to the following definition.

Definition: Indicator

For purposes of the ROE, an "indicator" is ***a numerical value derived from actual measurements of a pressure, ambient condition, exposure, or human health or ecological condition*** *over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment*. Indicators and their underlying data must meet criteria (see box below) for data quality, comparability, representativeness, and adequate coverage in time and space. Note that indicators rely on an underlying database or set of databases, but the databases themselves are not indicators.

In the above definition, "derived from" means that trends in *actual environmental observations* (e.g., rather than estimates or projections) must serve as the principal driver for trends in the indicators.

EPA has defined six indicator levels, as follows. Note that levels 1 and 2 are administrative indicators that measure progress in implementing environmental programs, and compliance with or response to those programs. They are *not* the subject of ROE07. Levels 3 through 6 indicators reflect environmental results/condition and are the subject of ROE07.

Description of Indicator Levels

Level 1 (Administrative—not covered by ROE07): Government Regulations/Activities. Examples: policy leadership, statutes, regulations, guidance, information.

Level 2 (Administrative—not covered by ROE07): Actions/Responses by Regulated and Non-regulated Parties. Examples: Pollution prevention and control, recycling, changes in consumer behavior, best management practices.

Level 3 (Environmental): Changes in Pressure or Stressor Quantities. Examples: Pollutants entering media, habitats altered or destroyed, hydrologic alteration.

Level 4 (Environmental): Ambient Conditions. Examples: Pollutant concentrations in media, food and drinking water, solid wastes in landfills, radiation; temperature, habitat condition, hydrology.

Level 5 (Environmental): Exposure or Body Burden/Uptake. Examples: Biological markers of uptake in people, plants, animals, or microorganisms.

Level 6 (Environmental): Changes in Human Health or Ecological Condition. Examples: Morbidity, mortality, biotic structure, and ecological processes.

Each indicator in ROE07 should conform to the following criteria:

Indicator Criteria

1) The indicator makes an important contribution to answering a question for the ROE. (In this context, "important" means that the indicator answers a substantial portion of and/or a critical part of the question.)
2) The indicator is objective. It is developed and presented in an accurate, clear, complete, and unbiased manner.
3) The underlying data are characterized by sound collection methodologies, data management systems that protect their integrity, and quality assurance procedures.
4) Data are available to describe changes or trends, and the latest available data are timely.
5) The data are comparable across time and space, and representative of the target population. Trends depicted in this indicator accurately represent the underlying trends in the target population.
6) The indicator is transparent and reproducible. The specific data used and the specific assumptions, analytic methods, and statistical procedures employed are clearly stated.

Section 3: Charge and Materials for the Individual Pre-Workshop Review

Attachment 1 lists all the ***proposed questions*** and ***associated indicators*** for the 2007 ROE by topic area. Pages 12 to 15 list the indicators to be reviewed by ecological condition reviewers[1]. Note that, for review purposes, there are three groups of indicators:

- **Group 1: Proposed Ecological Condition Indicators.** Indicators that are proposed to answer one of the five questions posed in the ecological condition chapter *and* that will be *written up in that chapter*.

- **Group 2: Referenced Ecological Condition Indicators & an Ecological Condition Indicator That Is Also Being Reviewed by Other Reviewers.** This group consists of:
  - Indicators that are proposed to answer one of the four questions posed in the ecological condition chapter but are written up in another chapter because they also answer a question in that chapter. These indicators will be *referenced in the ecological condition chapter*.
  - One ecological condition indicator that is also being reviewed by the air indicator reviewers because it falls within their area of expertise.

- **Group 3: Relevant Indicators from Other Chapters.** Indicators that are *proposed to answer a question in another chapter* and will be written up in that chapter, but peer-reviewed by ecological condition reviewers since they are ecological in nature.

[1] A few indicators are listed in a light gray font and marked as "Indicators to be Provided by July 2." These indicators are still being developed and, if available in time for this review, will be provided to you by July 2.

The materials and instructions for reviewing each group of indicators are described below. Please conduct the review in the sequence indicated. Forms are provided as Attachments 2 through 6 to this charge to structure your review. Attachment 7 provides background for Step 3, below. The materials to be reviewed are provided in Attachment 8.

Step 1: Review Group 1 Indicators

For each indicator in Group 1, Attachment 8 provides:

- *Draft text* introducing the indicator, identifying the underlying data used to evaluate the indicator, and describing data interpretations. EPA proposes including this text in the ROE07 TD.

- *Draft graphic(s)/table(s)* to help readers visualize spatial and temporal trends in the indicator. EPA proposes including these graphics in the ROE07 TD.

- *An information quality review form* that presents detailed background information on the indicator and its supporting data (e.g., data quality, coverage, processing). EPA documents this information for the overall project record and to facilitate peer review of the indicators.

Collectively, these three items should adequately present each indicator and thoroughly document the information that EPA considered when evaluating the indicators for ROE07. For each indicator in this category, you should thoroughly review the draft text, draft graphics/tables, and information quality review forms that are provided in Attachment 8. Then, document your review comments by filling out the “Comment Sheet” in Attachment 2 *for each indicator*.

This sheet asks you a series of questions about each indicator. For questions 1 through 4, you are asked to provide a numerical response on a scale of 1 to 4 and then a written explanation of the rationale for your numerical response. Question 5 asks about graphical presentation and question 6 asks you to provide any other comments, concerns, or suggestions about the indicator that you did not already cover in your responses to Questions 1 through 5. Question 7 asks you to state whether you think the indicator merits inclusion in ROE07.

Step 2: Review Group 2 Indicators

Some indicators may be suitable for answering more than one question in more than one chapter of the ROE07 technical document. For example, an indicator may be appropriate for answering a question in the water chapter *and* a question in the ecological condition chapter. In this case, the indicator will be presented in one chapter and referenced in the other. Group 2 comprises indicators that are presented in another chapter and referenced in the ecological condition chapter. It also includes one ecological condition indicator that is receiving a Group 1-level review by the air indicator reviewers because it is falls within their area of expertise.

For each Group 2 indicator, Attachment 8 provides the draft text, associated graphic(s), and information quality review form. Note that:

- The information quality review forms for these indicators are provided *as background only. You do not need to review them and you are not required to read them.* They are there for your perusal if you are interested.

- Other reviewers will be responding to the full suite of Attachment 2 review questions for these indicators. Therefore, *you do not need to consider or answer the Attachment 2 questions for these indicators*.

You are asked to read the text and graphic that present each indicator and to state:

- The appropriateness and usefulness of the indicator, and the extent to which you think this indicator contributes to answering the specific question in your topic area that it is referenced as answering.

- Any other comments or suggestions you may have concerning this indicator.

Attachment 3 provides a form for you to fill out *for each indicator in this category*.

Step 3: Consider General Questions for Group 1 and 2 Indicators

After completing your reviews for the individual Group 1 and 2 indicators, as described above, please use Attachment 4 to answer the following two questions for these indicators:

- **General Question 1:** Considering the Group 1 and Group 2 indicators collectively, do any of these indicators clearly seem to be more appropriate, adequate, or useful for evaluating ecological conditions or for establishing an overall picture of ecological conditions than others? Do any seem to be more important than the others for answering the question they are intended to answer? Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators or if it covers an area of diminishing interest environmentally.

- **General Question 2:** Are there any additional *national-level* indicators that currently exist, but were not proposed for ROE07, that you would recommend for ROE07? Proposed indicators should meet the ROE indicator definition and criteria, be national in scale, make an important contribution to answering one of the ROE questions in your topic area, be of a quality that likely would pass this type of peer review, and have data that are readily available (e.g., could be compiled within 6 weeks or less). For any new indicators proposed, provide detailed justification for their inclusion and list references or citations for the associated underlying data sources. As you consider this question, please read Attachment 7, which provides the list of ecological condition and other indicators presented in ROE03 that EPA does not intend to carry forward to ROE07, along with EPA's rationale for withdrawing them. If you disagree with EPA's rationale and feel any of these indicators should be included in ROE07, please so indicate in your response to this question, along with your rationale for why they should be included. Note: The full text and graphics for the ROE03 indicators can be viewed on-line at: http://www.epa.gov/indicators/roe/html/tsd/tsdEco.htm

Step 4: Review Group 3 Indicators

Group 3 indicators are indicators that are *proposed to answer a question in another chapter* and will be written up in that chapter, but peer-reviewed by ecological condition reviewers since they are ecological in nature. This group has two subsets:

- Group 3A comprises four indicators from the land chapter that will be reviewed *only* by the ecological condition reviewers. Therefore, they will receive the same level of review as Group 1 indicators.

- Group 3B comprises one indicator (from the air chapter). The ecological condition reviewers will answer some of the charge questions for this indicator. The air reviewers will answer other questions.

For each Group 3 indicator, Attachment 8 provides:

- *Draft text* introducing the indicator, identifying the underlying data used to evaluate the indicator, and describing data interpretations.

- *Draft graphic(s)/table(s)* to help readers visualize spatial and temporal trends in the indicator.

- *An information quality review form* that presents detailed background information on the indicator and its supporting data (e.g., data quality, coverage, processing).

Collectively, these three items should adequately present each indicator and thoroughly document the information that EPA considered when evaluating the indicators for ROE07. For each Group 3 indicator, you should thoroughly review the draft text, draft graphics/tables, and information quality review forms that are provided in Attachment 8. Then, document your review comments by filling out the "Comment Sheet" in:

- Attachment 5 for *each* **Group 3A indicator**.

- Attachment 6 for the **Group 3B indicator**.

Preparing for the Peer Review Workshop

After receiving the reviewers' pre-meeting comments, ERG will compile these comments and distribute them to all peer reviewers. Please familiarize yourself with the pre-meeting comments of the other ecological condition peer reviewers prior to the peer review workshop.

Note that the pre-meeting comments are preliminary in nature and are intended to help initiate discussion at the peer review meeting. Reviewers may change their comments based on discussion at the peer review meeting.

Section 4: The Peer Review Meeting

Most of the peer review meeting will take place with the peer reviewers split into breakout groups by topic area. Within each group, reviewers will consider the same questions they answered individually in their pre-meeting comments:

- Reviewers will discuss the merits of the individual Group 1 and 3 indicators based on responses provided on the "Comment Sheets" and, where possible, agree on a composite score for each indicator. They will also discuss the extent to which each Group 2 indicator contributes to answering the specific question it is referenced as answering.

- Then, considering the Group 1 and 2 indicators collectively, reviewers will identify any indicators that clearly do not seem to be on the same level of importance as the other indicators.

- Finally, reviewers will discuss and, where possible, reach agreement on any possible other national-level indicators they believe EPA should consider for the ROE07 TD.

ERG will prepare a summary report of the discussions at the peer review workshop. This report will document the peer reviewers' final conclusions and recommendations regarding the indicators for ROE07 TD. You will have a chance to check ERG's draft report of the meeting for accuracy and completeness before it is finalized.

Attachment 1:

Questions and Proposed Indicators for the ROE07 Technical Document

Attachment 2: Comment Sheet for Group 1 Indicators

Please fill out a separate sheet for each Group 1 indicator.

Your Name: ______________________________
Topic Area: **Ecological Condition**
Indicator Name: ____

1) Please indicate the extent to which you think the proposed indicator is appropriate, adequate, and useful (AA&U) for evaluating ecological conditions and therefore useful for contributing to an overall picture of ecological conditions.

1	2	3	4
Indicator is not AA&U	Indicator is of somewhat AA&U	Indicator is largely AA&U	Indicator is completely AA&U

Comments:

2) Please indicate the extent to which you think the proposed indicator makes an important contribution to answering the specific ROE question it is intended to answer (see Attachment 1 for list of questions). (Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators, or if it covers an area of less or diminishing importance environmentally.)

1	2	3	4
Indicator is not important	Indicator is of minor importance	Indicator is important	Indicator is critical

Comments:

3) To what extent do you think the indicator meets the following <u>indicator definition</u>:

An "indicator" is ***a numerical value derived from actual measurements of a pressure, ambient condition, exposure, or human health or ecological condition*** *over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment.*

1	2	3	4
Doesn't meet the definition	Only partly meets the definition	Largely meets the definition	Fully meets the definition

Please explain:

4) To what extent do you think the indicator meets each of the following <u>indicator criteria</u>:

a) The indicator makes an important contribution to answering a question for the ROE. (In this context, "important" means that the indicator answers a substantial portion of and/or a critical part of the question.)

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

b) The indicator is objective. It is developed and presented in an accurate, clear, complete, and unbiased manner.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

c) The underlying data are characterized by sound collection methodologies, data management systems that protect its integrity, and quality assurance procedures.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

d) Data are available to describe changes or trends, and the latest available data are timely.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

e) The data are comparable across time and space, and representative[2] of the target population. Trends depicted in this indicator accurately represent the underlying trends in the target population.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

f) The indicator is transparent and reproducible. The specific data used and the specific assumptions, analytic methods, and statistical procedures employed are clearly stated.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

Please explain:

[2] An indicator seeks to describe trends in an overall target "population" (e.g., land area, type of surface water, type of emissions, U.S. population), yet data often can only be sampled from a subset of this population. The validity of the trends described by the indicator will depend on the degree to which the sampled population is representative of the target population.

5) Do you have any suggestions for more effective graphic presentation of the data? If yes, please describe.

6) Please provide any additional comments, suggestions, or concerns regarding the indicator that you have not already noted in Questions 1 through 5. In particular, note any limitations to the indicator that you have not already described in your responses to the preceding questions.

7) Overall, this indicator:

_____ Should be included in ROE07 TD.

_____ Should be included in ROE07 TD with the modifications identified above.

_____ Should *not* be included in ROE07 TD.

Attachment 3: Comment Sheet for Group 2 Indicators

Please fill out a separate sheet for each Group 2 indicator.

Your Name: ______________________________
Topic Area: **Ecological Condition**
Indicator Name: ____

1) To what extent do you agree with this statement:

   This indicator is appropriate, adequate, and useful (AA&U) for evaluating ecological conditions and therefore useful for contributing to an overall picture of ecological conditions.

1	2	3	4
Indicator is not AA&U	Indicator is of somewhat AA&U	Indicator is largely AA&U	Indicator is completely AA&U

Comments:

2) To what extent do you agree with this statement:

   This indicator makes an important contribution[3] to answering the specific ROE question it is intended to answer (see Attachment 1 for list of questions).

1	2	3	4
Indicator is not important	Indicator is of minor importance	Indicator is important	Indicator is critical

Comments:

3) Please provide any additional comments, suggestions, or concerns regarding the indicator that you may have.

[3] Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators, or if it covers an area of less or diminishing importance environmentally.

Attachment 4: Comment Sheet for General Questions for Group 1 and 2 Indicators

Your Name: ______________________________
Topic Area: **Ecological Condition**

1) Considering the Group 1 and 2 indicators *collectively*, do any of these indicators clearly seem to be more appropriate, adequate, or useful for evaluating ecological conditions or for establishing an overall picture of ecological conditions than others? Do any seem to be more important than the others for answering the question(s) they are intended to answer? (Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators or if it covers an area of diminishing interest environmentally.)

2) Are there any additional ***national-level*** indicators that make an important contribution to answering one of the ROE questions in your topic area, but were not proposed for ROE07, that you would recommend? (Proposed indicators should meet the ROE indicator definition and criteria, be national in scale, be of a quality that likely would pass this type of peer review, and have data that are readily available. For any new indicators proposed, provide justification for their inclusion and list references or citations for the associated underlying data sources.)

   As you consider this question, ***please read Attachment 7***, which provides the list of ecological condition and other indicators presented in ROE03 that EPA does not intend to carry forward to ROE07, along with EPA's rationale for withdrawing them. If you disagree with EPA's rationale and feel any of these indicators should be included in ROE07, please so indicate in your response to this question, along with your rationale for why they should be included. Note: The full text and graphics for the ROE03 indicators can be viewed on-line at: http://www.epa.gov/indicators/roe/html/tsd/tsdEco.htm

Attachment 5: Comment Sheet for Group 3A Indicators

Please fill out a separate sheet for each Group 3A indicator.

Your Name: ______________________________
Topic Area (circle one): **Land Cover** or **Land Use**
Indicator Name: ____

1) Please indicate the extent to which you think the proposed indicator is appropriate, adequate, and useful (AA&U) for evaluating land cover or land use and therefore useful for contributing to an overall picture of land cover or land use.

1	2	3	4
Indicator is not AA&U	Indicator is of somewhat AA&U	Indicator is largely AA&U	Indicator is completely AA&U

Comments:

2) Please indicate the extent to which you think the proposed indicator makes an important contribution to answering the specific ROE question it is intended to answer (see Attachment 1 for list of questions). (Note: An indicator may be judged less important if it makes a smaller or less critical contribution to answering the question posed than the other indicators, or if it covers an area of less or diminishing importance environmentally.)

1	2	3	4
Indicator is not important	Indicator is of minor importance	Indicator is important	Indicator is critical

Comments:

3) To what extent do you think the indicator meets the following indicator definition:

An "indicator" is ***a numerical value derived from actual measurements of a pressure, ambient condition, exposure, or human health or ecological condition*** *over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment.*

1	2	3	4
Doesn't meet the definition	Only partly meets the definition	Largely meets the definition	Fully meets the definition

Please explain:

4) To what extent do you think the indicator meets each of the following indicator criteria:

a) The indicator makes an important contribution to answering a question for the ROE. (In this context, "important" means that the indicator answers a substantial portion of and/or a critical part of the question.)

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

b) The indicator is objective. It is developed and presented in an accurate, clear, complete, and unbiased manner.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

c) The underlying data are characterized by sound collection methodologies, data management systems that protect its integrity, and quality assurance procedures.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

d) Data are available to describe changes or trends, and the latest available data are timely.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

e) The data are comparable across time and space, and representative[4] of the target population. Trends depicted in this indicator accurately represent the underlying trends in the target population.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

f) The indicator is transparent and reproducible. The specific data used and the specific assumptions, analytic methods, and statistical procedures employed are clearly stated.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

Please explain:

[4] An indicator seeks to describe trends in an overall target "population" (e.g., land area, type of surface water, type of emissions, U.S. population), yet data often can only be sampled from a subset of this population. The validity of the trends described by the indicator will depend on the degree to which the sampled population is representative of the target population.

5) Do you have any suggestions for more effective graphic presentation of the data?
If yes, please describe.

6) Please provide any additional comments, suggestions, or concerns regarding the indicator that you have not already noted in Questions 1 through 5. In particular, note any limitations to the indicator that you have not already described in your responses to the preceding questions.

7) Overall, this indicator:

_____ Should be included in ROE07 TD.

_____ Should be included in ROE07 TD with the modifications identified above.

_____ Should *not* be included in ROE07 TD.

Attachment 6: Comment Sheet for the Group 3B Indicator

Your Name: ______________________________
Topic Area (circle one): Air
Indicator Name: Ozone Injury to Forest Plants

1) To what extent do you think the indicator meets the following <u>indicator definition</u>:

*An "indicator" is **a numerical value derived from actual measurements of a pressure, ambient condition, exposure, or human health or ecological condition** over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment*.

1	2	3	4
Doesn't meet the definition	Only partly meets the definition	Largely meets the definition	Fully meets the definition

Please explain:

2) To what extent do you think the indicator meets each of the following <u>indicator criteria</u>:

a) The indicator makes an important contribution to answering a question for the ROE. (In this context, "important" means that the indicator answers a substantial portion of and/or a critical part of the question.)

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

b) The indicator is objective. It is developed and presented in an accurate, clear, complete, and unbiased manner.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

c) The underlying data are characterized by sound collection methodologies, data management systems that protect its integrity, and quality assurance procedures.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

d) Data are available to describe changes or trends, and the latest available data are timely.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

e) The data are comparable across time and space, and representative[5] of the target population. Trends depicted in this indicator accurately represent the underlying trends in the target population.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

f) The indicator is transparent and reproducible. The specific data used and the specific assumptions, analytic methods, and statistical procedures employed are clearly stated.

1	2	3	4
Doesn't meet this criterion at all	Only partly meets this criterion	Largely meets this criterion	Fully meets this criterion

Please explain:

[5] An indicator seeks to describe trends in an overall target "population" (e.g., land area, type of surface water, type of emissions, U.S. population), yet data often can only be sampled from a subset of this population. The validity of the trends described by the indicator will depend on the degree to which the sampled population is representative of the target population.

3) Do you have any suggestions for more effective graphic presentation of the data? If yes, please describe.

4) Please provide any additional comments, suggestions, or concerns regarding the indicator that you have not already noted in Questions 1 through 3. In particular, note any limitations to the indicator that you have not already described in your responses to the preceding questions.

5) Overall, this indicator:

_____ Should be included in ROE07 TD.

_____ Should be included in ROE07 TD with the modifications identified above.

_____ Should *not* be included in ROE07 TD.

Attachment 7: List of and EPA Rationale for Withdrawn ROE03 Indicators

Background:
A number of indicators were included in EPA's 2003 Draft Report on the Environment (DROE03) that are not proposed to be included in ROE07. The general reasons for these changes are described below, followed by indicator-specific explanations.

> EPA's Science Advisory Board Committee review of the DROE03 recommended EPA develop and utilize a more precise definition of "indicator" than was used for DROE03.
>
> EPA developed a set of specific indicator criteria to provide a more precise conformance to Office of Management and Budget (OMB) and EPA Information Quality Guidelines.
>
> The ROE07 introduced a Regional Pilot Project and developed and implemented a relevant process. Sub-national or regional indicators that were included in DROE03 but did not go through this pilot are not recommended to be included in ROE07.

When screened against these factors, the ROE07 development team identified a small number of the indicators in DROE03 that did not appear to conform to one or more of these requirements. A group decision was made that developing indicator write-ups, quality forms, and graphics for these indicators was not the best use of team resources. Broadly speaking, the rationales for withdrawal fall into four categories, coded as follows:

> **(D) Definition** – The indicator fails to meet the improved indicator definition for ROE07 (most often because the indicator was a level 1 or 2 indicator, rather than a level 3, 4, 5, or 6 indicator).
>
> **(C) Criteria** – The indicator fails to meet one of the six indicator criteria that were established to conform with EPA Information Quality Guidelines.
>
> **(N) New indicator** – The indicator is replaced by a "new" and superior indicator that was not available for the DROE03.
>
> **(R) Regional –** The indicator is not national in scope and is not part of the ROE07 EPA Regional Pilot Project.

The following information briefly explains the rationale for excluding specific indicators from development for the ROE07 Indicator Peer Review. Each indicator is categorized as D, C, N, or R. The indicators are organized by general peer review topic.

Air

Production of Ozone Depleting Substances - C

This DROE03 indicator presents estimates of the amount of ODSs produced worldwide in 1986 and 1999, and annual U.S. production from 1958 to 1993. This indicator is being withdrawn because of issues concerning data reliability and relevance. Global ODC production data are not reliable with respect to comparability among reporting countries. The US estimates are more reliable because of legal reporting requirements and the small number of sources. However, the data set fails to account for imports, and annual production is not a good surrogate for emissions of ODCs into the environment because of the time between production and eventual entry into the environment is highly variable among the various products and recovery systems.

Number of People Living in Counties with Ambient Air Concentrations Above the NAAQS - C

This DROE03 indicator conveyed how many people (based on census) lived in counties where air pollutant levels at times were above the level of the NAAQS during the year stated. It was intended to give the reader some indication of the number of people potentially exposed to unhealthy air. Because of changing populations and air quality standards, however, this indicator masks actual trends in the levels of air pollutants. It is not a valid exposure indicator because it is not based on measurement of an actual marker of exposure measured on individuals.

Percent of Population Living in Homes Where Someone Smokes Regularly Inside the Home - D

This DROE indicator portrayed the percentage of homes in the U.S. in which young children were exposed to tobacco smoke in 1998 versus 1957. The survey is based on a questionnaire (do children live in the home, and does someone who smokes regularly live in the home), rather than on actual measurements of the amount of smoke actually present or the degree to which children are exposed to the resulting smoke. This indicator violates the ROE indicator definition, requiring that indicators be based on actual measurements, and blood cotenine (Indicator 102) provides a better indicator of children's exposure to smoke.

Water

Altered Fresh Water Ecosystems – C
Percent Urban Land Cover in Riparian Areas – C
Agricultural Lands in Riparian Areas - C

These DROE03 indicators are based on the percentage of land within 30 m of the edge of a stream or lake that is classified as urban or agriculture based on 1991 satellite data (NLCD). Baseline data are incomplete, and there are no reference points for the appropriate percentage of such cover, and it is not clear that the indicators could be reproduced with newer satellite data. There are no data for other alterations such as damming, channelization, etc.

Number of Watersheds Exceeding Criteria for Mercury, PCBs, & Dioxin – C

This DROE03 indicator is based on voluntary reporting of Hg contamination using data that has not undergone formal QA/QC review. It is not representative of the nation, or suitable for trend monitoring.

Lake Trophic State Index – R, C

This DROE03 indicator is based on phosphorous data collected in a one-time a statistical sample of lakes in the Northeast US during 1991-94. It is not included in the ROE07 Regional Pilot Project.

Sedimentation Index – R, C

This DROE03 indicator is based on data collected on freshwater streams in the Mid Atlantic Highlands Region during a one-time 1993-94 statistical survey. It is not included in the ROE07 Regional Pilot Project.

Contaminants in Fresh Water Fish (NAWQA) – C

This DROE03 indicator is based on reported concentrations of contaminants in fish collected by the US Geological Survey NAWQA program. While the data are collected from a large number of streams and are of high and consistent quality, the sample is not statistically representative of the nation, there are no national guidelines to serve as reference values for tissue concentrations, and Cycle II of NAWQA will not include comparable routine monitoring of trace organics and trace elements in fish tissues at sampling sites across the Nation.

Fish Index of Biotic Integrity – R, C

This DROE03 indicator is based on fish community data collected on freshwater fish in the Mid Atlantic Highlands Region during a one-time1993-96 statistical survey. Condition cannot be assessed in streams where no fish were caught, because data were insufficient to indicate whether the stream had poor quality or simply no fish. It is not included in the ROE07 Regional Pilot Project.

Macroinvertebrate IBI (MAIA) ⁻ R, C

This DROE03 indicator is based on benthic macroinvertebrate community data collected in freshwater streams in the Mid Atlantic Highlands Region during a one-time 1993-96 statistical survey. It is not included in the ROE07 Regional Pilot Project.

Beach Days Open – D

Waters with Fish Consumption Advisories - D

These DROE03 indicators are based on the frequency of beach closures or fish consumption advisories as reported to EPA voluntarilyby states and local government organizations. The data are not nationally or temporally consistent because of different and changing criteria for closing beaches or issuing fish consumption advisories in the different states, many of which do not involve actual water quality measurements. They are therefore level 1 indicators and fail to meet the definition for ROE indicators.

Contaminated Sediments in Fresh Water - C

This DROE03 indicator is based on reported concentrations of sediment contaminants collected by a large number of organizations focusing particularly on places where sediment contamination is perceived to be a problem (the EPA National Sediment Inventory). The database suffers from a number of limitations: the data are heavily biased toward sites at which there is a known or suspected toxicity problem and to particular geographic areas (non-representative of the nation), the data cover different dates in different locations- making estimation of trends difficult, and the data and procedures used to assign sites to a toxicity category are not uniform from watershed to watershed. It is unsuitable for trend estimation.

Chemical Contamination in Streams and Groundwater – C

This DROE03 indicator is based on data from a large number of NAWQA watersheds. The sampling and analytical protocols (including the analytes measured) are not comparable across all NAWQA watersheds.

Nitrate in Farmland, Forested and Urban Streams and Groundwater
Phosphorus in Farmland, Forested, and Urban Streams – N

These DROE03 indicators are being replaced by two new indicators, "Nitrate, Phosphorus, and Pesticides in Streams in Agricultural Watersheds" and "Nitrate and Pesticides in Groundwater in Agricultural Watersheds." The NAWQA streams in forested and urban watersheds were based on a small sample size, and may not be representative of forested and urban streams in general.

Phosphorus in Large Rivers - C

The indicator is based on phosphorus concentrations in large rivers sampled periodically by the USGS National Stream Quality Accounting Network (NASQAN). Monitoring at many of the large river NASQAN sites has been discontinued.

Chemicals

Sediment Runoff Potential from Croplands and Pasturelands - C

This DROE03 indicator represents the estimated sediment runoff potential for croplands and pasturelands based on topography, weather patterns, soil characteristics, and land-use land cover and cropping patterns for the U.S. and the Universal Soil Loss equation www.brc.tamus.edu/swat. The indicator addresses "potential" and not actual/current condition, and relies on a model to predict ambient characteristics (level 4 indicators) based on level 3 measurements, which violates a fundamental ROE protocol on the use of models in indicators. Trends in this indicator would likely be associated only with trends in land cover, cropping practices, and weather (topography and soil type are unlikely to change). No reliable spatial trend data at the appropriate scale exist for either cropping practices or land cover, and consequently trends in this indicator would be difficult to calculate.

Potential Pesticide Runoff from Fields - C
Pesticide Leaching Potential - C

These DROE03 indicators represent the potential movement of agricultural pesticides from the site of application to ground and surface waters, based on estimates of pesticide leaching and runoff losses derived from soil properties, field characteristics, management practices, pesticide properties, and climate for 243 pesticides applied to 120 specific soils in growing 13 major agronomic crops. The indicators address "potential" and not actual/current condition, and rely on models to predict ambient characteristics (level 4 indicators) based on level 3 measurements, which violates a fundamental ROE protocol on the use of models in indicators.

Risk of Nitrogen Export - C
Risk of Phosphorus Export - C

These DROE03 indicators represent the potential movement of N and P from the site of application to surface waters, based on a large empirical dataset relating land use to N and P observed in receiving streams over several decades at a variety of locations. The indicators address "potential" and not actual/current conditions, and rely on statistical models to predict ambient characteristics (level 4 indicators) based on level 3 measurements, which violates a fundamental ROE protocol on the use of models in indicators.

Pesticide Use - C

Agricultural pesticide usage data, measured at the national aggregate level for all pesticides is very difficult to interpret, given the wide year to year changes in the types of pests being controlled for and changes in agricultural production/chemical usage from year to year. From one time period to another the mix of pesticides changes, pest pressures change, agricultural practices change, agricultural acreage changes, regulatory status of key uses changes, and many other important variables change. Moreover, the effects of pesticide usage are encountered at three levels of the product's life cycle: production, usage, and residues on foods. The geographic distribution of those effects renders difficult the interpretation of national usage levels for all pesticides, taken as a group. While it is of course possible to compare magnitudes of aggregates at different times, the real significance for the environment is in the differences in the content and geographic distribution of the aggregates, not in the magnitude of the aggregate.

Contaminated Lands

Number and Location of Superfund NPL Sites - D

This DROE03 indicator is a category 1 indicator (it represents an administrative decision to force a cleanup, rather than an amount of waste present or removed), and therefore does not meet the ROE07 indicator definition.

Number of RCRA Corrective Action Sites - D

This DROE03 indicator, by itself, is a category 1 indicator (it represents an administrative decision to force a cleanup, rather than an amount of waste present or removed), and therefore does not meet the ROE07 indicator definition. The data are being combined into a new indicator, Quantity of RCRA Hazardous Waste Generated and Managed (which combines information from several DROE03 indicators).

Radioactive Waste Storage and Disposal - C

This DROE03 indicator is based on production and inventory data collected by the Department of Energy. Although the data continue to be collected, they are no longer publicly available post-September 11, 2001; therefore ongoing data trends are not and will not in the future be available for this indicator. Moreover, the earlier data reflected two distinct periods in the history of waste generation in the nuclear weapons complex. The first reflected a period during which wastes and other materials were being generated as an integral part of the production of weapons grade nuclear materials and components. The period after 1989 reflected the cessation of large-scale production of such materials and the initiation of clean-up activities and wastes from those initiatives. Thus, even before the truncation of data in the post 9/11 period, there were significant issues with the comparability of the data over time.

Human Health

Cardiovascular Disease Prevalence - C

This DROE03 indicator was based on data from NHANES III (1988-1994). Currently, no national trend data are available on cardiovascular disease (CVD) prevalence.

Blood VOC – C

This DROE03 indicator was based on a convenience sample whose representativeness cannot be determined or necessarily used as a baseline for future sampling. The indicator is based on detects only, so there is no reference level, and VOCs are cleared from the bloodstream rapidly (~ 1hr), so there is a significant possibility of false negatives, considering that exposures tends to be associated with occupational and indoor settings.

Urinary Arsenic - R
This DROE03 indicator was based on data from EPA Region 5 only, and is not part of the ROE07 Regional Pilot.

Ecological Condition

The Farmland Landscape - C
This DROE03 indicator represents croplands and the forests or woodlots, wetlands, grasslands and shrublands, that surround or are intermingled with them, and the degree to which croplands dominate the landscape http://www.heinzctr.org/ecosystems/farm/lndscps.shtml. The indicator relies on data generated using early 1990's satellite data, and it is unclear whether the definition of "farmland landscape" is sufficiently precise to be replicated independently, especially with respect to any future satellite data availability.

Extent of Estuaries and Coastline – C
This DROE03 indicator is based on remote sensing data, but is unlikely to show trends unrelated to sea level rise and changing tides, so it is not a very useful indicator for trends.

Coastal Living Habitats - C
This DROE03 indicator is based on remote sensing data of coastal wetlands, mudflats, sea-grass beds, etc., but the only system for which a national indicator has been developed is coastal vegetated wetlands, which already is covered in another indicator.

Shoreline Types - C
This DROE03 indicator is based on NOAA's Environmental Sensitivity Index. The index is based on a standardized mapping approach, but coverage is not complete for large parts of the coastline and the data in some of the atlases are more than 15 years old. Consequently, this indicator is not appropriate for measurement of representative, national trends.

Extent of Ponds, Lakes, and Reservoirs – C
This DROE03 indicator is based on data from the USGS National Wetlands Inventory. While these data are based on a valid statistical sampling design, the total amount of surface water is less than half of the area of lakes, reservoirs and ponds greater than 6 acres in size in the USGS National Hydrography Data Set. Until this discrepancy is resolved, the indicator may not satisfy the ROE criteria.

At-Risk Native Species – C
At-Risk Native Grassland and Shrubland Species – C
At-Risk Native Forest Species – C
Populations of Representative Forest Species – C
Non-Native Fresh Water Species – C
At-Risk Fresh Water Plant Communities – C
The Ecological Condition chapter is being restructured from the DROE03 organization per the recommendation of EPA's Science Advisory Board and numerous stakeholders. As such, the chapter

no longer requires that the above indicators be broken out by ecosystem. In addition, the ability to track trends of many of these indicators is currently in question.

Population of Invasive and Non-invasive Bird Species – R
This DROE03 indicator is based on an analysis of USGS Breeding Bird Survey data in grassland and shrubland ecosystems for 5 year periods ranging from the late 1960s to 2000. Because the ecological condition questions are no longer directed at specific ecosystems types, this appears to be a regional indicator. It is not clear at this time that this indicator will be updated.

Bird Community Index – R
This DROE03 indicator is not national in scope or part of the ROE EPA Regional Pilot.

Fish Diversity – R
This DROE03 indicator is based on a statistical sample of fish trawls in Mid-Atlantic estuaries during 1997-98. This indicator is not part of the ROE07 Regional Pilot project, and EMAP is no longer collecting fish samples to support this indicator.

Fish Abnormalities - C
This DROE03 indicator is based on a statistical sample of fish trawls in estuaries in the Atlantic and Gulf, but the data are no longer being collected by EMAP to support this indicator.

Unusual Marine Mortalities – C
This DROE03 indicator is based on voluntary reporting of unusual mortality events to NOAA. Because there is no systematic requirement to report, these data are not suitable to support national trends in the indicator.

Animal Deaths and Deformities – C
This DROE03 indicator is based on data reported by a number of different organizations to USGS on incidences of death or deformities in waterfowl, fish, amphibians, and mammals. Trends are available only for waterfowl, and because data reporting is voluntary rather than systematic, the data are not adequate to determine actual trends versus trends in reporting.

Tree Condition – C
This DROE03 indicator is based on an ongoing statistical sample of forests across the conterminous US and comprises components that relate to crown (tree canopy condition), the ratio of dead to live wood, and the fire class. This indicator likely relates more to forest management practices than to environmental condition, and for this reason has low relevance value to EPA.

Processes Beyond the Range of Historic Variation – C
This DROE03 indicator is based on an analysis of recent Forest Inventory and Analysis data on climate events, fire frequency, and forest insect and disease outbreaks, which were then compared to anecdotal data for the period 1800-1850. Because the early data are anecdotal, and because the data mostly relate to forest management practices, etc., it is proposed that this indicator has low relevance and that trend data are of questionable utility as an ROE indicator.

Soil Compaction – C
Soil Erosion – C
These DROE03 indicator are based on an ongoing statistical sample of soils in forests across the conterminous US, but the actual indicators are based on models rather than measurement, and they likely relate more to forest management practices than to environmental condition, and for this reason have low relevance value to EPA.

Soil Quality Index - R

This DROE03 indicator was based on a survey of soils in the Mid Atlantic region during the 1990s, and was neither repeated and is not part of the Regional Pilot Project for ROE07.

Chemical Contamination – C

This DROE03 indicator combines data from the USGS NAWQA program that are not consistent in terms of sampling frequency or analytical protocols.

Attachment 8: Indicator Materials for Review

NOTE: ATTACHMENT 8 COMPRISES THE SUBSEQUENT SECTIONS OF THIS BINDER

Indicator: Extent of Coral Reef Cover (210)

It is generally acknowledged that coral reef ecosystems are increasingly threatened on a global scale due to a variety of factors including runoff of nutrients, sediments, and pollutants; changes in water temperature and clarity; as well as effects of the fishing industry (Gardner et al., 2003, 2005). Reefs serve an important ecological function by serving as nursery, habitat, and feed areas for many marine species. As such, coral reefs are often hotspots of marine biodiversity (Gardner et al., 2005). Recent assessments suggest that a significant fraction (10-16%) of the historical extent of coral reef coverage worldwide has been lost with a like fraction severely damaged (Wilkinson, 2000). There is a wealth of small-scale quantitative studies currently available for synthesis covering the US section of the Caribbean basin over the last 20 to 30 years. Given the lack of long-term monitoring studies, meta-analysis of these independent studies provides the best window into the status and trends US Caribbean coral reef ecosystems during the recent past.

A total of 79 independent studies representing the years 1973 to 2002 were examined for this analysis. The areas covered are the US Virgin Islands, Gulf of Mexico, Puerto Rico, the Florida continental coast, and the Florida Keys. The data points presented are mean hard coral cover values from individual studies. The data were collected in one of two ways: 1) transect data or 2) quadrat data. Thus, each data point consists of a mean, sample size, and some error measure (standard deviation or standard error) based on replicated transects or quadrats at a particular point in time and space. Error estimates are not presented here.

What the Data Show

In Figure 1, data combined from the Caribbean studies reveal a variable, but highly significant decline in overall percent hard coral cover over time ($P<0.001$). The mean percent of hard coral cover dropped from 60% in 1973 to just over 20% in 2002.

Indicator Limitations

- Because this indicator represents a meta-analysis of other studies, the temporal and spatial coverage of the data is somewhat heterogeneous.
- This indicator covers only coral reefs in the U.S. section of the Atlantic Caribbean basin and therefore represents only a small portion of the world's total coral reef cover.

Data Sources

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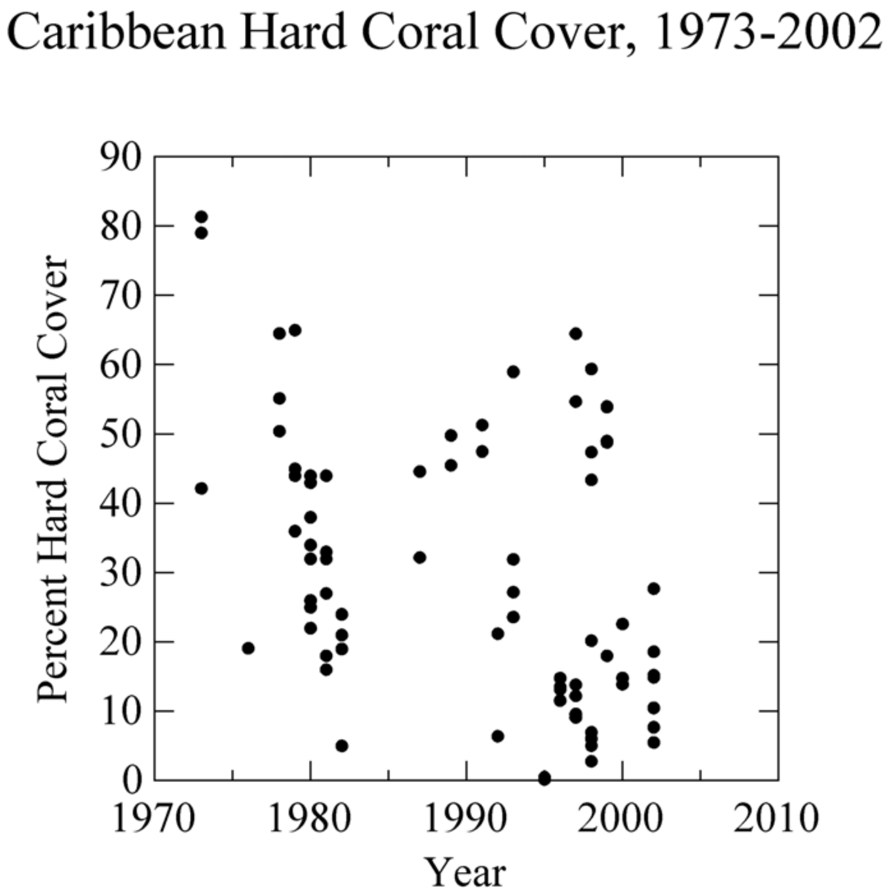
Graphics

Figure 1



R.O.E. Indicator QA/QC

Data Set Name: EXTENT OF CORAL REEF COVER
Indicator Number: 210 (89505)
Data Set Source: Multiple independent studies
Data Collection Date: Irregular: ca. 1970-present
Data Collection Frequency: Roughly yearly
Data Set Description: Percent Hard Coral Cover
Primary ROE Question: What are the trends in the extent and distribution of the Nation's ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The methods are a subset of those used by Gardner and colleagues (2003) and developed by Rosenberg, Adams, and Gurevitch (2000). Gardner, T., I. Cote, J. Gill, A. Grant, and A. Watkinson (2003). Long-term region-wide declines in Caribbean corals. Science 301: 958-960. Rosenberg, M., D. Adams, and J. Gurevitch (2000). MetaWin: Statistical Software for Meta-Analysis. Version 2. Sinauer Assoctiates, Sunderland, MA.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The metadata uses standard transect and quadrat coral field sampling techniques. Gardner, T., I. Cote, J. Gill, A. Grant, and A. Watkinson (2003). Long-term region-wide declines in Caribbean corals. Science 301: 958-960.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The data are direct measurements. The analyses are well-established. Gardner, T., I. Cote, J. Gill, A. Grant, and A. Watkinson (2003). Long-term region-wide declines in Caribbean corals. Science 301: 958-960. Gurevitch, J., and L. Hedges (1999). Statistical issues in meta-analyses. Ecology. 80: 1142-1149.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The indicator speaks directly to the extent of one of the Nations important ecosystems that provide habitat for a wide range of coastal marine species. The sampling designs are appropriate for the individual studies. The data are metadata, and as such, are not from a single monitoring program. Although there is data from several monitoring programs. Also, being metadata, they are not homogeneous with respect to sample size, averaging time, etc. The central data set covering the Caribbean contains 79 data records. These are mean percent hard coral cover data for the US Caribbean region. They are brought together from a multitude of studies but all contain sample size and variance data.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems? Because of threats from pollution, water warming, and a number of other issues, the entire Caribbean region can be classified as a sensitive ecosystem with regard to hard coral cover.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?
There are no established reference points for what constitutes a desirable threshold for the extent of coral reefs, but the relatively long time series available from metadata allows a solid trend to be established.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?
The list of references compiled for the metadata. See the indicator text document; the list is too long to fit here.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The complete data set is available both as Excel and Systat files. (Thomas Forbes: forbes.thomas@epa.gov, 202-566-0810.)

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. Only complete and sufficient designs were selected for the database. In this case, complete means that 1) there was a standard method of collection (quadrat or transect) and 2) a mean, N, and error was included. A reference for QA in Meta-analysis is:Gurevich, J., Curtis, P.S., and M.H. Jones. 2001. Meta-analysis in ecology. Adv. Ecol. Res. 32: 199-247.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The procedures for sampling and data collection are completely accessible in the assembled literature for the metadata (available from Thomas Forbes: forbes.thomas@epa.gov, 202-566-0810). Procedures for the meta analysis can be found in: Gardner, T., I. Cote, J. Gill, A. Grant, and A. Watkinson (2003). Long-term region-wide declines in Caribbean corals. Science 301: 958-960. Gurevich, J., and L. Hedges (1999). Statistical issues in meta-analyses. Ecology. 80: 1142-1149. Rosenberg, M., D.

Adams, and J. Gurevitch (2000). MetaWin: Statistical Software for Meta-Analysis. Version 2. Sinauer Assoctiates, Sunderland, MA.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. See: Gardner, T., I. Cote, J. Gill, A. Grant, and A. Watkinson (2003). Long-term region-wide declines in Caribbean corals. Science 301: 958-960. Gurevitch, J., and L. Hedges (1999). Statistical issues in meta-analyses. Ecology. 80: 1142-1149. Rosenberg, M., D. Adams, and J. Gurevitch (2000). MetaWin: Statistical Software for Meta-Analysis. Version 2. Sinauer Assoctiates, Sunderland, MA.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. All metadata consists of sample size, mean, and error values. Contact: Thomas Forbes, forbes.thomas@epa.gov, 202-566-0810, for a list of references.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Sources of error and potential biases are those of all ecological meta analyses. For a comprehensive discussion, see: Gardner, T., I. Cote, J. Gill, A. Grant, and A. Watkinson (2003). Long-term region-wide declines in Caribbean corals. Science 301: 958-960. Gurevitch, J., and L. Hedges (1999). Statistical issues in meta-analyses. Ecology. 80: 1142-1149. Rosenberg, M., D. Adams, and J. Gurevitch (2000). MetaWin: Statistical Software for Meta-Analysis. Version 2. Sinauer Assoctiates, Sunderland, MA.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?
No. The limitation (no long term, consistent, monitoring data) was handled with meta analysis.

Indicator: Ecological Framework (308R)

Ecosystems function naturally to provide clean air through the removal of particulate matter and storage of carbon, clean water through the assimilation of nutrients and sediment reduction, and better protected lands that can control flood waters and maintain biological diversity. These services that enhance the quality of life depend on an *ecological framework* of high-quality land consisting of central hubs interconnected by corridors that provide for the movement of energy, matter, and species across the landscape. This framework is threatened by agricultural, silvicultural, and road development practices and "urban sprawl" that are fragmenting the landscape and threatening this ecological framework.

This Ecological Framework (EF) indicator is inclusive of five sub-indicators that contribute to the necessary ecological infrastructure of Region 4 (http://geoplan.ufl.edu/epa/download/sef_report.pdf). Hub and Corridor Connectivity shows the location of critical ecosystems in the southeast region of the United States. Potential Land Use Change shows those areas of the EF that are most likely to be fragmented based on an urban growth model that uses distance to roads and existing urban areas to identify potential areas of growth. The Biodiversity Index is comprised of nine data layers associated with levels of species diversity (all of the EF is important to biodiversity for the region, but some locations have higher ratings because they satisfy multiple criteria important to biodiversity). The Ecosystem Services Index is developed from seven data layers related to direct or indirect services provided by functioning ecological systems (including priority groundwater and surface water areas, proximity to shellfish harvesting, potential for storm water protection and other water resource protection data). Riparian corridors within the EF show a particularly high propensity for providing services due to their proximity to water. Gross Primary Productivity (GPP) captures the fixation of carbon in the landscape based on 1 kilometer data derived from MODIS (MOD17) satellite data. The EF indicator provides a baseline for the period 1992-93.

What the Data Show

The Ecological Framework (EF) Hub and Corridor Connectivity indicator covers 43% of the available land and water resources in the Region. A total of 61% of the EF consists of hubs and 39% consists of corridors associated with the EF (Figure 308R-1). Currently, 22% of the EF is protected, 12% is in the public domain as open water, and 14% is classified as wetlands for a total of 48% of the Ecological Framework being afforded some type of long-term protection.

The Ecological Framework (EF) Potential Land Use Change indicator shows that 65% of the EF area has a low potential of fragmentation; 22% are at moderate risk of fragmentation, and 9% are at high risk of fragmentation (Figure 308R-2). The remaining 4% of the EF was identified as having no potential for development because the areas were so far removed from current development patterns. The red areas identified in the figure are the most likely to be fragmented as a result of the outward expansion of urban development.

The Ecological Framework (EF) Biodiversity Index shows that the area with the lowest scores (1 to 3) in the normalized index comprise 20% of the EF, 38% of the area scored between 4 to 7, and 43% of the EF scored 8 to 10 (Figure 308R-3).

The Ecological Framework (EF) Ecosystem Services Index shows 25% of the area in the EF to have the lowest scores (1-3); 39% of the area to have scores of 4-7; and 35% to have the highest scores of 8-10 (Figure 308R-4). The total does not equal 100% due to rounding errors.

The Ecological Framework (EF) Gross Primary Productivity (GPP) indicator shows that 5% of the EF that is represented by GPP of less than 1000m^2; 80% falls between 1000gm/m^2/yr and 2000 gm/m^2/yr;

and the remaining 15% has a GPP greater than 2000gm/m2/yr (Figure 308R-5). The highly productive areas are coastal wetlands. The total GPP of the EF was calculated to be 697 million tons of carbon per year (Ajtay 1979 and Milesi 2003).

Indicator limitations

- The most important data layer used in the EF indicator suite is the National Land Cover Data (NLCD), which date from 1992-93.

Data Sources

The data supporting this indicator can be found at:
http://geoplan.ufl.edu/epa/index.html
http://landcover.usgs.gov/natllandcover.asp
http://ntsg.umt.edu/default.htm

References

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Graphics

Figure 308R-1

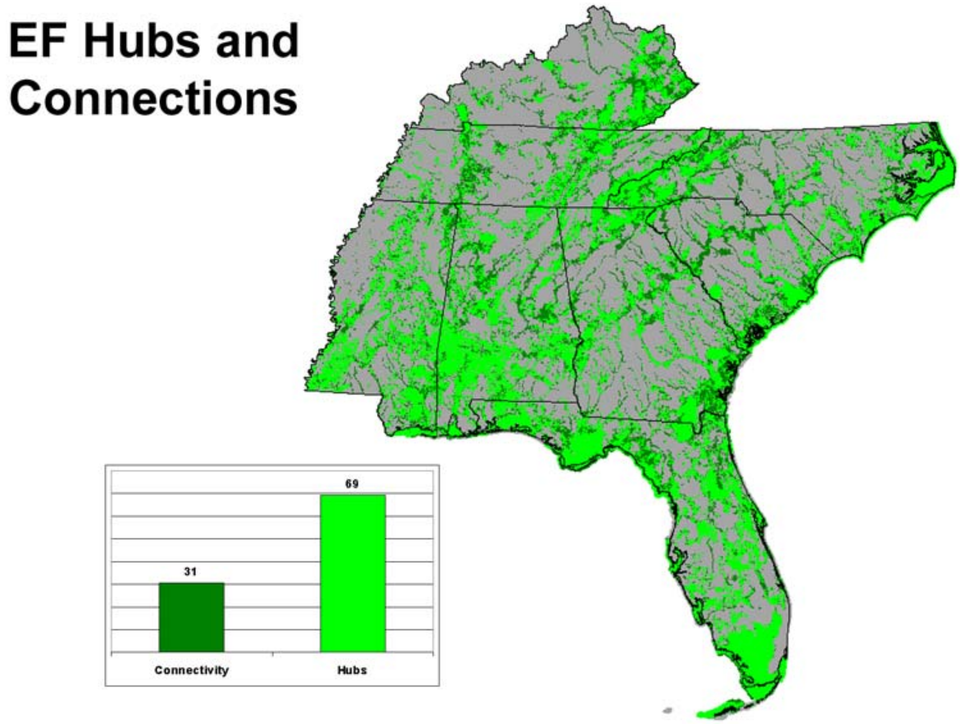


Figure 308R-2

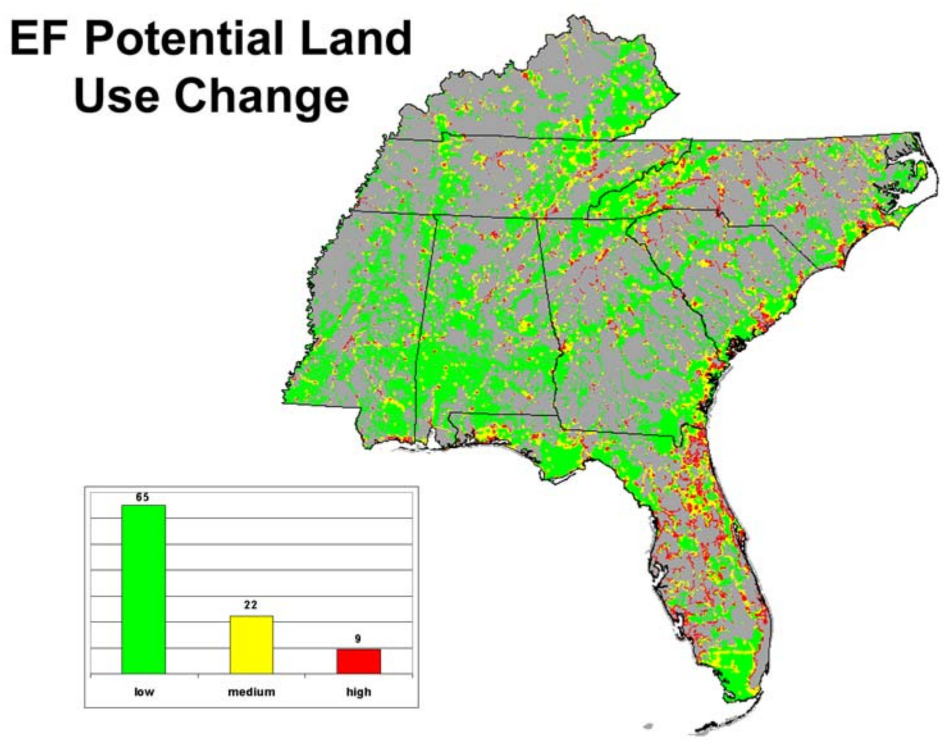


Figure 308R-3

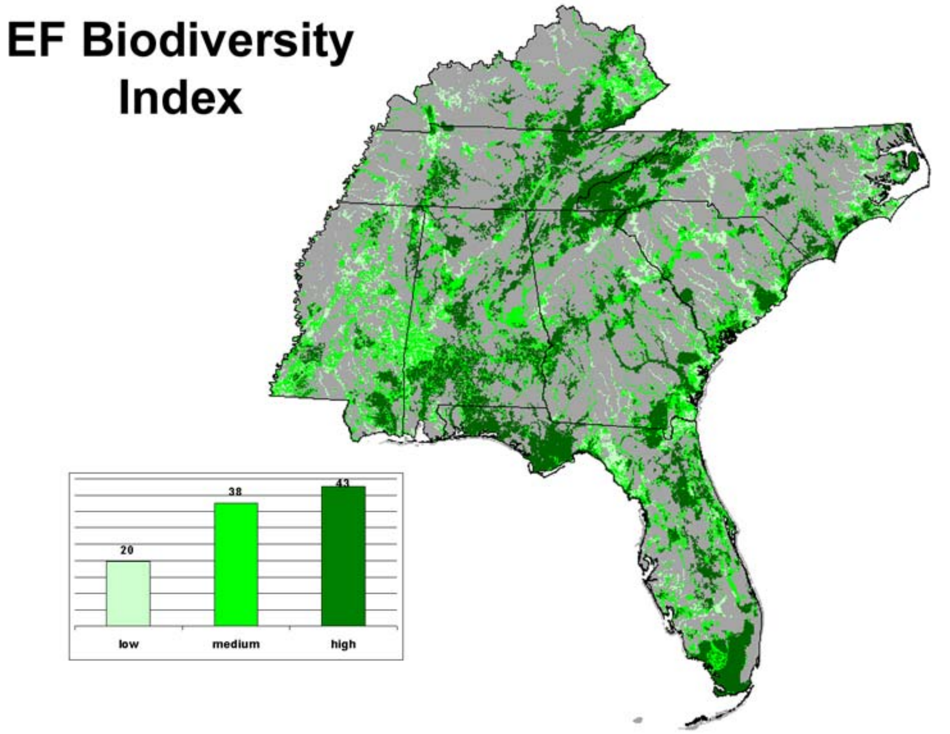


Figure 308R-4

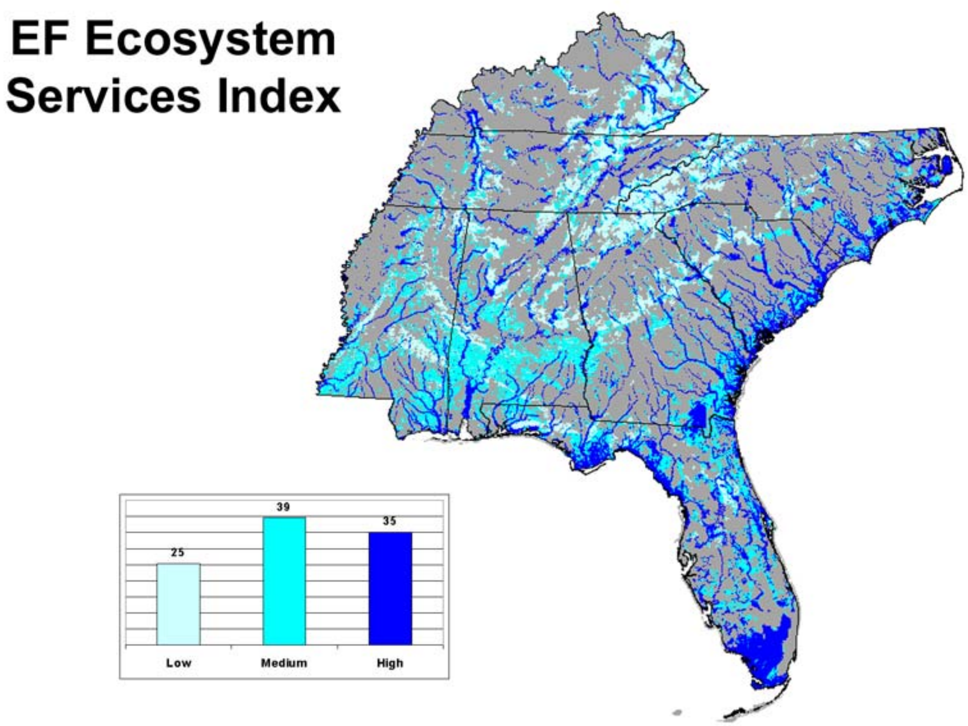
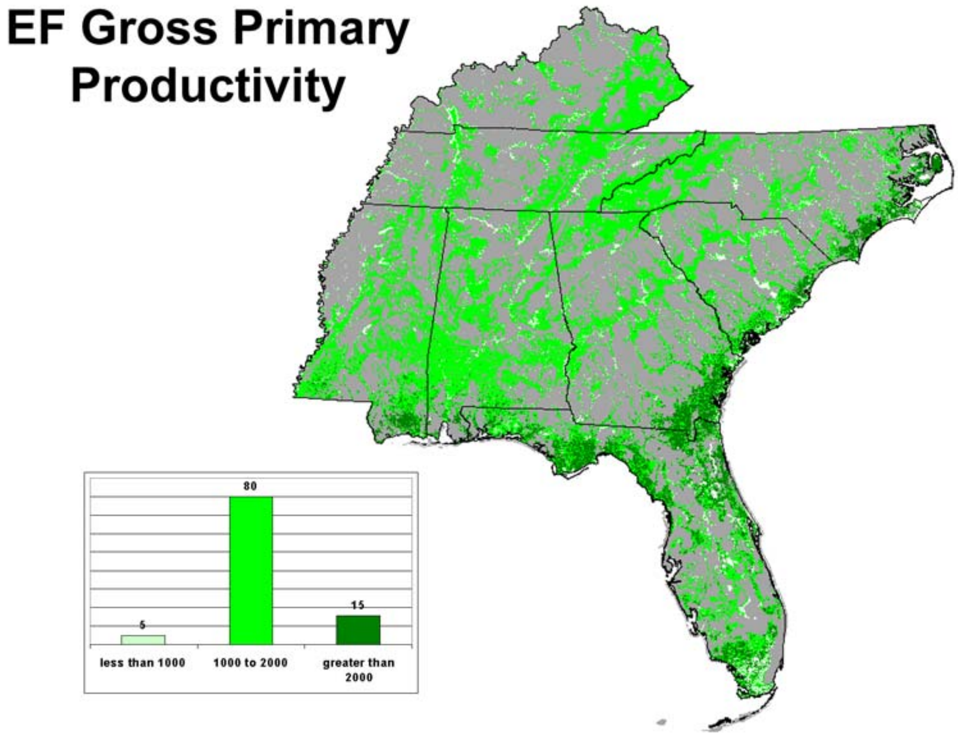


Figure 308R-5



R.O.E. Indicator QA/QC

Data Set Name: ECOLOGICAL FRAMEWORK
Indicator Number: 113290 (113290)
Data Set Source: Primary data source is the National Land Cover Data
Data Collection Date: ongoing: 1992 - present
Data Collection Frequency: landcover obtained every 8 years
Data Set Description: Ecological Connectivity identifies an ecological prespective of important landscapes across the southeast. Landscape ecologists have known for a long time that piece-meal protection of the environment often leads to degradation of the parts being protected. The resulting fragmentation prevents the operation of many large-scale processes from adequately functioning to protect the land, air and water quality of the region. Environmental protection of these critical ecosystems and their connectivity with other natural areas is an important principle for the long-term health of the Southeast.
Primary ROE Question: What are the trends in the extent and distribution of the Nation's ecological systems?
Comment: The challenges of the new century will be focused on how human actions impact ecosystem function. To address these challenges, EPA will need to address the greatest threats to ecosystem function from natural landscape fragmentation resulting from current population and economic development trends. Roads, agriculture, and sprawl, represent the most prevalent changes in our natural landscape and cause natural systems to become divided into isolated parts. Research shows that landscapes lose their ecological integrity with increasing fragmentation, which can include the loss of biological diversity, the degradation of water quality and the loss of other important ecological services. Many natural ecosystem

types in the southeast have suffered significant losses and degradation. Longleaf pine forests, bottomland hardwoods and wetlands have lost 98%, 78% and 28% percent respectively of their pre-settlement extent in this region. In addition, many acres of remaining forests have been modified and are in plantation forestry, leaving even smaller, sometimes-isolated areas to preserve native habitat and ecosystem function. These dwindling natural systems are falling under increased pressure to support a growing human population. By identifying a large-scale connected framework, it is possible to provide a foundation in which protection of the ecological properties and processes can be optimized in support of EPA's goals and objectives for benefits at the local and regional scale. Of the remaining natural areas in the region, not all are equal in their support of ecosystem services. Critical areas may include wetlands located up stream of drinking water intakes. Other critical areas may be identified as flood protection for a small farming town or riparian buffers to eliminate the need of a sediment filtration system. There are also many areas that have high ecological integrity or high biological diversity, have critical roles in watershed protection, or can provide the only possible linkages between other existing natural areas.

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Trends in conservation are leading to integrative, comprehensive approaches to natural resource conservation. Related concepts that are now being forwarded include Ecological Networks, Regional Conservation Planning, Green Infrastructure Planning and Wildland Reserve Networks many organizations such as the World Wildlife Fund, The Nature Conservancy, and the Trust for Public Land are attempting to use geographical information system tools for identifying hot spots, priority areas, or the last great remaining places. A significant problem with any approach is identifying the appropriate scale to evaluate natural resources, the amount and consistency of data available and stakeholder involvement or local ownership of the final product. Each aspect has significant hurdles to overcome and often leaves room for improvement on any product eventually developed. In 1995, the Southern Appalachian Man and Biosphere (SAMAB) Cooperative completed the Southern Appalachian Assessment (SAA) through the collaborative efforts of federal agencies, state agencies, universities, special interest groups, and private citizens. The effort was an attempt to evaluate the living systems of the Southern Appalachian Region - the animals, the plants, and the land, air, and water that support them - and the enormous changes that have taken place during the 20th century. This marked the first attempt at developing a consistent data set for evaluating natural resources and received the Hammer Award. The SAA, however, fell short in providing useful information for local decision makers. One problem was due in large part to the complexity of the GIS tools available at the time and little training by municipal officials in the technology. A second significant problem with the SAA was that the majority of data was developed to identify trends at a county level and provided little opportunity for understanding landscape changes within a county. Although point data and land use coverage were included in the final SAA, further difficulty lied in the fact that no analysis of the relationship of one data set with another was developed to give a firm indication of what land may be at risk from existing or potential growth in the future.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Three steps were involved in the design of the Ecological Framework. The first included the identification of priority and significant ecological areas. The second focused on identifying the ecological hubs. The third involved the delineation of landscape linkages across the landscape and between the hubs. The identification of the Ecological Framework involved four primary steps. First, in what can be termed the inventory phase, all relevant available Geographical Information System (GIS) data were collected, including regional, sub-regional, and state data layers. These GIS data were then assessed to determine areas of ecological conservation significance called Priority Ecological Areas and Significant Ecological Areas as well as landuse and landscape features that could impact ecological integrity. Second, the largest intact areas of ecological significance (Hubs) were delineated. Third, a GIS model was developed to identify the best opportunities to maintain ecological connectedness (Corridors) between selected Hubs. Finally, all framework components were integrated and optimized to create the Ecological Framework.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The Ecological Framework was developed based on the University of Florida's experience in creating the Florida Ecological Network (FEN) for the State of Florida. Following the work of Harris, Noss and other ecologists, the state adopted the concept of an integrated habitat network as part of the Florida Greenways Program in 1992. Although greenways are often associated with linear recreational features such as rails-to-trails, the Florida concept was to include wildlife corridors, landscape linkages, and landscape-level conservation areas within an ecological network connecting public and private conservation lands across the state. As part of the process to develop a statewide greenways plan, the University of Florida developed a spatial analysis model to help identify the best opportunities to protect ecological connectivity statewide. GIS software was used to analyze all of the best available data on land use and significant ecological areas including important habitats for native species, important natural communities, wetlands, road less areas, floodplains, and important aquatic ecosystems. This information was then integrated in a process that identified the FEN containing all of the largest areas of ecological and natural resource significance and the landscape linkages necessary to protect a functional statewide network. The process was collaborative and overseen by three separate state-appointed greenways councils. During the development of the model, technical input was obtained from the Florida Greenways Commission, the Florida Greenways Coordinating Council, other state, regional and federal agencies, scientists, university personnel, conservation groups, planners and the general public in over 20 sessions. When the modeling was completed, the results were thoroughly reviewed in public meetings statewide as part of the development of the Greenways Implementation Plan completed in 1999, and the work was published in Conservation Biology, in August, 2000 (Hoctor et al. 2000). The FEN delineation process combined a systematic landscape analysis of ecological significance and the identification of critical landscape linkages in a way that could be replicated, enhanced with new data, and applied at different scales. The FEN connects and integrates existing conservation areas with unprotected areas of high ecological significance. This information can be used in concert with other information on conservation priorities to develop a more integrated landscape protection strategy.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The modeling process utilized in both the FEN and the EF has important strengths that facilitate its ability to serve as an indicator for different regions or scales. The process combines a systematic landscape analysis of ecological significance, large intact landscapes, and opportunities for ecological connectivity in a way that can be replicated, enhanced with new data, and applied at different scales. The identification of Priority Ecological Areas and corridors is query-based, which allows great flexibility in model inputs and decision-making processes. Without relying on complex weighting schemes, the modeling process can be adapted to various situations with different objectives and data sources. Criteria, thresholds, and the scale of the analysis can easily be changed, which can either be used to modify the existing model results or to re-run the model as resources allow. This affords the opportunity to develop the model process for other regions and allows for iterative identification processes as new data becomes available. The model can also be applied from local to regional scales, and local versions of the modeling process can be created using even more resolute and specific data sets to assist in connecting local conservation planning initiatives with larger scale ecological processes. In addition, ever-increasing sophistication of computer technology is allowing for large regional assessments to be done using more resolute data and analyses.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The Ecological Framework incorporates all large conservation lands, large wetland basins and intact riparian areas around all major rivers, all major forested roadless areas, and other intact areas of ecological significance throughout Region 4. Approximately 98% of existing conservation lands in Region 4 is incorporated within the EF. The EF also contains 77% of the wetlands and 56% of all forested lands within the region. Coincidentally only about 2% of the EF is comprised of agricultural lands (pastures or croplands) and only approximately 2% of the agricultural lands in the southeast 4 are found within the EF. The agricultural lands that do occur within the EF are either within the boundaries of conservation areas or were added as part of landscape linkages in some cases, particularly within the ranchlands of south-central Florida and in some linkages along the fall line along the Piedmont and coastal plain boundary.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Hubs represent the Priority Ecological Areas after the exclusion process that are also 5,000 acres or larger. These represent larger intact areas that can serve as the building blocks for local to regional networks of protected lands. In this model Hubs became the focal step of the linkage process, where all opportunities to protect existing or restore connectivity between Hubs was assessed. There are still many areas within Region 4 that meet the criteria for being ecological Hubs with 28% of the region within Hubs. Hubs were then optimized spatially to fill gaps that contained suitable land cover and create more intact edges wherever possible. Optimized Hubs add slightly more acreage and incorporate 30% of Region 4. The linkage portion of the model is then run to identify the best opportunities for physical ecological connections between appropriate Hubs. Linkage types include: 1. Riparian linkages including all major river systems and coastal water bodies such as lagoons and connected estuaries. 2. Upland linkages were used primarily in mountain and plateau ecoregions. 3. General Hub-to-Hub linkages consider wetlands and uplands as potentially suitable and were used primarily in the Coastal Plain and Piedmont ecoregions. Landscape Linkages are identified with an AML-based user interface in Arc-Info. The least cost path function, which can be used to identify the lowest cost, or conversely, the most suitable path between destinations was the primary algorithm used in the interface. Cost surfaces were created for each linkage type, where most appropriate landscape features for supporting a landscape linkage are given the lowest number and the least suitable landscape features are assigned the highest number. Landscape linkages are then identified using a process where hub pairs are selected for potential connection, resulting least cost paths are examined, and accepted least cost paths are buffered based on the length of the linkage and the characteristics of the particular landscape. After buffering least cost paths, all linkages are "smoothed" using an algorithm that deletes outlier cells. The upland linkages are also optimized by adding Category II (agricultural) land uses within 500 meters of the least cost path. The values in the cost surface represent the resistance to going through an individual cell. As an example, the path would go through 99 cells valued as 1 instead of going through a single cell valued as 100. All three cost surfaces include the identification of large blocks of intact natural or semi-natural vegetation to help locate landscape linkages in wide, intact areas instead of narrow corridors whenever possible. These intact areas are separated into two classes: large and moderate. Large intact areas are defined as natural and semi-natural vegetation within both a 590 hectare area and 65 hectare area containing 90% or more natural or semi-natural vegetation in blocks 5000 acres or larger and without primary roads. Moderate intact areas are defined as natural and semi-natural vegetation within both a 590 hectare area and 65 hectare area containing 90% or more natural or semi-natural vegetation in blocks 1000 acres or larger and without primary roads.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Final Report: Southeastern Ecological Framework; www.geoplan.ufl.edu/epa/download/sef_report.pdf; May 2002; Hoctor, et al. Review of the Southeastern Ecological Framework: An EPA Science Advisory Board Report; http://www.epa.gov/science1/pdf/epecl02002.pdf; June 2002; Glaze, Young and Dale.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes, there is a complete data set available. www.geoplan.ufl.edu/epa or contact Dr. John Richardson; richardson.john@epa.gov; 404-562-8290

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?
Yes

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Final Report: Southeastern Ecological Framework; www.geoplan.ufl.edu/epa/download/sef_report.pdf; May 2002; Hoctor, et al.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

No.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes, the accuracy of the 1992 NLCD land-cover map was conducted by EPA federal region (see figure) using a probability sampling design incorporating three levels of stratification and two stages of selection. Details of the methodology and results have been published. Although some regional variation in protocol and implementation exists, all of the regions shared a common general framework. The goals of this framework were to insure that: 1) satisfy protocols defining a probability sample; 2) sufficient sample sizes were acquired for each land-cover class; 3) reasonable cost controls were maintained and 4) a spatially well-distributed sample was acquired. Reference land-cover labels were acquired through the photo-interpretation of NAPP aerial photographs, or DOQQs. A correct classification was defined as occurring when the primary or secondary reference label matched the mode class present in a 3x3 block centered on the sample point. Assessments were conducted at both the Anderson level I and II levels of classification. In addition to the above accuracy reports, research has been conducted in evaluating different sampling schemes, as well as the impact of landscape characteristics on accuracy.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not really, since we are looking at a regional or broad scale. However, scale can certainly impair conclusions in trying to utilize the information contained in the ecosystem connectivity indicator when attempting to draw conclusions at a local level.

T4Q4 re there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

No. The limitations are related to the completion of the NLCD for 2000 from which comparisons can be drawn.

Indicator: Forest Fragmentation (110)

The amount of forestland in the United States monitored by the USDA Forest Service has remained nearly constant over the past century, but the patterns of human land-use have affected its distribution from one region to another. Forest fragmentation involves both the extent of forest and its spatial pattern, and is the degree to which forested areas are being broken into smaller patches, and pierced or interspersed with non-forest cover.

Forest fragmentation is a critical aspect of the extent and distribution of ecological systems. Many forest species are adapted to either edge or interior habitats. When the degree or patterns of fragmentation change, it can affect habitat quality for the majority of mammal, reptile, bird, and amphibian species found in forest habitats (Fahrig, 2003). As forest fragmentation increases beyond the fragmentation caused by natural disturbances, edge effects become more dominant, interior-adapted species are more likely to disappear, and edge- and open-field species are likely to increase.

This indicator, forest fragmentation, was developed by the USDA Forest Service and has appeared in other recent reports (USDA, 2004; Heinz Center, 2002. The USDA Forest Service's Southern Research Station performed a re-analysis of National Land Cover Data (NLCD), aggregating the four NLCD forest cover classes (coniferous, deciduous, mixed, and wetland forest) into one forest class and the remaining land cover classes into a non-forest class and a "missing" class consisting of water, ice/snow, and bare ground (Riitters, et al., 2002). A model that classifies forest fragmentation based on the degree of forestland surrounding each forest pixel (a square approximately 30 meters on each edge) for various landscape sizes (known as "windows") provides a synoptic assessment of forest fragmentation for the conterminous United States by assessing each pixel's "forest neighborhood" within various distances.

Results are based on three degrees of land cover and five landscape sizes. Degrees of land cover are designated "core" if a subject pixel is surrounded by a completely forested landscape (no fragmentation); "interior" if a subject pixel is surrounded by a landscape that is at least 90% forest; and "connected" if a subject pixel is surrounded by a landscape that is at least 60% forest. These degrees of land cover are not mutually exclusive; a pixel that meets the core criterion also meets the other two. Landscape sizes are based on the number of square pixels surrounding the subject pixel. The five landscape sizes are 5.6 acres (a 5 by 5 pixel square), 18.0 acres (a 9 by 9 pixel square), 162 acres (a 27 by 27 pixel square), 1459 acres (an 81 by 81 pixel square), and 13,132 acres (a 243 by 243 pixel square).

What the Data Show

At every scale, the Forest Service found a majority of the nation's forestland to be "connected" to other forestland, appearing as landscapes dominated by forest (Figure 110-1). However, the data for "interior" and "core" forests suggest that fragmentation is extensive, with few large areas of complete, unperforated forest cover. At every scale, the Forest Service found a majority of forestland to be "connected" to other forestland, but the data for "interior" and "core" forests show that fragmentation affects much of the nation's forestland (Figure 110-1). In small landscape areas of 5.6 acres, 68.7% of forest pixels are at least 90% surrounded by other forestland, but in larger areas of 13,132 acres, the percentage drops to 24.2%. The percentage of forest pixels surrounded by a fully forested landscape drops from 56.5% in the smallest areas (5.6 acres) to 9.9% in areas of 162 acres, and to zero for large, 13,132-acre areas. Forestland in the eastern U.S. is slightly less fragmented than forestland in the western U.S. (USDA, 2004).

Indicator Limitations

- The dataset uses the NLCD, which is based on an inventory of land cover circa 1992. No trends over time can be established, and the satellite imagery is more than a decade old.
- NLCD data do not include land cover classes for Hawaii or Alaska, which accounts for about one out of every six acres of forestland in the United States
- Not every non-forest NLCD land cover class was aggregated as “non-forest.” In this analysis, the “other” NLCD classes (water, ice/snow, bare ground) were treated as missing values and were not considered a reflection of forest fragmentation. Together, this “missing” class covers about 60 million acres.
- Because the non-forest land cover classes were aggregated, the contributions of specific types of non-forest land cover to forest fragmentation cannot be calculated, making it difficult to distinguish between natural and anthropogenic fragmentation.
- Fragmentation by roads was only partly captured by basing the analysis on the NCLD maps, which show some roads but not all. Not including road maps probably underestimates fragmentation on most public forestlands (Riiters et al., 2004).

Data Sources

Riitters, K.H. 2003. Report of The United States on the Criteria and Indicators for the Sustainable Management of Temperate and Boreal Forests, Criterion 1: Conservation of Biological Diversity, Indicator 5: Fragmentation of Forest Types. Final Report. February 1, 2003.

References

Fahrig, L. 2003. Effects of habitat fragmentation on biodiversity. *Annu. Rev. Ecol. Evol. Syst.* 34: 487–515.

Riitters, K.H., Wickham, J.D., O'Neill, R.V., Jones, K.B., Smith, E.R., Coulston, J.W., Wade, T.G., Smith, J.H. 2002. Fragmentation of Continental United States Forests. *Ecosystems* 5:815-822. http://www.srs.fs.usda.gov/pubs/ja/ja_riitters002.pdf.

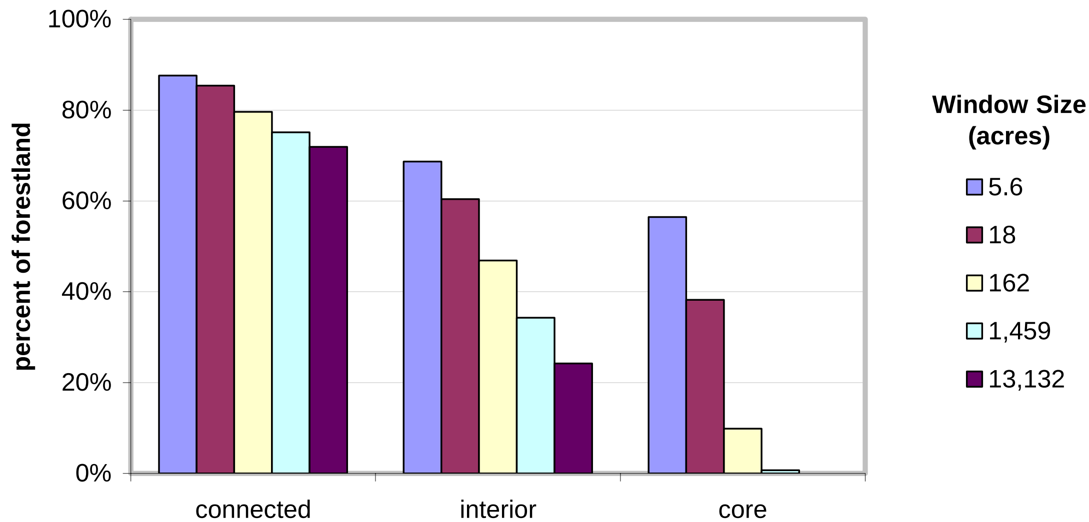
Riitters, K., Wickham, J., and Coulston, J. 2004. Use of road maps in national assessments of forest fragmentation in the United States. *Ecology and Society* 9(2):13. http://www.ecologyandsociety.org/vol9/iss2/art13/.

The H. John Heinz III Center for Science, Economics, and the Environment. 2002. The State of the Nation’s Ecosystems: Measuring the Lands, Waters, and Living Resources of the United States. New York, NY: Cambridge University Press, September 2002. Forest Fragmentation and Pattern Indicator: http://www.heinzctr.org/ecosystems/forest/frgmnt.shtml.

USDA Forest Service. 2004. National Report on Sustainable Forests—2003. FS-766. http://www.fs.fed.us/research/sustain/.

Graphics

Figure 110-1. Patterns of Forest Fragmentation, 1992



<< more fragmented **less fragmented >>**

connected = surrounded by at least 60% forestland
interior = surrounded by at least 90% forestland
core = surrounded by 100% forestland

R.O.E. Indicator QA/QC

Data Set Name: FOREST PATTERN AND FRAGMENTATION
Indicator Number: 110 (89604)
Data Set Source: Riitters, K.H., Wickham, J.D., O'Neill, R.V., Jones, K.B.,
Data Collection Date: Based on 1992 NLCD
Data Collection Frequency: NA
Data Set Description: Examines status and trends of forest fragmentation
Primary ROE Question: What are the trends in the extent and distribution of the Nation's ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The indicator is based on an aggregate forest land cover class derived from NLCD land cover classes, which provide the only synoptic classification of land cover in the conterminous United States. Each pixel of forest land cover is assessed for degree of fragmentation within five landscape (window) areas, based on the amount of forest and non-forest land within a specific surrounding area. Units of measurement are the percent of forested landscape (within a specific landscape area of the subject forest pixel). Uncertainty measurements are not available at a national level. The methodology is best described in the following article: Riitters, K.H., Wickham, J.D., O'Neill, R.V., Jones, K.B., Smith, E.R., Coulston, J.W., Wade, T.G., Smith, J.H. 2002. Fragmentation of Continental United States Forests. Ecosystems. 5:815-822. http://www.srs.fs.usda.gov/pubs/ja/ja_riitters002.pdf.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. NLCD data has gone through extensive peer review and QA/QC. The methodology used by the researchers to assess forest fragmentation re-analyzes NLCD data, and assesses degree of forest fragmentation based on an aggregate forest land cover class.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The development of the authors' fragmentation index allows for the inclusion of both the specific forest pixel and the surrounding landscape in calculating the degree of forest fragmentation. Fragmentation is thus viewed as a property of the landscape that contains the forest, in contrast to a view of fragmentation as a property of the forest itself. From this model, the data are able to show that forest is generally connected over large regions, but that fragmentation is so pervasive that edge effects influence ecological processes on most forested lands.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Analysis of the sampling design and monitoring plan for NLCD data are included in the Land Cover (324) indicator metadata form. Aggregating NLCD forest cover classes into one forest cover class allows for analysis of forest fragmentation caused by non-forest classes of land cover. NLCD data provides 30 meter resolution, allowing for accurate classification of forest and non-forest cover. The indicator was included in the Ecological Condition Chapter of the 2003 Report on the Environment http://www.epa.gov/indicators/roe/pdf/tdEco5-2.pdf.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems? The database is based on a synoptic coverage of the U.S. and represents an aggregation of various forest classes. Sensitive populations and ecosystems are not specifically identified.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

The study authors developed a fragmentation index for each of five specific landscape sizes. "Core" signifies that 100% of the surrounding landscape area consists of forest land; that is, forest fragmentation does not exist. "Interior" and "connected" correspond to 90% and 60%, respectively, of surrounding landscape area being forested.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The analytical procedures are described in Riitters, K.H., Wickham, J.D., O'Neill, R.V., Jones, K.B., Smith, E.R., Coulston, J.W., Wade, T.G., Smith, J.H. 2002. Fragmentation of Continental United States Forests. Ecosystems. 5:815-822. http://www.srs.fs.usda.gov/pubs/ja/ja_riitters002.pdf.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The complete data set and metadata for the fragmentation model are available: see Riitters, K.H. 2003. Report of The United States on the Criteria and Indicators for the Sustainable Management of Temperate and Boreal Forests, Criterion 1: Conservation of Biological Diversity, Indicator 5: Fragmentation of Forest Types. Final Report. February 1, 2003. Related reports are available at http://www.srs.fs.usda.gov/pubs/ja/ja_riitters002.pdf (by Kurt Riitters, the author of the main study on which this indicator is based) and http://www.heinzctr.org/ecosystems/forest/frgmnt.shtml (by the Heinz Center).

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. The model used to quantify forest fragmentation as described is clear enough to allow for replication. NLCD data, broken down by class, are available to the public.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

QA/QC of NLCD data is extensive and well documented (http://landcover.usgs.gov/accuracy/index.asp). Descriptions of the QA/QC for the analytical procedures employed in developing the forest fragmentation are not readily available.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

As the fragmentation model is based on forest land cover classes from the NLCD, a one-time inventory (and not sample) of land cover in the conterminous United States, generalization via statistical methods is unnecessary and unfeasible.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

For the eastern seaboard, the forest versus non-forest classification accuracy of the NLCD is 86% (based on commission error) and 94% (based on omission error). Estimates for other regions are currently being developed. Yang L, Stehman SV, Smith JH, Wickham JD. 2001. Thematic accuracy of MRLC land cover for the eastern United States. Remote Sensing Environment, 76:418-22.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No. NLCD satellite imagery permits a consistent assessment of forest fragmentation for the conterminous United States at unprecedented spatial resolution. The accuracy of NLCD forest classification suggests that forestland can be accurately determined from satellite imagery, and analyzed within a larger landscape area.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Alaska accounts for about one out of every six acres of forestland in the United States according to the Forest Inventory Analysis, so the inability to assess forest fragmentation in Alaska detracts from the ability to provide a national picture. It is important to clarify that this indicator does not apply to Alaska. In developing the fragmentation model, the authors chose to exclude the water and bare rock NLCD land cover classes for their aggregate non-forest land cover class (they were treated as missing values), so these were not included when calculating forest fragmentation. The reasons for this were not entirely explained.

Indicator: Land Cover Change in the Puget Sound Basin (250R)

Changes in land use and land cover can alter the basic functioning and resilience of local ecosystems, such as small watersheds, and larger ecosystems, such as the drainage basin of Puget Sound. Ecoregions denote areas of general similarity in ecosystems and in the type, quality and quantity of environmental resources (Omernik, 1987). The Puget Sound river valley low-lands, Cascade Mountain range, and Olympic Mountain range are examples of notable ecoregions in northwestern Washington. At more local scales, changes in land use and land cover can alter the basic physical, chemical, and biological processes associated with watersheds (NWP, 1995; Thom and Borde, 1998). While local impacts to a landscape may appear to be insignificant, their combined impacts on watersheds can have substantial effects on water quality, species composition, and flood buffering (PSAT, 2002; 2004). Such impacts are often referred to as 'cumulative effects.' Forest and urban land cover are two of the most important factors affecting the condition of watersheds in the Puget Sound Basin over a wide range of spatial scales (Alberti and Marzluff, 2004; Alberti, 2005).

This indicator compares changes in three metrics between 1995 and 2000 for the U.S. portion of the basin and between 1992-1999 for the Canadian side of the basin. It represents the change in the sum of all patches of urban, forested, or agricultural patches divided by total landscape area in the given watersheds. The underlying data are derived from four assembled USGS Landsat scenes covering the US portion of the Puget Sound Basin and from a combined scene covering the Canadian land area. The land cover data for all USGS 6th field watersheds in the basin was produced from NOAA C-CAP data and from Canadian BTM data. The USGS Hydrolgic Units (HUCs) and Canadian watershed groupings provide topographically delineated watersheds which are aggregated, or rather 'nested', into larger sub-basin and basin units.

What the Data Show

Little or no change in forest cover was observed in 2,068 watersheds in the Puget Sound and Georgia Basin between 1995 and 2000 for the U.S. side of the basin and between 1992 and 1999 for the Canadian side of the basin (Figure 250R-1). However, 279 watersheds saw at least 2.5% of their total area converted from forest cover to some other classification. More concentrated and rapid forest conversion occurred in coastal and mid-elevation watersheds, where there are more extensive private forest lands. At somewhat higher elevations, however, another group of 205 of watersheds showed a net increase in forest cover, as young stands have re-grown into more mature forest cover classes. The watersheds gaining forest cover were mostly in areas containing higher proportions of forest land under public ownership, occurring mostly at the higher elevations along the slopes of the Cascade Mountains and Olympic Mountains. A similar pattern is observed for the northern, British Columbia side of the basin, where the higher elevation watersheds along the eastern portion of the basin generally gained mature forest cover while the coastal watersheds along the south-eastern side of Vancouver Island showed more concentrated loss of forest cover.

While little or no change in urban land cover occurred in 2,329 watersheds of the basin, there was an increase in urbanization across many low elevation watersheds and shoreline areas, with 158 watersheds gaining urban area between 0.7% to 2% of the total area of their watershed within the indicator timeframe and another 58 watersheds showing increases between 2% and 19%. Unlike the Canadian side of the basin, which shows more concentrated patterns of urbanization, urbanization is more widely distributed across watersheds in the U.S. side of the Basin. Once watersheds have developed roughly 10% of their drainage area into an impervious or paved condition, there is a high potential for physical, chemical, and biological impairments to both water quality conditions and other aquatic resources (NWP, 1995; McMurray and Bailey eds., 1998). Current assessments are finding that relatively large numbers of Puget Sound watersheds are nearing or exceeding this level of development (Alberti et al., in preparation).

Agricultural lands showed little change in 2,632 watersheds in the basin, but 26 watersheds indicated a loss of agricultural land of as much as 1% of the watershed area within the indicator timeframe. The loss of agricultural land in these watersheds was mostly due to a conversion to urban land cover. In the same period, 67 watersheds gained agricultural land, of which 65 were in British Columbia and were associated with the inclusion of a mixed residential and small-scale agricultural category. This increase in agricultural and urban land cover generally results from conversion of forest land. In the U.S. portion of the basin, forest land appears to be converted more directly from forest to urban cover without any increase in agricultural land.

Indicator Limitations

- While the U.S. C-CAP data and the Canadian BTM data have similar and overlapping time periods, as currently presented, the U.S. data reflect change between 1995 and 2000 and the Canadian data reflect change between 1992 and 1999. The data are currently being normalized to an annual rate of change.

- The size of the data pixels and the minimum mapping unit size affects the classification of certain features such as narrow riparian corridors, and can affect the percentges in the indicators.

Data Sources

1995-2000 C-CAP trend assessment: Chris Davis or Matt Stevenson w/ CommEnSpace. http://www.commenspace.org (206)749-0112
2002 Landsat status assessment: Marina Alberti, Urban Ecology Research Lab, Department of Urban Planning, University of Washington. malberti@u.washington.edu (206) 685-9597

Links for this indicator and the supporting data layers will be available through the Region 10 website later this spring. Please contact Michael Rylko. Rylko.michael@epa.gov.

References

Alberti, M. 2005. The Effects of Urban Patterns on Ecosystem Function. *International Regional Science Review*. Forthcoming.

Alberti, M. and J. Marzluff. 2004. Resilience in Urban Ecosystems: Linking Urban Patterns to Human and Ecological Functions. Urban Ecosystems 7:241-265.

Alberti, M. et al. 2004. Urban Land-Cover Change Analysis in Central Puget Sound. Photogrammatic Engineering & Remote Sensing Vol. 70, No. 9 pp. 1043-1052.

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Omernik, J.M. 1987. Level III and IV Ecoregions for the Continental US, Annals of the Association of American Geographers, v. 77, no. 1, pp. 118-125.

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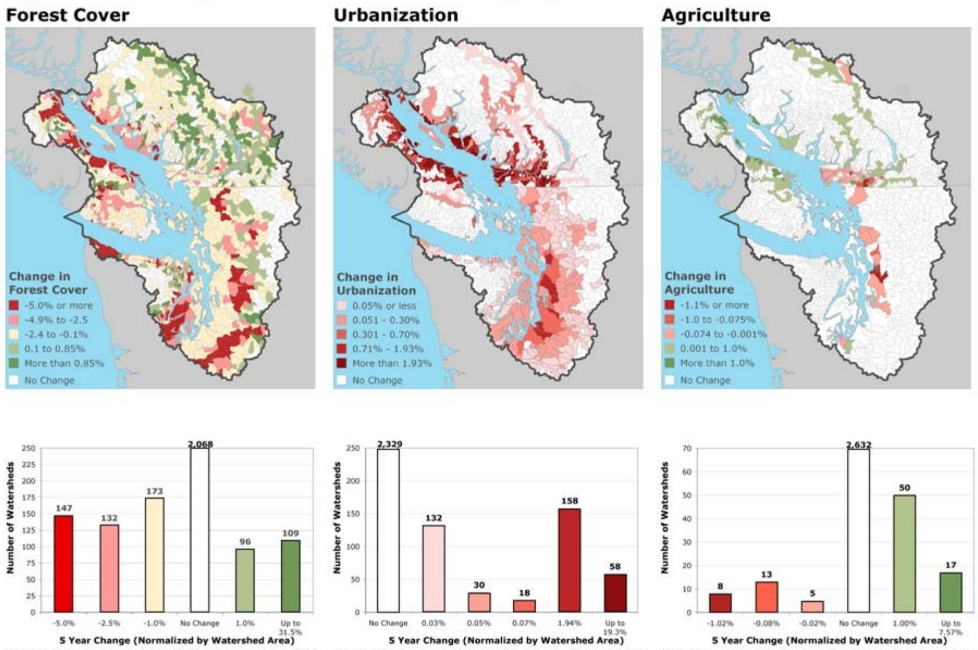
Puget Sound Action Team. 2004. State of the Sound. Report to the Washington State Legislature. Olympia, WA

Puget Sound Georgia Basin (PSGB) Transboundary Indicator Indicator Working Group. 2002. Georgia Basin-Puget Sound Ecosystem Indicators Report. Washington State Department Of Ecology Publication Number 02-01-002.

Graphics

Figure 250-1: Puget Sound Land Cover Change by Watershed



Forest cover is comprised of three C-CAP classes and two BTM classes. The C-CAP classes are Coniferous Forest, Deciduous Forest, and Mixed Forest. The BTM classes are Young Forest and Old Forest. For the C-CAP data, total forest area for 1995 was subtracted from total forest area for 2000, and BTM data is a single data source containing change classes for 1992 - 1999. For both data sets the result is expressed as the percentage of the total area of each watershed. Across the entire basin, little or no change occurred in 2,068 watersheds, 279 watersheds lost 2.5% or more forest cover, and 205 watersheds gained forest cover over the respective change periods.

Urbanization is comprised of the High Intensity Developed and Low Intensity Developed C-CAP classes and a single Urban BTM class. Little or no change occurred in 2,329 watersheds, 48 watersheds saw an increase in urbanization between 0.05% and 0.70%, and 216 watersheds gained urbanization equivalent to as much as 19.3% of their total area (Bowen Island, in British Columbia's Howe Sound).

Very few watersheds in the Puget Sound/Georgia Basin contain land cover classified as Cultivated in the C-CAP or BTM data. The BTM data contains a Agriculture class and a secondary class called Residential Agriculture Mixtures, which has no equivalent in the C-CAP data. No change in the extent of agricultural land occurred in 2,632 watersheds, 26 watersheds lost agricultural land, and 67 watersheds gained agricultural land. Sixty-five of the watersheds that gained agriculture are located in British Columbia, and the gain is due largely to the inclusion of the mixed agriculture/residential class.

March 16, 2005
Cartography by
CommEn Space
www.commenspace.org

R.O.E. Indicator QA/QC

Data Set Name: LAND COVER CHANGE IN THE PUGET SOUND BASIN
Indicator Number: 250R (114764)
Data Set Source: CCAP and Landsat Satellite Data
Data Collection Date: CCAP 1995 and 2000; Landsat 2002.
Data Collection Frequency: irregular
Data Set Description: Urbanization of Puget Sound Watersheds
Primary ROE Question: What are the trends in the extent and distribution of the Nation's ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The proposed landscape indicator metrics have been shown to represent important conditions and stressors to the physical integrity of both terrestrial and aquatic ecosystems, including watersheds at a range of spatial scales. The proposed metrics are valuable indicators for assessing the condition of local ecosystems and corresponding resources including water quality, flow, habitats, and utilization of water and fisheries resources. The proposed metrics are also responsive to time series analysis. Alberti, M. and J. Marzluff. 2004. Resilience in Urban Ecosystems: Linking Urban Patterns to Human and Ecological Functions. Urban Ecosystems 7:241-265.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. A limited time series for all of the watersheds within the basin has been produced from NOAA C-CAP remotely sensed data and analyzed by USGS 5th field watershed units. This trend analysis will only use a general and commonly used land cover classification that includes 4 major cover clasess (i.e. urban, forest, agriculture, and bare ground). When normalized as a percent of similarly classed lands within the respective watershed units, this will provide a reasonable basis for generalized trends in land-cover change for the period from 1995 to 2000. The Land Cover Status for the Puget Sound Basin for 2002 is comprised of four assembled USGS Landsat scenes covering the US portion of the Puget Sound Basin. This assembled coverage has been classified using a more discriminating methodology that enables assessment of both composition and configuration metrics and yet is still compatible with more generalized, hierarchical land cover classification schemes (including those used in the 1995-2000 C-CAP general trends in land cover assessment). This makes it quite useful and well suited for more refined trend monitoring of land cover changes. Watershed Analysis Units (WAUs) and USGS Hydrolgic Unit Codes (HUCs) are both topographically delineated watersheds, useful for studying environmental concerns. Reference: Alberti, M., Weeks, R., and S. Coe. 2004. Urban Land Cover Change Analysis for the Central Puget Sound: 1991-1999. Journal of Photogrammetry and Remote Sensing 70:1043-1052.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Changes in land use and land cover can alter the basic physical, chemical, and biological processes associated with ecosystems (NWP, 1995; Thom and Borde, 1998; Alberti and Marzluff, 2004). Metrics that serve as indicators of landscape patterns aim to measure two major characteristics of the landscape: land cover composition and spatial configuration. Landscape composition refers to the presence and amount of different patch types within the landscape without explicitly describing its relative spatial features. The composition metrics proposed include percent land cover by each land cover class - reflecting what percentage of the study area is covered by a given land cover type. Percentage of landscape cover quantifies the proportional abundance of each land cover type in the defined landscape. It is a measure of landscape composition which is important in many ecological applications. The two compostion metrics being reported are: Percent of Urban Land Cover is the percent of paved land and is calculated by the sum of the area of all paved patches divided by total landscape area. Percent of Forest Cover is the percent of forest land cover and is calculated by the sum of all patches of forested patches divided by total landscape area. Alberti, M. and J. Marzluff. 2004. Resilience in Urban Ecosystems: Linking Urban Patterns to Human and Ecological Functions. Urban Ecosystems 7:241-265. Northwest Environment Watch (NWEW). 2002. This Place on Earth: Measuring What Matters. Seattle WA Northwest Environment Watch (NWEW. 2004. Cascadia Scorecard: Seven Key Trends Shaping the Northwest. Seattle WA Northwest Forest Plan (NWP). 1995. Ecosystem Analysis at the Watershed Scale, Federal Guide for Watershed Analysis. USFS Regional Ecosystem Office, Portland, OR.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

There is a high level of correlation of the proposed indicator metrics to both the primary ROE question (trends in land use)and secondary ROE question (water quality stressors and conditions). Landsat and C-CAP data are collected on an ongoing basis, however, the utility of any particular scene is dependent on both duiurnal and seasonal variables (i.e. vegetation condition, whether conditrions, light conditions, etc...).

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The Puget Sound lowland ecoregion represents an ecosystem that is under significant stress with many habitats and species considered at-risk of local extirpations. Land development that results in significant changes to land cover has been shown to have extensive effects on watershed processes that maintain water quality, aquatic habitat, etc. Reference: Puget Sound Georgia Basin (PSGB) Transboundary Indicator Indicator Working Group. 2002. Georgia Basin-Puget Sound Ecosystem Indicators Report. Washington State Department Of Ecology Publication Number 02-01-002.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

In general terms, yes. Research has shown that once watersheds begin approaching or exceeding about 10% of their drainage area in an impervious or paved condition, there is a high potential for physical, chemical, and biological impairments to both water quality conditions and other aquatic resources. Realted research has shown that watersheds, particularly those along the west side ranges of the Pacific Northwest, require about 65% forest cover to retain the hydrological processes that minimize surface water runoff during storms and retain and infiltrate water into ground-water and summer base flows in local streams and rivers. References: G. McMurray and R. Bailey (eds.). 1998. Change in Pacific Northwest Coastal Ecosystems. NOAA, Coastal Ocean Office, WA D.C. T. Schueler and H. Holland (eds.) 2000. The Practice of Watershed Protection. Center for Watershed Protection, WA D.C.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Primary reference: Alberti, M. R. Weeks, and S. Coe. 2004. Urban Land-Cover Change Analysis in Central Puget Sound. Photogrammatic Engineering & Remote Sensing Vol. 70, No. 9 pp. 1043-1052. also see other publications and methodologies via: http://www.urbaneco.washington.edu/

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

At this point in time, the complete digital data sets are not available for general access. Data summaries (classified images), metadata, and analytical methodologies are currently available. The unclassified sattelite scenes are generally available. For 1995-2000 C-CAP trend assessment: Chris Davis or Matt Stevenson w/ CommEnSpace. http://www.commenspace.org (206)749-0112 For 2002 Landsat status assessment: Marina Alberti, Urban Ecology Research Lab, Department of Urban Planning, University of Washington. malberti@u.washington.edu (206) 685-9597

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. See, Alberti, M. R. Weeks, and S. Coe. 2004. Urban Land-Cover Change Analysis in Central Puget Sound. Photogrammatic Engineering & Remote Sensing Vol. 70, No. 9 pp. 1043-1052. also see other publications and methodologies via: http://www.urbaneco.washington.edu/

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The principle and co-investigators for this research and resulting methods have many related publications in this field which are broadly available. Primary reference: Alberti, M. R. Weeks, and S. Coe. 2004. Urban Land-Cover Change Analysis in Central Puget Sound. Photogrammatic Engineering & Remote Sensing Vol. 70, No. 9 pp. 1043-1052. also see other publications and methodologies via: http://www.urbaneco.washington.edu/

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

N/A

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes, an accuracy assessment is available in: Alberti, M. R. Weeks, and S. Coe. 2004. Urban Land-Cover Change Analysis in Central Puget Sound. Photogrammatic Engineering & Remote Sensing Vol. 70, No. 9 pp. 1043-1052. also see other publications and methodologies via: http://www.urbaneco.washington.edu/

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No. The analysis is run for a very large number of sampled pixels. While error for a given pixel is certainly possible, the large number of pixels sampled and strong observed patterns provide a high level of credibility to the indicator.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

There are other metrics that provide useful indictors of landscape change. There are also other scales of analysis and assessment of these and other relevant metrics. The metrics presented have been selected for clarity and ease of presentation. Both the size of the data pixels and the minimum mapping unit affects the classification of certain features such as narrow riparian corridors.

Indicator: Relative Ecological Condition of Undeveloped Land in Region 5 (206R)

Ecological condition in EPA's Report on the Environment is approached using four questions broadly relating to landscape, biological diversity, ecological function, and the physical and chemical make up of the environment, but no attempt is made at the national level to capture ecological condition in a single index. In this indicator, the ecological condition of undeveloped land in EPA Region 5 (Illinois, Indiana, Michigan, Minnesota, Ohio and Wisconsin) is characterized based on an index derived from criteria representing diversity, self-sustainability, and the rarity of certain types of land cover, species, and higher taxa.

A spatially explicit model using ecological theory and geographic information system (GIS) technology was used to create twenty data layers of 300m x 300m cells from 1991-92 NLCD data to generate estimates of the three criteria:

- Ecological Diversity - the relative diversities of populations (species), communities, and ecosystems in any given location on the landscape
- Ecological Self-Sustainability - the potential for an ecosystem to persist for years without external management, and is negatively impacted by two factors: landscape fragmentation and the presence of chemical, physical, and biological stressors
- Rarity - the rarity of land cover, species, and higher taxa.

The model produces composite layers that are statistically independent. The composite score for a criterion is normalized from 1 to 100 so that each contributes equally to the final index, and all of the data layers are weighted equally. Summing the three composite scores results in a final score for each cell. Each undeveloped land cover cell in Region 5 thus is assigned a rating, potentially ranging between 0 and 300. The scores were divided into six categories based on inflections in the derivative of the change in ecosystem scores versus the number of cells. The three categories with the highest rankings (A, B, and C) correspond to approximately 0.1%, 1%, and 10% of the undeveloped area in the Region, respectively (see inset in Figure 206R-1). This analysis could be rerun for the entire US, although the cut points for the categories may vary from one area to the next.

What the Data Show

The majority of undeveloped land in Region 5 lies in along the northern forests of Minnesota, Wisconsin, and Michigan, along the large rivers in Ohio, Indiana, and Illinois (Figure 206R-1). The highest quality (A, B, and C) sites, however, occur in areas that are remote or already protected. As of the 1991 baseline, the total amount of undeveloped land in classes A, B, is approximately 3%, in classes C and D, approximately 68%, and in the poorest classes (E and F), 29% (Histogram, Figure 206R-1). When the 2001-02 NLCD data are available, this analysis can be rerun, and compared to the 1991 data using the same class cut points to detect changes in the amount and ecological quality of undeveloped land in the Region.

Indicator Limitations

- This is a relative comparison of the condition of the undeveloped land within Region 5. The analysis was ranked within ecoregions for some of the indicators in order to account for different geophysical, geochemical and climatic regions.
- An EPA Science Advisory Board review cautioned that the resolution and uncertainty of the results make comparing the ecosystem condition score of one individual cell (300m x 300m) with another inappropriate, but this is not the case for comparison between larger landscapes.

- The model will not be fully field validated to insure that modeled results are reflective of actual ecosystem condition until summer, 2005.
- The ability to track trends will be dependent on the comparability of the 2001 round of the NLCD with the 1991-2 MRLC data used to develop this indicator.

Data Sources

An appendix containing spatial representations of the indicator layers are available at:
http://www.epa.gov/region5/osea/science/CrEAM_appendices.pdf

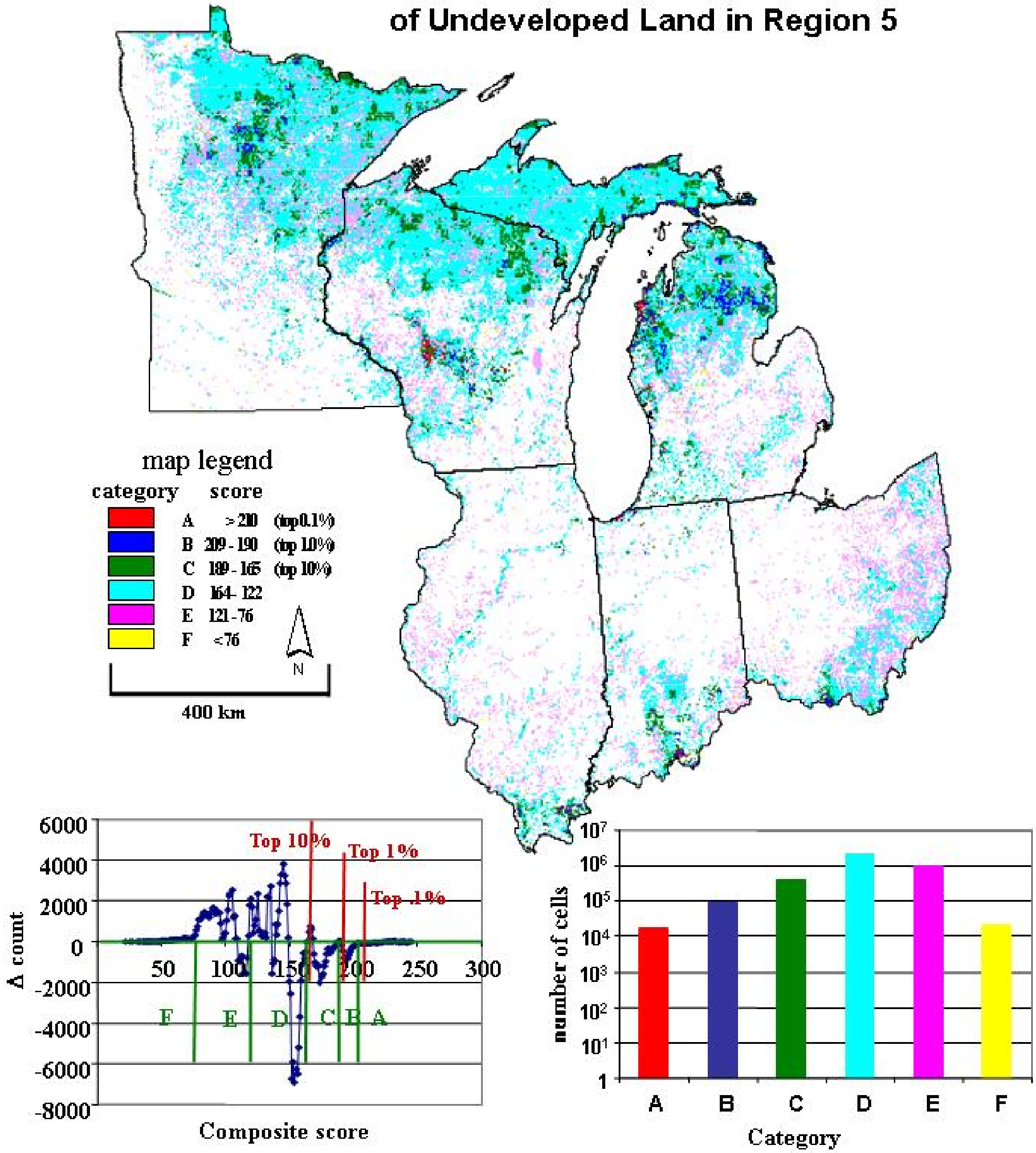
The metadata for the data used to generate each indicator is available at:
http://www.epa.gov/region5/osea/science/CrEAMMeta.htm

The text explaining the analysis is available at:
http://www.epa.gov/region5/osea/science/CrEAM_text.htm

and the DRAFT Science Advisory Board review of the model and data is available at:
http://www.epa.gov/sab/pdf/cream_report_12_14_04.pdf

Graphics

Figure 206R-1: Relative Ecological Condition of Undeveloped Land in Region 5



Plotting the first derivative of the frequency curve identifies six categories of ecosystem significance scores. The bins are delineated by green lines and letters (bottom), the top .1, 1 and 10% of the total scores are delineated by red (top).

The study area (top) with composite scores categorized as shown (right). Bar chart shows the number of cells of each category present in 1992, an indicator that can be recalculated for subsequent years and compared to this baseline.

R.O.E. Indicator QA/QC

Data Set Name: RELATIVE ECOLOGICAL CONDITION OF UNDEVELOPED LAND
Indicator Number: 206R (89174)
Data Set Source: primary - National Land Cover Database; secondary - various public access sources
Data Collection Date: irregular: 1992 completed, 2000 in process
Data Collection Frequency: n/a
Data Set Description: Ecological Condition of Undeveloped Land in Region 5
Primary ROE Question: What are the trends in the critical physical and chemical attributes of the Nation's ecological systems?
Comment: The indicator gives a relative ranking of the ecosystem condition of the undeveloped lands in Region 5. The ranking is a composite of chemical, physical and biological properties.

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

The SAB review concluded that for the most part, the measurements are scientifically and technically valid. The draft review (located at http://www.epa.gov/sab/pdf/cream_report_12_14_04.pdf) suggests limits for the use of the indicator based on the quality of data and analysis available at this time. The text is available at: http://www.epa.gov/region5/osea/science/CrEAM_text.htm and the appendices are available at: http://www.epa.gov/region5/osea/science/CrEAM_appendices.pdf

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

The sampling design was to find already published data that was representative of the 1990-1992 time period and that was consistently collected over the six state region. The DRAFT review addresses data availability and is at: http://www.epa.gov/sab/pdf/cream_report_12_14_04.pdf

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The DRAFT review is available at: http://www.epa.gov/sab/pdf/cream_report_12_14_04.pdf. In general the reviewers concludes that the data layers do represent the best available data to indicate the ecological phenomenon. They recommend changes to some of them, and if/when the changes can be incorporated the ulitity of the results will able to be extended beyond their existing recommendations.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The ecosystem condition metric which is calculated by the GIS model can answer the question "what was the relative ecological condition of the undeveloped land in Region 5 in 1992?" If the metric is recalculated for the year 2000 data, it can be used to track trends in ecosystem condition between 1992 and 2000. The sample size and location were determined by the National Land Cover Data Base (NLCD) which has a pixel resolution of 30m. Computational limitations necessitated the aggregation (by majority) to a 300m cell size resulting in 3,634,183 cells of undeveloped land. Twenty GIS data layers were used to characterize relative ecological condition. Each data layer has it's own resolution which can be found in the metadata at: http://www.epa.gov/region5/osea/science/CrEAMMeta.htm

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

One of the three criteria for which a metric is calculated is ecosystem scale rarity.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

No, this is a relative comparison of the condition of the undeveloped land within Region 5. The analysis was ranked within ecoregions for some of the indicators in order to account for different geophysical, geochemical and climatic regions. It should be noted that the analysis could be rerun using the whole US because the data sets utilized are available nation wide.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

the text is available at: http://www.epa.gov/region5/osea/science/CrEAM_text.htm and the appendices are available at: http://www.epa.gov/region5/osea/science/CrEAM_appendices.pdf

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Most of the data is in the public domain. The rare and endangered species data which was provided to Region 5 EPA under a confidential business agreement cannot be given out in its original form. We are only allowed to disseminate the summary results. However, with the advent of EcoServ, this data can be obtained though other sources with less restrictions. Metadata files are available at http://www.epa.gov/region5/osea/science/CrEAMMeta.htm Contact Dr. Mary White white.mary@epa.gov 312-353-5878

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Methodology is documented in the report submitted to the Science Advisory Board. the text is available at: http://www.epa.gov/region5/osea/science/CrEAM_text.htm and the appendices are available at: http://www.epa.gov/region5/osea/science/CrEAM_appendices.pdf The methodology has been used to evaluate ecosystem condition for the state of Texas. Region 6 was a partner in this effort.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Methodology is documented in the report submitted to the Science Advisory Board. the text is available at: http://www.epa.gov/region5/osea/science/CrEAM_text.htm and the appendices are available at: http://www.epa.gov/region5/osea/science/CrEAM_appendices.pdf The methodology has been used to evaluate ecosystem condition for the state of Texas. Region 6 was a partner in this effort.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Best professional judgement validation has been conducted and the results are favorable. Field validation will take place in the summer of 2005 and statistical summaries of this work will be done then.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes, these are described in the Report to the Science Advisory Board.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

The sensitivity analysis shows that the criteria chosen and the data used to determine a metric for each criteria were robust and non duplicative. One model assumption that would change the results was that all factors were weighted evenly. We have discussed our reasons for this in the report, however if there were compelling evidence and rationale that this should be changed, the results would change.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

The Science Advisory Board review identified limitations in the model as it exists today. They are: results should not be used at the finest resolution (300m x 300m) but rather as a relative comparison between larger landscapes, the results should not be used for individual permitting and enforcement decisions, but rather as a priority determinations in workload allocation, awarding contracts, and ecosystem condition assessment.

Indicator: Bird Populations (340)

Bird populations are among the most visible and important biological components of ecosystems, and provide important ecological services including seed dispersal, plant pollination and pest control. Some birds migrate over entire continents, while others have more restricted ranges and habitats, but in all cases trends in bird populations and in the abundance of species integrate the influences of changes in landscape and habitat, the availability and quality of food, toxic chemicals, and climate. The North American Breeding Bird Survey (BBS) began in 1966 with approximately 600 surveys conducted in the U.S. and Canada east of the Mississippi River. Today there are approximately 3,700 active BBS routes across the continental U.S. and southern Canada (Sauer et al., 1997: http://www.mbr-pwrc.usgs.gov/bbs/genintro.html).

Trends have been computed for observed population sizes of 654 bird species for the period 1966-2003 (Sauer et al 2004 http://www.mbr-pwrc.usgs.gov/bbs/bbs.html). The Audubon Society, 2004, http://www.audubon.org/bird/stateofthebirds/ categorized each species according to its primary habitat: grassland, shrubland, woodland, urban, and water and wetlands. This indicator reflects the numbers of species for which adequate trend data exist in which population counts significantly increased or decreased between 1996 and 2003. "Significant" increases or decreases were defined for this study as those in which the observed populations on BBS routes increased or decreased by more than two-thirds between 1966 and 2003.

What the Data Show

The results point to dynamic changes in bird populations in all habitat types (Figure 340-1), although there were no consistent changes in direction.

- Of 47 grassland species, only 4% showed significant population increases and 40% showed significant decreases, and of 107 shrubland species, 11% showed significant increases, while 26% showed significant declines.

- Of 104 woodland species, 29% showed significant populations increases and 26% showed significant decreases, and of 45 primarily urban species, 38% showed significant population increases and 22% had significant decreases.

- Of 268 water and wetland bird species, 14% showed significant increases and 5% showed significant decreases.

Indicator Limitations

- The BBS produces an index of relative abundance rather than a complete count of breeding bird populations. The data analyses assume that fluctuations in these indices of abundance are representative of the population as a whole.

- The BBS data do not provide an explanation for the causes of population trends. To evaluate population changes over time, BBS indices from individual routes are combined to obtain regional and continental estimates of trends. Although some species have consistent trends throughout the history of the BBS, most do not. For example, populations of permanent resident and short-distance migrant species (birds wintering primarily in the U.S. and Canada) are adversely affected by periodic episodes of unusually harsh winter weather.

- Few species have consistent population trends across their entire ranges, so increases or decreases in this indicator may not reflect the situation across the entire range of the species.

Data Sources

The data sources for this indicator were The U.S. Geological Survey National Breeding Bird Survey (http://www.pwrc.usgs.gov/bbs/retrieval/menu.cfm, http://www.pwrc.usgs.gov/bbs/index.html).

References

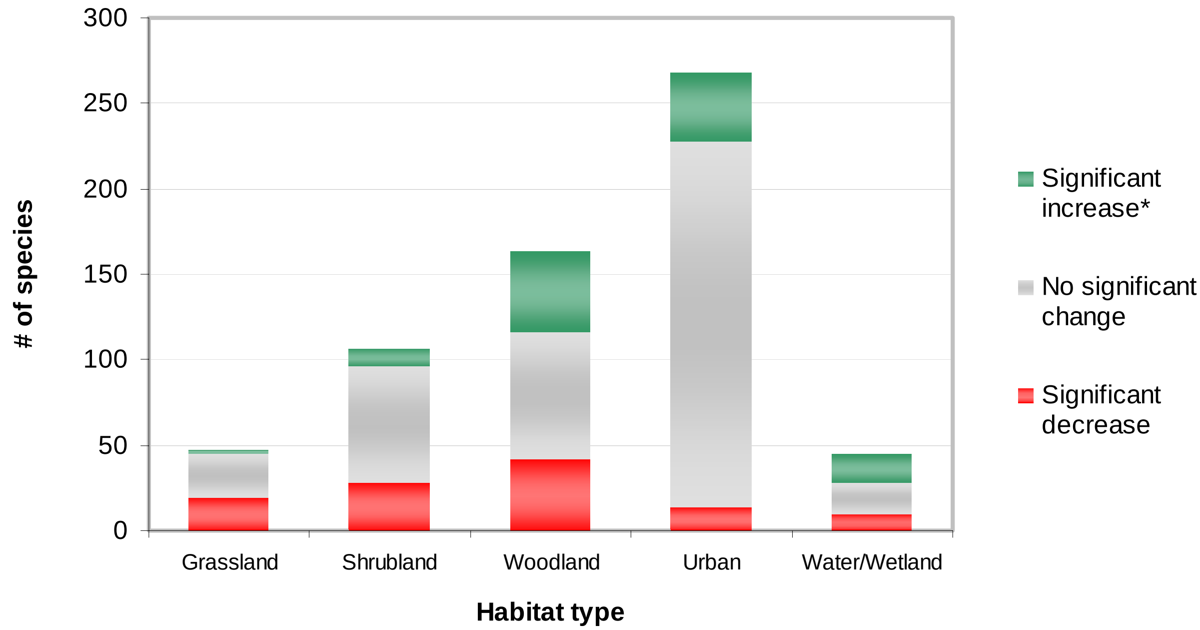
Audubon Society. 2004. State of the Birds USA 2004. *Audubon Magazine*. September-October 2004.

Sauer, J. R., J. E. Hines, G. Gough, I. Thomas, and B. G. Peterjohn. 1997. *The North American Breeding Bird Survey, Results and Analysis. Version 96.4. USGS Patuxent Wildlife Research Center, Laurel, MD.*

Sauer, J. R., J. E. Hines, and J. Fallon. 2004. *The North American Breeding Bird Survey, Results and Analysis 1966 - 2003. Version 2004.1. USGS Patuxent Wildlife Research Center, Laurel, MD.*

Graphics

Figure 340-1. Numbers of bird species with significant inreases, significant decreases, or no significant changes - 1966-2003



* “Significant” increases or decreases are those in which the observed populations on BBS routes increased or decreased by more than two-thirds between 1966 and 2003.

Changes in bird populations, 1966-2003

Source: Sauer, J. R., J. E. Hines, and J. Fallon. 2004. The North American Breeding Bird Survey, Results and Analysis 1966 - 2003. Version 2004.1. USGS Patuxent Wildlife Research Center, Laurel, MD.
Coverage: lower 48 states and southern portions of Canada

R.O.E. Indicator QA/QC

Data Set Name: BIRD POPULATIONS
Indicator Number: 340 (89685)
Data Set Source: U.S. Geological Survey Breeding Bird Survey (BBS)
Data Collection Date: regular: 1966 - 2003
Data Collection Frequency: 1yr.
Data Set Description: Bird Populations
Primary ROE Question: What are the trends in the diversity and biological balance of the Nation's ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. This indicator is based on the U.S. Geological Survey Breeding Bird Survey (BBS). The BBS is a long-term, large-scale, international avian monitoring program initiated in 1966 to track the status and trends of North American bird populations. Participants skilled in avian identification collect bird population data along roadside survey routes each year during the height of the avian breeding season (June for most of the U.S.). See http://www.mbr-pwrc.usgs.gov/bbs/genintro.html for details. (See T1Q3 for peer review results.)

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Each survey route is 24.5 miles long with stops at 0.5-mile intervals. At each stop, a 3-minute point count is conducted. During the count, every bird seen within a 0.25-mile radius or heard is recorded. Surveys start one-half hour before local sunrise and take about 5 hours to complete. Over 4100 survey routes are located across the continental U.S. and Canada. Trend estimates for more than 420 bird species and all raw data are currently available via the BBS web site. See http://www.mbr-pwrc.usgs.gov/bbs/genintro.html for details. (See T1Q3 for peer review results.)

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Trend estimates for more than 420 bird species and all raw data are currently available via the BBS web site. Analytical models for the trend data are presented by Sauer, J. R., J. E. Hines, and J. Fallon. 2004. The North American Breeding Bird Survey, Results and Analysis 1966 - 2003. Version 2004.1. USGS Patuxent Wildlife Research Center, Laurel, MD. In April 1999, a Review Panel was commissioned by the USGS Patuxent Wildlife Research Center to review the scientific and operational aspects of the U.S. Breeding Bird Survey (BBS). The Panel's report consisting of 31 recommendations was released in February 2000 and is presented at http://www.pwrc.usgs.gov/bbs/bbsreview/ in its entirety, along with the implementation plan addressing each of the recommendations. The Audubon Society, 2004, http://www.audubon.org/bird/stateofthebirds/ categorized each population according to its primary habitat: grassland, shrubland, woodland, urban, and water and wetlands. This indicator reflects the number of species whose populations significantly increased or decreased over that time period.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The relevant question asks about trends in the diversity and biological balance of ecosystems. Bird populations are an important component of biological diversity, and the design design of the BBS was deemed to be highly appropriate to tracking trends in bird populations by the BBS peer review: http://www.pwrc.usgs.gov/bbs/bbsreview/.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The indicator is not sensitive to bird populations with relatively low abundance, which may represent the most sensitive or threatened species.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator compares trends in relative abundances over the period of record, and does not identify any independent reference point relative to trends before this time or the extent to which the observed trends are natural or influenced by human alteration of the environment.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Analytical procedures for making bird counts along the BBS routes are documented on the BBS website at http://www.mbr-pwrc.usgs.gov/bbs/instruct.html. Sampling procedures (placement of routes) is described at http://www.mbr-pwrc.usgs.gov/bbs/genintro.html. Trend analyses are documented in: Geissler, P.H., and J.R. Sauer. 1990. Topics in route-regression analysis. Pp. 54-57 in J.R. Sauer and S. Droege (eds.) Survey designs and statistical methods for the estimation of avian population trends. U.S. Fish Wildl. Serv., Biol. Rep. 90(1). Link, W. A., and J. R. Sauer. 1994. Estimating equations - estimates of trend. Bird Populations 2:23-32.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Data for the BBS are readily available at http://www.pwrc.usgs.gov/bbs/retrieval/disclaim.cfm.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The survey design, along with maps of the BBS routes, is documented at http://www.mbr-pwrc.usgs.gov/bbs/genintro.html.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Data quality in the BBS is dependent on the volunteer observer force. BBS personnel take pains to provide detailed guidance to BBS personnel and to maintain a trained cadre of observers, but age (hearing loss necessary to distinguish calls), and youth of some observers can cause data problems. The BBS peer review recommended that the BBS publish, either via the Web or in the literature, an assessment for every species represented in the BBS database, indicating geographic, temporal, and other major limitations in sampling that affect quality or generality of trend estimates. All PWRC web sites presenting BBS results should indicate which species have had such limitations identified (preferably linking to the specific details) http://www.pwrc.usgs.gov/bbs/bbsreview/. See also Sauer, J. R., B. G. Peterjohn, and W. Link. 1994. Observer differences in the North American Breeding Bird Survey. The Auk 111: 50-62.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

The large number of BBS routes and geographic coverage suggest that for most of the species, trends noted in the indicator should be reasonably generalizable, but obviously cannot be extrapolated to species not observed on the routes. But see the limitations in T4Q4.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Uncertainties arise from a combination of differential coverage of BBS routes over time and space; efficiencies in sampling birds not sampled by the BBS, birds with a small sample-size, highly variable bird populations, or species with low relative abundance; and with statistical estimation of trends. These issues are discussed in detail at: http://www.mbr-pwrc.usgs.gov/bbs/introbbs.html.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Overall, 204 (41%) of the 504 species we analyzed for 25-year trends were in at least one of the categories listed in T4Q2 (small sample size, highly variable populations, or low relative abundances). The guild with the lowest proportion of species in the lists was urban species (8%), while hunted, wetland nesting, and waterfowl guilds had > 41% of their species in 1 of the 3 categories http://www.mbr-pwrc.usgs.gov/bbs/introbbs.html.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

All BBS analyses incorporate data only from BBS routes. Analysis of survey data cannot tell us the proportion of the individuals of a species that is breeding outside the range of the survey. Species that are recorded only on the margins of the surveyed area are often of low sample size or are highly variable, but many species (e.g., Canada Goose) may have substantial populations within the survey area. Trends are always specific to the areas surveyed. Roadside biases. The BBS is a roadside survey, and a major criticism of the survey has been that habitat changes along roadsides may not be representative of regional habitat changes. Trends from the BBS may therefore reflect only populations along roads rather than regional bird population changes. Within the range of the BBS, many habitats are not well covered, and species that populate those habitats are poorly sampled. Wetland birds and species occupying alpine tundra habitats are examples of groups thought to be poorly represented in the survey. Additional limitations described below are documented at http://www.mbr-pwrc.usgs.gov/bbs/introbbs.html, and are based on the following sources: Bystrak, D. 1981. The North American Breeding Bird Survey. Pp. 34-41 in C. J. Ralph and J. M. Scott, eds. Estimating numbers of terrestrial birds. Studies in Avian Biol. No. 6. Droege, S. 1990. The North American Breeding Bird Survey. Pp. 1-4 in J. R. Sauer and S. Droege, eds. Survey designs and statistical methods for the estimation of avian population trends. U.S. Fish Wildl. Serv. Biol. Rep. 90(1). The BBS produces an index of relative abundance rather than a complete count of breeding bird populations. The data analyses assume that fluctuations in these indices of abundance are representative of the population as a whole. The BBS data do not provide an explanation for the causes of population trends. To evaluate population changes over time, BBS indices from individual routes are combined to obtain regional and continental estimates of trends. Although some species have consistent trends throughout the history of the BBS, most do not. For example, populations of permanent resident and short-distance migrant (birds wintering primarily in the U.S. and Canada) species are adversely affected by periodic episodes of unusually harsh winter weather. Few species have consistent trends across their entire ranges, so geographic patterns in trends are of considerable interest to anyone concerned with the status of the continent's birds.

Indicator: Fish Faunal Intactness (128)

Intactness, the extent to which ecological communities have retained their historical composition, is a critical aspect of the biological balance of the Nation's ecological systems (NRC 2000). It is of particular importance in freshwater systems that are impacted by pollution, habitat alteration, fisheries management, and invasive species.

This indicator tracks the intactness of the native freshwater fish fauna in each of the nation's major watersheds by comparing the current faunal composition of those watersheds with their historical composition. Specifically, the indicator measures the reduction in native species diversity in each 6-digit USGS hydrologic cataloging unit (HUC) in the 48 conterminous states. Intactness is expressed as a percent based on the formula:

reduction in diversity = 1 – (# of current native species / # of historic native species).

The native species diversity indicator proposed by the NRC (NRC 2000) compared expected native species diversity with observed diversity, with the "expected" value projected from species-area-curve models. This "Fish Faunal Intactness" indicator makes use of empirical, rather than modeled data sets, and focuses on a well-known group of organisms with a fairly strong historical record.

The fish distributional data underlying this indicator were gathered by NatureServe, a non-profit research organization, and are derived from a number of sources, including species occurrence data from state natural heritage programs, a broad array of relevant scientific literature (e.g., fish faunas), and expert review in nearly every state. These data were assembled during the period 1997-2003. The underlying data include distributions for 782 native freshwater fish species across small watersheds (8-digit HUC). For this indicator, data were pooled and reported by larger 6-digit HUCs to reduce potential errors of omission in the smaller watersheds.

What the Data Show

Watersheds covering about one-fifth (21%) of land area in the conterminous United States are fully intact, retaining their entire complement of fish species (Figure 128-1). Watersheds covering nearly a quarter (24%) of land area, however, have lost 10% or more of their native fish fauna. Reductions in diversity are especially severe in the Southwest (e.g., the lower Colorado River watershed) and the Great Lakes, with eight major watersheds (representing 2% of total land area) having lost more than half of their native fish fauna.

Indicator Limitations

- The incomplete historical record for freshwater fish distributions and inconsistent inventory records for contemporary fish distributions are sources of uncertainty.
- Because the indicator is expressed as a ratio, it does not reflect the magnitude of species losses in a given watershed. The southeastern United States, for instance, is far richer in numbers of freshwater fish species by HUC than the southwestern United States. Although some southeastern HUCs have experienced significant losses in the absolute number of species (e.g., in the state of Mississippi), due to the large number of species overall, the fish fauna can still appear relatively intact when viewed on a percentage rather than numeric basis.
- Although NatureServe has attempted to compile the most complete distributional information possible for these species at the 8-digit HUC level, these data are dynamic: new records frequently are added and existing records are revised as new information is received and as

taxonomic changes occur. Consequently, these distributional data could benefit from additional quality control, updating, and expert review.

- The period of record currently is too short to track trends in fish faunal intactness, but this indicator provides a sound baseline for the period 1997-2003.

Data Sources

The identity and status (current vs. historical) of all native fish species recorded in each 8-digit HUC are available at: http://www.natureserve.org/getData/dataSets/watershedHucs/index.jsp. Species-by-species distribution maps at the 8-digit HUC level are available on the NatureServe Explorer website (www.natureserve.org/explorer). Analyses based on these data have previously been reported in Master et al. (1998), Master et al. (2003), and Stein et al. (2000).

References

Master, L.L, S.R. Flack, and B.A. Stein. 1998. "Rivers of Life: Critical Watershed for Protecting Freshwater Biodiversity." The Nature Conservancy, Arlington, VA. Summary available at http://www.natureserve.org/publications/riversOflife.jsp.

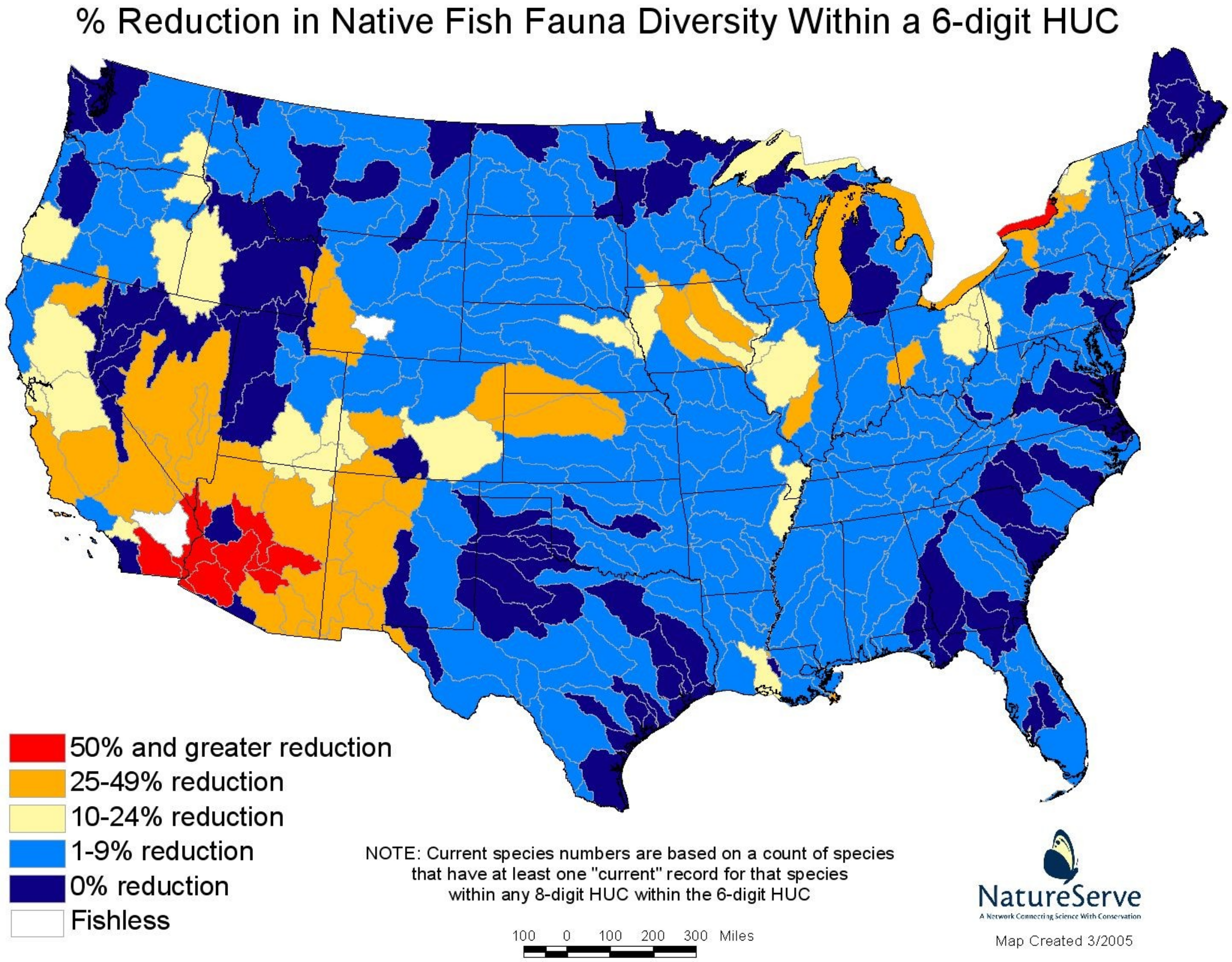
Master, L., A. Olivero, P. Hernandez, and M. Anderson. 2003. Using small watershed fish, mussel, and crayfish historical and current presence data to describe aquatic biogeography and inform its conservation. Abstract # PO67. Society for Conservation Biology Annual Meeting, Duluth, Minnesota. Abstract available at http://www.d.umn.edu/ce/conferences/scb2003/poster.htm.

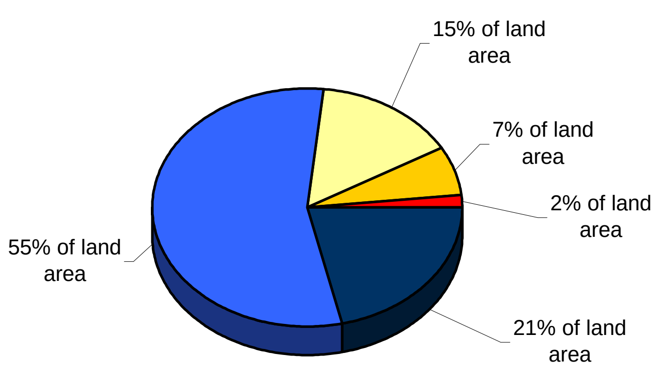
National Research Council (2000). "Ecological Indicators for the Nation". National Academy Press, Washington, DC. Full text available at http://www.nap.edu/openbook/0309068452/html/.

Stein, B.A., L.S. Kutner, and J.S. Adams. 2000. "Precious Heritage: The Status of Biodiversity in the United States". Oxford University Press, New York. Summary available at http://www.natureserve.org/publications/preciousHeritage.jsp.

Graphics

Figure 128-1.





R.O.E. Indicator QA/QC

Data Set Name: FISH FAUNAL INTACTNESS
Indicator Number: 128 (116468)
Data Set Source:
Data Collection Date:
Data Collection Frequency:
Data Set Description: Fish Faunal Intactness (NatureServe)
Primary ROE Question: What are the trends in the diversity and biological balance of the Nation's ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The methods make use of well-established techniques for documenting species distributions. These distribution data focus on the current and historic distributions by small watershed (USGS 8-digit hydrologic cataloging unit) of all native freshwater fishes of the United States, exclusive of Alaska and Hawaii. These data derive in part from precise locational data (element occurrences) compiled by state natural heritage programs for vulnerable or imperiled fish species. Standards and protocols for documenting and mapping element occurrences are described in Stein et al. (2000) and available at: http://www.natureserve.org/prodServices/eodata.jsp. These natural heritage locational data were supplemented with information from the scientific literature and from individual species experts. State and regional experts then reviewed the data to refine the small-watershed distribution for these species. Current and historical species distributions were mapped using a geographic information system, and resulting 8-digit HUC range maps for each of the 782 native freshwater fish species are available at http://www.natureserve.org/explorer. These data are also summarized for each of the 2,064 8-digit HUCs in the conterminous US at: http://www.natureserve.org/getData/dataSets/watershedHucs/index.jsp. Distributional data at the 8-digit HUC level were then pooled by 6-digit HUC and the number of native species calculated. These data were compiled over a six year period, from 1997 to 2003. Results based on these data have been presented in Master et al. 1998. “Rivers of Life: Critical Watershed for Protecting Freshwater Biodiversity” (http://www.natureserve.org/publications/riversOflife.jsp). The Nature Conservancy, Arlington, VA., Master et al. 2003, . Using small watershed fish, mussel, and crayfish historical and current presence data to describe aquatic biogeography and inform its conservation (http://www.d.umn.edu/ce/conferences/scb2003/poster.htm). Abstract No. PO67, Society for Conservation Biology Annual Meeting, Duluth Minnesota, and Stein et al. 2000. Stein, B.A., L.S. Kutner, and J.S. Adams. 2000. “Precious Heritage: The Status of Biodiversity in the United States” (http://www.natureserve.org/publications/preciousHeritage.jsp). Oxford University Press, New York.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. These data are derived from the existing scientific record of collections and observations, rather than through a de novo sampling and inventory program. The distributions of freshwater fishes are relatively well known, due to a combination of 1) extensive scientific inventory and collection efforts directed towards this faunal group, 2) widespread use of fishes in water quality sampling programs, and 3) the activities of both recreational and commercial fisheries. The indicator is designed to rely on presence data alone, and as such can accept validated data from any of these sources.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The conceptual model used for this indicator is based on a recommended indicator—Native Species Diversity—in the National Research Council (2000) report "Ecological Indicators for the Nation." It differs from that approach, however, in using empirical data (historical composition) rather than modeled data as a baseline for comparison. The indicator is also conceptually similar to an Index of Biotic Integrity, in which a known sample is compared with a reference condition (e.g., Karr et al. 1986. Karr, R. J., K.D. Fausch, P.L. Angermeier, P.R. Yant, and I.J. Schlosser. 1986. Assessment of biological integrity in running waters: A method and its rational. Illinois Natural History Survey special Publication No. 5. Illinois Natural History Survey, Champaign, IL). In this instance, the reference condition is the documented historic composition of the fish fauna, with the "sample" the current native species composition.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The indicator speaks directly to a central issue of relevance to the ROE, that is, what is the biological condition of the nation's ecosystems, and how are they changing? In this instance, the key change being measured is the degradation of faunal communities at a regional scale, as measured by reduction in native species diversity. Indeed, this is one of the few groups for which data is sufficiently robust to provide such a measure of faunal intactness.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Although this indicator tracks overall loss of diversity in major watersheds, many of the watershed-level species losses involve rare or endangered species. The indicator is particularly robust in its representation of sensitive populations because the underlying data draw from the most comprehensive database available on the known localities for rare and endangered species in the United States. Furthermore, the distributions of these species have been reviewed by state and regional experts, including natural heritage biologists, who represent some of the foremost authorities on the distribution of rare sensitive species and populations in their states.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

There are no established thresholds for what constitutes the desirable state of intactness for a major watershed. We use 10%, 25%, and 50% reductions as thresholds. The threshold for what constitutes "historical" occurrence was set at 1970 (i.e., 25 years), consistent with established NatureServe guidelines for assigning population viability assessment ranks ("EO Rank Specifications").

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Documentation for the underlying data set used in the calculation of this indicator is available at: http://www.natureserve.org/getData/dataSets/watershedHucs/index.jsp.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Data on the identity and status (current vs. historic) of fish species recorded for each of the 2,064 8-digit HUCs in the conterminous United States are available at: http://www.natureserve.org/getData/dataSets/watershedHucs/index.jsp. Distribution data for each of the 782 native US freshwater fish species included in the study is available on the NatureServe Explorer web site (www.natureserve.org/explorer).

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The description of the approach followed, which involved quality control by state and regional experts for state and regional subsets of the data, is described in Master et al. (1998). Each record for a fish species in an 8-digit HUC was documented in a database with the source of that record, permitting users of the data to check the sources of the information recorded. The development of this distributional database represents a best effort given the available resources and data at the time. Additional resources and research would undoubtedly uncover more data sources, which would likely yield additional database records.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

This indicator is based on direct calculation, and does not make use of statistical inference.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Incompleteness in the historical record for freshwater fish distributions and inconsistent inventory records for contemporary fish distributions are sources of uncertainty. There is no current means for measuring the level of such underlying uncertainties.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Uncertainties in the indicator relate to gaps in either inventory coverage or in database capture of available distributional records. Historical data are most likely to be subject to gaps in coverage, although the mechanism by which the indicator is calculated ameliorates this by including all contemporary and historical species in the denominator of the indicator formula. In other words, for this purpose, all contemporary species are also assumed to have been present historically. In certain circumstances (e.g., where an undocumented historical species has disappeared from a watershed) the resulting underestimate of historical distributions would have the effect of decreasing the baseline (denominator), and increasing the apparent intactness of the watershed. Conversely, there are undoubtedly instances in which a species continues to exist in a watershed, but has not been documented since 1970, or those reports were not captured in the creation of this dataset. This would have the effect of overstating apparent reductions in diversity. These potential errors, and their associated uncertainties, will be most significant at the 8-digit HUC level, which represents the geographic scale at which these distributional data were gathered. Pooling these distribution data by the 334 6-digit HUCs (vs. > 2,100 8-digit HUCs) and reporting out the indicator at that geographic level, has the effect of decreasing the potential impact of these uncertainties.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

This indicator provides information about the degree to which current fish faunas have changed relative to historical conditions, based on the analyzed data sources. As such, the indicator currently represents a baseline, which could be improved with analysis of additional data sources. Future updates of the underlying data would be required to document a continuation of the trends displayed.

Indicator: Nonindigenous Species as Ecological Stressors in the Estuaries of Oregon and Washington (249R)

Nonindiginous species (NIS) are one of the greatest threats to aquatic ecosystems and can significantly impact local and regional economies (Lowe et al., 2004). The number of invasive species in estuaries of Washington and Oregon (including Puget Sound, Columbia Estuary, Coos Bay) is rising, and these areas can then become as sources of invasives to other locales and outward along other transportation routes. Coastal waters are particularly vulnerable to NIS transported in ballast water and introduced via aquaculture (PS Update, 2002). It is becoming apparent that NIS are capable of significantly impacting estuaries along the west coast, even though they are rarely addressed in routine monitoring studies. One limitation is the lack of standardized invasion metrics.

This indicator focuses on estuarine soft-bottom communities of the Columbian Biogeographic Province located along the Pacific Coast from Cape Mendocino, CA north to the mouth of the Strait of Juan de Fuca, WA. It is limited to sites with salinities >= 5 parts per thousand. The indicator is based on the percent abundance of NIS individuals, relative to the combined abundance of native and NIS individuals in a benthic grab sample.

The data for this indicator were collected by the Environmental Monitoring and Assessment Program using a probability sample covering the period 1999-2001 and by a special study focusing on minimally exposed estuaries (Nelson et al., 2004; Nelson et al., in review). Probability sampling provides unbiased estimates of the percent abundance of NIS in all estuaries in the study area, but because the data for the special study have not yet been statistically expanded, data for this indicator is based on stations sampled rather than area.

Reference levels for the indicator are based on observations in estuaries with minimal exposure to invasion (ballast water discharges and aquaculture of exotic oysters) within the Columbia Biogeographic Province. Three levels of invasion were assigned to the indicator: “minimal” or “reference” when NIS constituted 0-10% of the individuals; “moderately invaded” when NIS constituted 10-50% of the individuals; and “highly invaded” when NIS were more abundant than the native species (>50% NIS).

What the Data Show

Approximately 15% of the stations in the Columbian Province were highly invaded (abundance of NIS > abundance of natives) and another 20% were moderately invaded (Figure 249-1). The study showed that nonindigenous species were among the most frequently occurring anthropogenic stressors in this biogeographic region when compared to indicators of sediment contamination or eutrophication (Nelson et al., 2004).

The extent of invasion was not uniform, however. Estuaries with greater exposure to shipping ballast water and aquaculture were more invaded: 44% of the stations in the estuaries exposed to these invasion vectors were moderately to highly invaded, compared to only 20% of the stations in estuaries with no or minimal exposure to these vectors (Figure 249-2). Nonetheless, the observation that 20% of the stations in these "pristine" estuaries were at least moderately invaded indicates that non-native species can disperse widely once they are introduced into a region, so even estuaries with no direct exposure to ballast water or aquaculture are at risk of invasion.

Indicator Limitations

- Studies in the San Francisco Estuary (Lee et al., 2003) and in Willapa Bay (Ferraro and Cole, in progress) have shown that the percent of NIS can vary substantially among communities., e.g. hard bottom versus sea grass beds. Reference points for Washington and Oregon estuaries as a whole may not be appropriate for specific community types.
- This indicator represents percent NIS in individual benthic grabs, but does not characterize the total number of NIS in the estuaries; it also does not include fish or other NIS not subject to benthic grab sampling.
- The invasion metrics are structural indicators; further research is needed to understand the relationship between these structural changes and impacts on ecosystem function.

Data Sources

EMAP Coastal Assessments 1999, 2000, 2001.
http://www.epa.gov/emap/html/pubs/docs/groupdocs/symposia/symp2004/Abstracts/Poster/lee.html

References

Lee II, Henry, B. Thompson, and S. Lowe. 2003. Estuarine and scalar patterns of invasion in the soft-bottom benthic communities of the San Francisco Estuary. Biological Invasions 5:85-102.

Lowe, S., Browne, M., Boudjelas, S., and M. De Poorter. November, 2004. 100 of the World's Worst Invasive Alien Species – A Selection from the Global Invasive Species Database. Published by the Invasive Species Specialist Group (ISSG) of the World Conservation Union (IUCN).

Nelson, W.G., H. Lee II, J.O. Lamberson, V. Engle, L. Harwell, and L.M. Smith. 2004. Condition of Estuaries of the Western United States for 1999: A Statistical Summary. EPA.620/R-04/200, U.S. Environmental Protection Agency, Washington DC.

Nelson, W.G., H. Lee II, and J. Lamberson. (in review). Condition of Estuaries of California for 1999: A Statistical Summary. U.S. EPA Report.

Puget Sound ActionTeam, 2002. Puget Sound Update; the Eighth Report of the Puget Sound Ambient Monitoring Program (PSAMP).

Graphics

Figure 249-1: Percent of Stations Falling into % NIS Abundance Classes - EMAP 1999

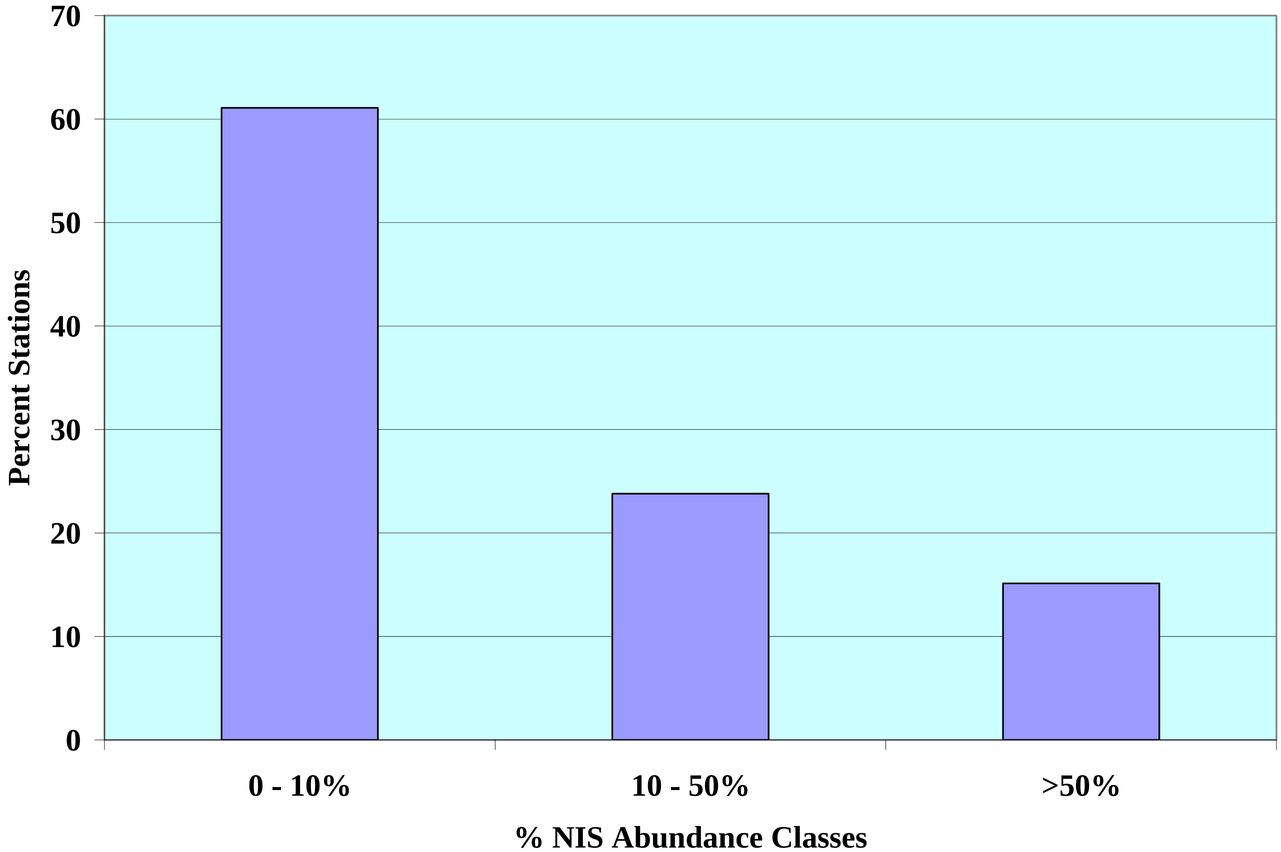
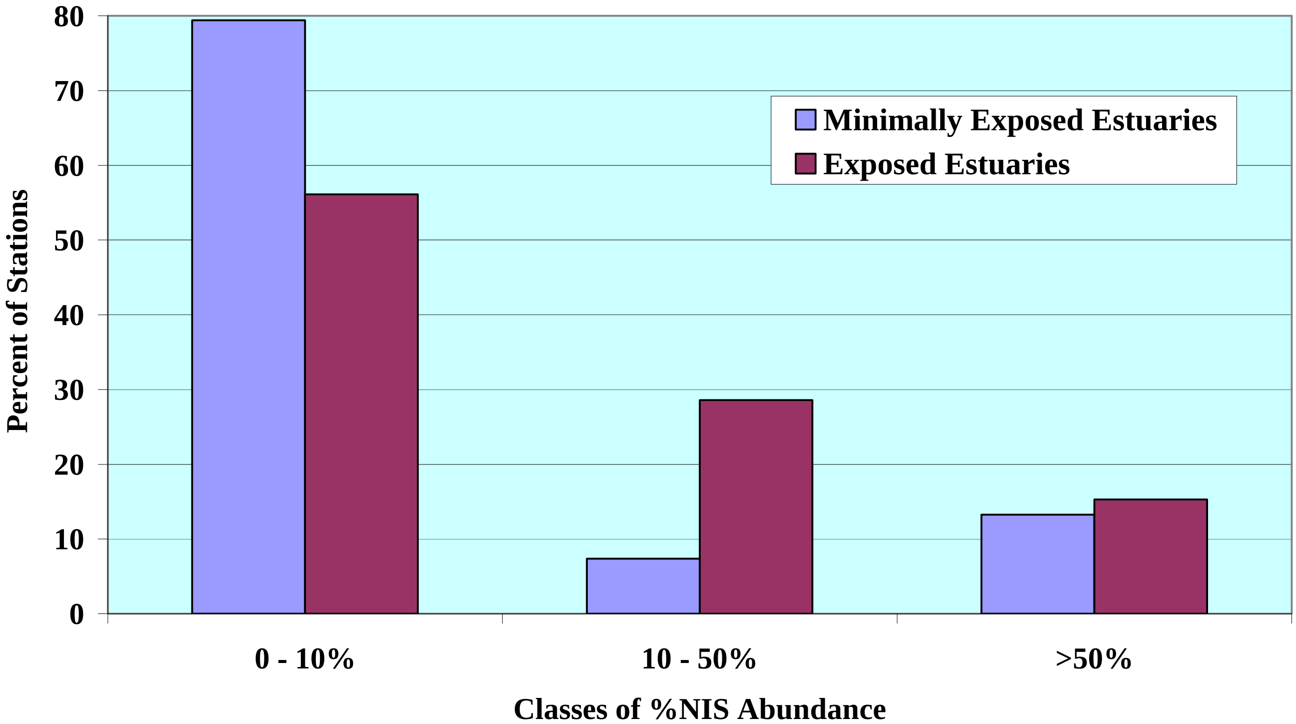


Figure 249-2: Benthic Index of Estuarine Nonindigenous Species (NIS): Percent of stations in Columbia Biogeographic Province falling into three levels of invasion based on the relative abundance of NIS for 'Minimally exposed" and "Exposed" estuaries.



R.O.E. Indicator QA/QC

Data Set Name: NON-INDIGENOUS SPECIES IN THE ESTUARIES OF OREGON AND WASHINGTON
Indicator Number: 249R (114765)
Data Set Source: Coastal Environmental Monitoring and Assessment Program (EMAP) data from estuaries of OR and WA.
Data Collection Date: 1999-2000,2002
Data Collection Frequency: 1/yr-1/2yr (irregular)
Data Set Description: Non-Indigenous Species in the Estuaries of Oregon and Washington as an Indicator of Ecological Stress.
Primary ROE Question: What are the trends in the diversity and biological balance of the Nation's ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. Standard EMAP protocols are used for sample collection, handling, and analysis, including standardized taxonomy for both the Washington and Oregon collections. These protocols are described in "U.S. EPA, 2001. National Coastal Assessment: Quality Assurance Project Plan 2001-2004. EPA/620/R-01/002" and "Nelson, et al., 2004. Condition of Estuaries of the Western United States for 1999: A Statistical Summary. EPA/620/R-04/200".

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. The data presented is from Washington, Oregon, and Northern California collected under the Environmental Monitoring and Assessment Program (EMAP). The purpose of EMAP is to estimate the current status and trends in the condition of nation's ecological resources. The coastal component of EMAP creates an integrated coastal monitoring program along the west coast by taking water column measurement in conjunction with information about sediment characteristics and chemistry, benthic organisms (including nonindigenous species or NIS), fish to describe the current estuarine condition. EMAP is designed in such a way to provide a valid estimate for the entire resource of interest, in this case the small estuaries of Oregon and Washington. The data are collected using the Coastal EMAP protocols developed by EPA's Office of Research and Development. The QA plan and protocol(U.S. EPA, 2001. National Coastal Assessment: Quality Assurance Project Plan 2001-2004. EPA/620/R-01/002) is available at http://www.epa.gov/emap/nca/html/docs/qaprojplan.html while a description of the Coastal EMAP project in Region 10 is available at http://www.epa.gov/r10earth/emap.htm.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The first cut at developing invasion metrics will be limited to those that can be derived from the benthic abundance/composition within individual benthic grabs (point scale). This is considered an exploratory effort, and other indices at this or additional spatial scales (e.g., entire estuaries) and with different target organisms (e.g., fishes) need to be evaluated in the future. The sites were selected using the EMAP probability design to represent that estuaries of Oregon and Washington with known levels of confidence.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

There are many stressors that influence the ecological condition of estuarine waters Non-indigenous species is one of theses stressors, but it is rarely addressed in state or regional monitoring studies. The ROE provides a methodical line of inquiry into the status, condition, and future trends for this non-indigenous species indicator. The examples of regional indicators allows the highlight of smaller scales - which is likely to have relevance to many audiences interested in the primary question of Ecological condition of estuaries regarding diversity and balance of species.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

While estuaries can themselves be considered sensitive ecosystems, the sampling sites were randomly selected using the EMAP probability design. The samples are intended to represent the estuaries of Oregon and Washington, with known levels of confidence. The relative percentage of stations sampled in small estuaries of Washington and Oregon found to contain various types of environmental stressors at levels of some significance is depicted in data figure 249-2. The indicators shown were selected due to their importance as strtessors on the health of estuaries which are generally recognized as sensitive and highly valued ecosystems.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

The most basic and unambiguous reference point for invasive species is their absence, which the invasive indices capture (Figure 249-2). However, invasion is not totally an "all-or-none" phenomenon as the extent of invasion can have direct management implications, and the two indices capture two different but complementary aspects of the extent of an invasion. The %NIS Abundance index is a measure of the current alteration in the benthic community due to invasions. The %NIS Species index is both as a measure of change in community structure and a measure of the potential risk of future changes in benthic community structure. The %NIS Species might also be viewed as an exposure measure for invasion vectors. These indices can be used to be used to assess the extent of invasion within classes of estuaries (Figure 249-1) or across a region (Figure 249-2), with the objective of prioritizing among estuaries or of assessing the importance of various invasion vectors. Additionally, by determining how these indices change over time, they can be used as performance measures to determine if the extent (or rate) of invasion is changing in response to management practices (e.g., ballast water management) or changes in the ecosystem condition (e.g., increased eutrophication, flow diversions).

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Lee, H., et al. 2003. Estuarine and scalar patterns of invasion in the soft bottom benthic communities of the San Frnacisco Estuary. Biological Invasions 5: 85-102, 2003.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Benthic data are available for 21 small estuaries and 9 large estuaries, with the number of grabs ranging from 1 to 28 per estuary (>5 ppt). Henry Lee, U.S. EPA ORD, NHEERL, Western Ecology Division, Newport Lab. (541) 867-5001 "Nelson, et al., 2004. Condition of Estuaries of the Western United States for 1999: A Statistical Summary. EPA/620/R-04/200."

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. While there are no standardized invasion metrics to assess the extent or patterns of invasion of aquatic ecosystems or bio-geographic regions, this effort proposes invasion indices for estuarine soft-bottom communities along the Pacific Coast of Northern California, Oregon, and Washington. The first cut at developing such invasion metrics will be limited to those that can be derived from the benthic abundance and composition within individual benthic grabs (point scale). These indices capture the relative abundance of species of non-indigenous species (NIS) of soft-bottom organisms compared to the native species - at the spatial scale of a single benthic grab sample. The approach is reproducable.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The data are collected using the Coastal EMAP protocols developed by EPA s Office of Research and Development. The QA plan and protocol (U.S. EPA, 2001. National Coastal Assessment: Quality Assurance Project Plan 2001-2004. EPA/620/R-01/002) is available at http://www.epa.gov/emap/nca/html/docs/qaprojplan.html.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes. The probabilistic sampling design used in EMAP generates statistically unbiased estimates of the condition of estuaries. Additionally, a discussion of the scalar properties of the invasion indices can be found in: Lee, H., et al. 2003. Estuarine and scalar patterns of invasion in the soft bottom benthic communities of the San Frnacisco Estuary. Biological Invasions 5: 85-102, 2003.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. The data are collected using the Coastal EMAP protocols developed by EPA s Office of Research and Development. The QA plan and protocol is available at http://www.epa.gov/emap/nca/html/docs/qaprojplan.html, while the specifics of the 1999 sampling program are available in "Nelson, et al., 2004. Condition of Estuaries of the Western United States for 1999: A Statistical Summary. EPA/620/R-04/200". Additional information can be provided by Henry Lee, U.S. EPA ORD, NHEERL, Western Ecology Division, Newport Lab. (541) 867-5001

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not likely. Studies in the San Francisco Estuary (Lee et al., 2003) and in Willapa Bay (Ferraro and Cole, in progress) have shown that the percent of NIS can vary substantially among community or habitat types. Thus, the values of the indices, in part, reflect the specific communities sampled (e.g., seagrass bed vs. sand shrimp bed). However, since both the EMAP and small estuary studies used probabilistic sampling, the case can be made that they sampled community types in approximate proportion to their areal extent, and thus are an accurate estimate of invasion within each estuary or estuary class.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

Studies in the San Francisco Estuary (Lee et al., 2003) and in Willapa Bay (Ferraro and Cole, in progress) have shown that the percent of NIS can vary substantially among communities.Thus invasion reference or cut-points developed for an entire estuarine ecosystem may not be appropriate for a specific habitat (e.g., seagrass community). The indicators assess the extent of invasion at the point scale (i.e., benthic grab), which does not necessarily represent the extent of invasion within an entire community or estuary. That is, the indices do not directly measure the total number of nonindigenous species found within an estuary. Determining the statistical and functional relationships between local measures of invasion (as measured by these indices) and estuarine- or regional-scales of invasion is one possible future avenue in the development/validation of invasion indicators. The invasion metrics are structural indicators; further research is needed to understand the relationship between these structural changes and impacts on ecosystem function. Determining such relationships is another possible future avenue in the development/validation of invasion indicators.

Indicator: Terrestrial Plant Growth Index (145)

Primary productivity (the amount of solar energy captured by plants through photosynthesis) is a key indicator of ecosystem function (NRC, 2000; EPA, 2002). Generally, ecosystems will maximize their primary productivity through adaptation (Odum, 1971), so primary productivity can increase under favorable conditions (e.g., increased nutrients or rainfall) or decrease under unfavorable conditions (e.g., plant stress caused by toxic substances or disease). Changes in primary productivity can result in changes in the way ecosystems function, in the yield of crops or timber, or in the animal species that live in the ecosystems. Over a sufficiently long period, trends in Normalized Difference Vegetation Index (NDVI) could be an important indicator of increasing or decreasing plant growth resulting from changing climate, UV-B exposure, air pollution, or other stressors.

Gross primary productivity is related to the standing crop of the photosynthetic pigment chlorophyll and can be thought of as an index of plant growth. The Terrestrial Plant Growth Index indicator developed by The Heinz Center (2003) is based on the NDVI, which measures the amount of chlorophyll using satellite data (Reed and Yang, 1997). Although the standing crop of chlorophyll is not identical to primary productivity, NDVI also correlates well with net uptake of carbon dioxide and plant biomass production (Birky, 2001). The index shows, for any given year, whether plant growth for an ecosystem type was above or below the 13-year average (1989-2002).

This indicator is based on data collected by the Advanced Very High Radiation Radiometer (AVHRR) aboard NOAA's polar orbiting satellites between 1989 and 2002 (except for 1994 when the satellite failed). Each 1.1 km^2 pixel is sampled twice each day. Because the relationship between NDVI and absorbed, photosynthetically-active radiation varies by cover type, the growing season accumulated NDVI was calculated separately for the forest, farmland, and grassland/shrubland areas in each county of the conterminous 48 states. The NDVI was calculated at 2-week intervals and summed throughout the growing season using only values that exceeded non-growing-season background. The values in each county segment for each year then were normalized to the corresponding 13-year average for that county segment to produce a plant growth index for which a value of 1.0 equals the long-term average (a value of 1.5 represents 1.5 times the long-term average). The system-specific plant growth indices are the area-weighted averages of the segments contained within the system. The calculation algorithm and the resulting data for this indicator were updated in the 2003 Annual Update of *The State of the Nation's Ecosystems* (The Heinz Center, 2003).

What the Data Show

No overall trend in plant growth is observed from 1989 through 2002 for any of the land cover types studied, although year-to-year measurements can fluctuate by up to 40 percent of the 13-year average (Figure 145-1). The similarity in year-to-year variation among systems (e.g., above-average growth in 1993 and below-average growth in 1996) is striking. The reason for these trends is not clear (The Heinz Center, 2003).

Indicator Limitations

- In 2000, the NOAA satellite drifted to a new orbit; as a result, U.S. NDVI data began to reflect measurements made in late afternoon rather than midday. The effect of this drift on plant growth index is not fully known. However, because the index is accumulated from the beginning of the growing season—a point that is identified each year from the inherent seasonal patterns in the NDVI data—scientists at the EROS Data Center believe the 2000 estimates are comparable to those of previous years.
- Data for 1994 are unavailable because of satellite failure.

- Alaska and Hawaii are not included in this analysis.

Data Source

The data source for this indicator was The State of the Nation's Ecosystems, The Heinz Center, 2003 Annual Update, using data collected by the National Oceanic and Atmospheric Administration's Advanced Very High Resolution Radiometer. Data on accumulated NDVI and analysis of those data are from the USGS Earth Resources Observations Systems (EROS) Data Center, Sioux Falls, South Dakota (http://edc.usgs.gov/products/landcover/ndvi.html).

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The H. John Heinz III Center for Science, Economics, and the Environment. 2003. The State of the Nation's Ecosystems: Measuring the Lands, Waters, and Living Resources of the United States. New York, NY: Cambridge University Press, September 2002. Web update 2003: http://www.heinzctr.org/ecosystems.

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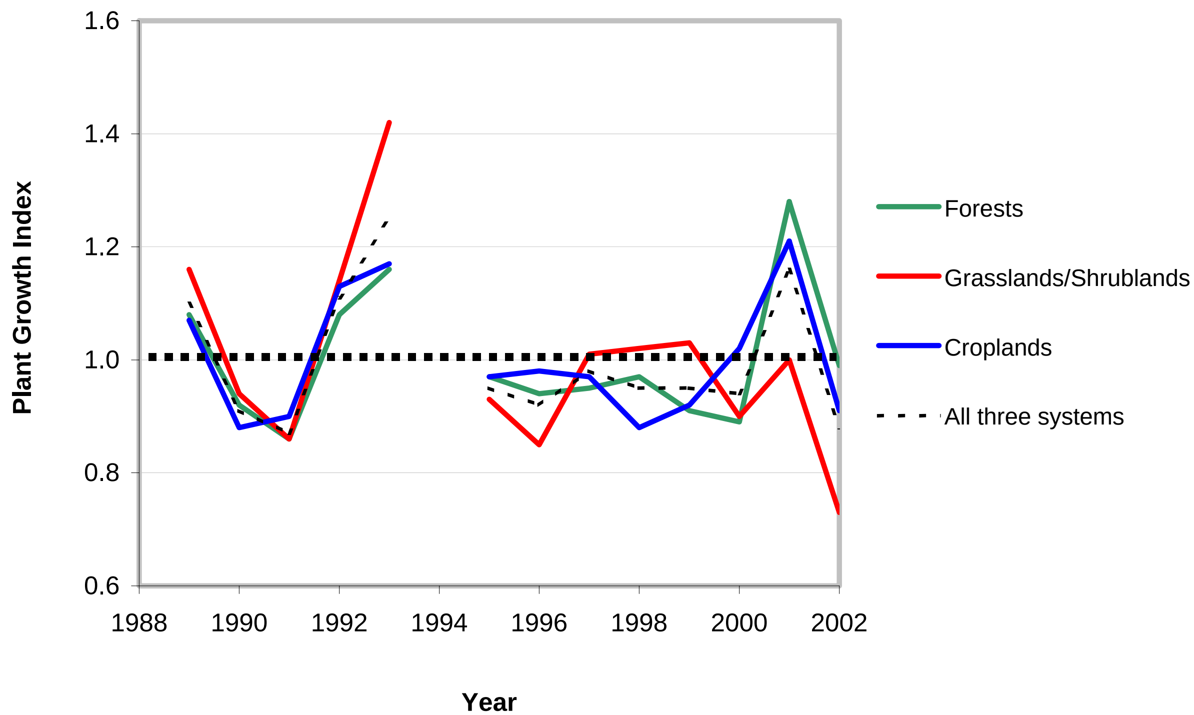
Graphics

Figure 145-1. Terrestrial Plant Growth Index



Source: The Heinz Center. The State of the Nation's Ecosystems. 2002. Online update 2003.
Data from the U.S. Geological Survey; Multi-Resolution Land Characterization Consortium
Coverage: lower 48 states

R.O.E. Indicator QA/QC

Data Set Name: TERRESTRIAL PLANT GROWTH INDEX
Indicator Number: 145 (89666)
Data Set Source: National Oceanic and Atmospheric Administration (NOAA)
Data Collection Date: regular: 1989 - 2002
Data Collection Frequency: daily
Data Set Description: Terrestrial Plant Growth Index
Primary ROE Question: What are the trends in the diversity and biological balance of the Nation's ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

The Terrestrial Plant Growth Index is based on the Normalized Difference Vegetation Index (NDVI), which measures chlorophyll using satellite data. USGS collects the raw data to support this indicator using the Advanced Very High Radiation Radiometer (AVHRR) aboard NOAA's polar-orbiting satellites. Currently, AVHRR data is available for the years 1989 to 2002 (except 1994, when a satellite failure prevented data collection). This sensor measures reflection/absorption of light; in this case, it measures the "greenness" of the vegetation below. Greenness relates to the amount of chlorophyll present; thus, this indicator represents a proxy for productive capacity. The raw data are not available to the public, as USGS performs several analytical steps before the data can be used for comparisons or indicators (see T1Q3). The Heinz Center (2003) reports that measurements are made in the visible wavelengths (0.58 to 0.68 meters) and near-infrared wavelengths (0.725 1.1 meters), corresponding with AVHRR channels 1 and 2. USGS documents these methods at http://edc.usgs.gov/greenness/whatndvi.html, with a list of supporting references at http://edc.usgs.gov/greenness/refs.html. USGS describes the NDVI concept with additional graphics and detail at http://edc.usgs.gov/greenness/helppage.html; this page also contains several links to information about NOAA s satellites. In addition to satellite data on sunlight absorption, this indicator also requires information on land cover type in order to create separate growth indices for each of the major types of vegetative land cover in the United States (forest, grassland/shrubland, farmland). Land cover data come from the National Land Cover Dataset (NLCD), compiled in the 1990s by a consortium of government agencies (USGS, EPA, USDA Forest Service). The Heinz Center (2003 update) documents this classification process briefly (http://www.heinzctr.org/ecosystems/national_technotes/natl_extent.shtml); a more detailed discussion can be found in Vogelmann et al., 1998 and 2001: Vogelmann, J.E., T.L. Sohl, P.V. Campbell, and D.M. Shaw. 1998. Regional land cover characterization using LANDSAT Thematic Mapper data and ancillary data sources. Environmental Monitoring and Assessments 51: 415 428. Vogelmann, J.E., S.M. Howard, L. Yang, C.R. Larson, B.K. Wylie, and N. van Driel. 2001. Completion of the 1990s national land cover data set for the conterminous United States from Landsat Thematic Mapper data and ancillary data sources. Photogrammetric Engineering & Remote Sensing 67:650 662.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Neither the Heinz Center nor the government agencies responsible for data collection explicitly discusses the design of the raw data collection process. The Heinz Center reports that measurements are made twice a day, and that each measurement pixel corresponds with a mapping area of about 1.1 square kilometers (km) a relatively high resolution on a national scale.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

To derive this indicator, USGS processed the raw data through several layers of analysis:

(1) USGS converted the raw data into a Normalized Difference Vegetation Index (NDVI). First, USGS combined information from two AVHRR sensor channels into one raw NDVI figure for each data point, as described at http://edc.usgs.gov/greenness/whatndvi.html. Because clouds, atmospheric perturbations, and variable illumination or viewing geometry can all contaminate raw data, USGS employs a smoothing algorithm to reduce the impact of such extraneous factors. To smooth the data, USGS groups the data into 2-week intervals, performs a series of least-squares regressions around each data point, averages the regression values, and then interpolates between points to generate a continuous curve. USGS also incorporates a factor that weights NDVI in favor of peaks rather than minima, since contamination typically causes lower-than-expected values of NDVI. USGS's website discusses this process briefly (http://edc2.usgs.gov/phenological/methods.html#methodsTS); a more in-depth discussion can be found in: Swets, D.L., B.C. Reed, J.R. Rowland, S.E. Marko, 1999. A weighted least-squares approach to temporal smoothing of NDVI. In 1999 ASPRS Annual Conference, From Image to Information, Portland, Oregon, May 17-21, 1999, Proceedings: Bethesda, Maryland, American Society for Photogrammetry and Remote Sensing, CD-ROM, 1 disc.

The Heinz Report's 2003 web update describes an additional smoothing algorithm employed during a recent revision of the data set (http://www.heinzctr.org/ecosystems/national_technotes/natl_plant_growth_index.shtml). USGS's Earth Resources Observations Systems (EROS) recently developed a new protocol to remove the influence of water vapor, which interferes with one of AVHRR's measurement channels, artificially depressing many NDVI values (Heinz Center, 2003). For the Heinz Center's 2003 update, EROS reprocessed all raw data following this new protocol. EROS based this protocol on several sources, described and cited at http://edc.usgs.gov/greenness/whatnew.html.

(2) To determine the temporal bounds of the growing season, USGS calculated a moving average around each NDVI data point. A strong positive deviation from the moving average signaled the start of the growing season. Conversely, a lower-than-expected data signaled the end of the growing season. USGS describes this methodology in moderate detail online (http://edc2.usgs.gov/phenological/methods.html#methodsTS). While USGS lists no specific supporting references, it may be possible to learn more about growth season determination from some of the general NDVI references listed at http://edc.usgs.gov/greenness/refs.html.

(3) For a given year, all 2-week NDVI composites from the growing season were added together, generating a single "accumulated NDVI" value for the year. USGS does not mention this step online, but the Heinz report suggests that it obtained its data from USGS in this accumulated form. The Heinz Center (2003) notes that a detailed explanation of calculating growing-season

accumulated NDVI can be found in: B.C. Reed and L. Yang. 1997. Seasonal vegetation characteristics of the United States. Geocarto International 12(2):65–7.

(4) USGS sorted data by land cover type (forest, shrub/grassland, and cropland) in accordance with the National Land Cover Dataset (NLCD). In the NLCD system, each “pixel” of land (about 100 feet on a side) is assigned to one of 21 land-use categories, based on information from Landsat imagery and various US government agencies. USGS provides documentation for the NLCD system at http://landcover.usgs.gov/.

(5) The final presentation of this indicator compares annual NDVI values with an average of all 13 years for which data are available (1989-1993; 1995-2002). The Heinz Center obtained data from USGS in the form of NDVI data for each land cover type within each county. To derive a national NDVI figure for each land cover type, the Heinz Center averaged all county figures, weighted by land area. For each land cover type, the Heinz Center also calculated the average of all 13 years of annual NDVI data, creating a long-term mean for comparison. For this indicator, the long-term average is assigned a value of 1. If one year shows an NDVI value of 1.5 on this index scale, it means that particular year’s NDVI was 1.5 times the 13-year average.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

Since changes in plant growth can be indicative of several different environmental stressors (e.g., soil moisture, carbon dioxide levels, nitrogen deposition, ground-level ozone, climate change), it seems appropriate that a proxy for plant growth be considered when assessing functional trends in the nation s ecosystems. This sampling method is broad enough to cover national trends, while detailed enough to allow data to be broken down by region or by specific land cover type if desired. Data were collected by high-resolution equipment aboard a satellite, covering the entire surface of the lower 48 states down to 1 km squares. Broken down by land type and/or region, this indicator may also shed light on particular areas of concern e.g., a noticeable decline in farmland productivity that might indicate a problem with farm management or topsoil loss. The Heinz Center (2003) reports that NDVI data correlate well with other measures of plant growth, such as net carbon uptake and plant biomass production (http://www.heinzctr.org/ecosystems/national_technotes/natl_plant_growth_index.shtml). In addition, results for this indicator suggest some broad trends that are consistent across many regions and land cover types (e.g., high growth in 1993, low growth in 1996), although the Heinz Center could not explain what caused these patterns to occur. Still, sample design poses a few obstacles to fully answering the question this indicator was intended to answer (see also T4Q3 and T4Q4). Neither USGS nor the Heinz Center discusses the degree to which light absorption by plants may vary throughout the course of a day, and thus neither source provides explicit assurance that twice-daily measurements are sufficient to capture the full range of plants light absorption patterns within the overall indicator. The Heinz Center and USGS also do not discuss whether measurement time-of-day stayed consistent enough to allow for meaningful comparisons, although USGS/EROS scientists have indicated that they believe it was sufficiently consistent. In particular, the Heinz Center notes that one satellite drifted to a significantly later overpass time in 2000 (see T4Q4), but USGS/EROS scientists concluded that it was not a significant source of potential error (Heinz, 2003: http://www.heinzctr.org/ecosystems/national_technotes/natl_plant_growth_index.shtml; Carolyn Gacke, USGS, personal communication, 2005).

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

USGS designed this sample to generate a broad national index, so it is not targeted at any one sensitive population or ecosystem. However, because the indicator does allow data to be broken down by both region and vegetation type, it may be possible to track changes within a particular region or land use category of concern.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

No benchmark values of NDVI or terrestrial plant growth index are available to support any kind of unambiguous quantification of the state of the environment. The Heinz Center averaged 13 years of data to establish a baseline for comparison, but as these data all come from 1989 or later, this baseline should not necessarily be assumed to reflect the natural state of plant growth.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

USGS provides complete documentation of the AVHRR technology used to collect the raw data for this indicator (basic information at http://edcdaac.usgs.gov/1KM/avhrr_sensor.asp; Polar Orbiter Data User s Guide at http://www2.ncdc.noaa.gov/docs/podug/; similar information at http://edc.usgs.gov/guides/avhrr.html and http://edc.usgs.gov/greenness/tables.html). In addition, both the Heinz Center and USGS discuss the resolution and frequency of data collection for this indicator (http://www.heinzctr.org/ecosystems/national_technotes/natl_plant_growth_index.shtml; http://edc2.usgs.gov/phenological/methods.html#methodsTS). Several sources document the analytical procedures employed in the creation of this indicator. USGS s EROS website discusses the basic process of adding and subtracting data from two satellite channels in order to arrive at an NDVI figure for each data point (http://edc.usgs.gov/greenness/whatndvi.html). USGS also provides a brief online discussion of the process of smoothing the raw data into bi-weekly NDVI values (http://edc2.usgs.gov/phenological/methods.html#methodsTS); greater detail can be found in: Swets, D.L., B.C. Reed, J.R. Rowland, S.E. Marko, 1999. A weighted least-squares approach to temporal smoothing of NDVI. In 1999 ASPRS Annual Conference, From Image to Information, Portland, Oregon, May 17-21, 1999, Proceedings: Bethesda, Maryland, American Society for Photogrammetry and Remote Sensing, CD-ROM, 1 disc. USGS lists several related references at http://edc2.usgs.gov/phenological/overview.html#references and http://edc.usgs.gov/greenness/refs.html. USGS describes the process of determining growing season bounds at http://edc2.usgs.gov/phenological/methods.html#methodsTS. For each growing season, USGS adds NDVI data to arrive at a single accumulated value for the year; this process is detailed in: B.C. Reed and L. Yang. 1997. Seasonal vegetation characteristics of the United States. Geocarto International 12(2):65 71. USGS separates data by land cover type using the National Land Cover Dataset (NLCD), a general description of which appears at http://landcover.usgs.gov. According to the Heinz Center (personal communication 2004), the creation of the NDVI index requires an area-weighted averaging approach because USGS reports annual accumulated NDVI by county, not by individual pixel. For the index, the long-term (13-year) mean receives a value of 1.0 and annual figures are depicted based on percent deviation from this mean. USGS does not directly document the procedure by which the full data set was recently recalculated to correct for the influence of water vapor (these new data appear in the Heinz Report s 2003 update). However, USGS does provide several references for this procedure at http://edc.usgs.gov/greenness/whatnew.html.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Raw satellite data are not available online. However, USGS does provide access to the full set of NDVI data, which has already been smoothed and compiled (http://edc.usgs.gov/products/landcover/ndvi.html). This data set includes bi-weekly NDVI, total growing season NDVI, growing season start and end data, and start-of-season NDVI. The Heinz Center specifically reports that data obtained from USGS were already sorted by county and by land cover type within each county. The Heinz Center has published numerical data corresponding with the graphs in the 2002 Heinz Report: http://www.heinzctr.org/ecosystems/national/datasets/plant_growth_by_ecosystem.shtml; http://www.heinzctr.org/ecosystems/national/datasets/plant_growth_west.shtml; http://www.heinzctr.org/ecosystems/national/datasets/plant_growth_east.shtml Basic NLCD data are available at http://landcover.usgs.gov/. While several additional sources of land cover data exist (e.g., USDA Forest Service; see list at http://www.heinzctr.org/ecosystems/national_technotes/natl_extent.shtml), USGS only used NLCD data for this indicator.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Reliance on historical measurements poses a limitation to the complete reproducibility of this study. However, USGS has already re-analyzed all of its original NDVI data, after recently developing a protocol to account for the distorting effect of water vapor in the atmosphere. This re-analysis exposes the possibility of reproducing the analytical portion of this study, provided that the raw data and specific algorithms can be obtained from USGS.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

NOAA has published a Polar Orbiter Data User s Guide that includes a section on the calibration of AVHRR Data: http://www2.ncdc.noaa.gov/docs/podug/html/c3/sec3-3.htm. USGS has not published quality control/quality assurance procedures specifically related to its NDVI data.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

This indicator does not require any spatial extrapolation, as NOAA s satellites can gather data from the entire land area of the lower 48 states at least twice daily. Although measurements cannot be taken through cloud cover, USGS smoothes the twice-daily data over 2-week periods in order to minimize cloud effects, ensuring that the overall indicator represents all data locations. This indicator does employ a great deal of spatial generalization as it combines 1-km pixels and county-level NDVI values into a single national index for each land cover type. USGS and the Heinz Center have generalized appropriately, using an area-weighted approach to ensure that national NDVI reflects each county's NDVI proportional to land area (for each NLCD type). Because measurements are taken every day of the year, this indicator requires no temporal extrapolation. However, the analytical process does require some degree of temporal generalization in order to reduce the influence of various extraneous factors that can distort satellite measurements. This "smoothing" takes place following regression and weighting procedures that are accepted by USGS and documented in: Swets, D.L., B.C. Reed, J.R. Rowland, S.E. Marko, 1999. A weighted least-squares approach to temporal smoothing of NDVI. In 1999 ASPRS Annual Conference, From Image to Information, Portland, Oregon, May 17-21, 1999, Proceedings: Bethesda, Maryland, American Society for Photogrammetry and Remote Sensing, CD-ROM, 1 disc. In addition, the data collection system requires that overall results be generalized from two measurements per day. Neither the Heinz Center (2003) nor USGS explicitly discusses whether this level of generalization is appropriate to capture the full range of variation in plant behavior over the course of a given day.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Neither the Heinz Center nor USGS has published uncertainty estimates for the raw satellite data or the smoothed NDVI data. USGS has published uncertainty measurements for the National Land Cover Dataset (NLCD). According to basic information from the Heinz Center, the NLCD has 80% or higher accuracy for the eastern United States, while the western United States is still under review. A detailed discussion of error in the NLCD can be found at http://landcover.usgs.gov/accuracy.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

The AVHRR represents a precise measuring technology, presumably with low uncertainty. However, without explicit uncertainty measurements for the raw data set, it is not possible to quantify any uncertainty that may exist. The data include some natural variability, but it does not negatively impact the utility of this indicator. While cloud cover and other factors can variability, USGS has designed the smoothing process to weed out these influences as much as possible. USGS also uses a specific protocol to handle the establishment of growing season boundaries another source of variability that is at least somewhat minimized through the use of statistical smoothing.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

(1) Geographic limitations. USGS did not analyze data for either Alaska or Hawaii, so this indicator cannot give any information about some of the unique ecosystem health issues that may be pertinent to Alaska or Hawaii. Particularly in the case of Alaska, where temperature has recently warmed faster than the global average and the treeline appears to be moving north as the permafrost melts (Lloyd and Fastie, 2003), plant growth index might reveal interesting trends. Lloyd, A.H., Fastie, C.L. 2003. Recent changes in treeline forest distribution and structure in interior Alaska. Ecoscience 10(2). (2) Absence of baseline data. Data are available from USGS beginning in 1989, with one year (1994) missing from the sampling period. Without more data, it is hard to tell whether trends are related to natural variability, natural climate oscillations, or long-term changes that should raise concerns. (3) Effects, not causes. While this indicator might identify trends, it does not identify specific underlying causes. In this sense it is essentially a holistic measure of how well plants are growing. Even if it can be determined that a particular trend in NDVI is attributable to long-term changes rather than natural variability or climate oscillation, it may not be easy to determine the actual mechanism of that change. (4) The Heinz Center notes that one satellite drifted to a new overpass time in 2000, causing NDVI to be

measured in late afternoon rather than at the normal measuring time closer to midday. While USGS (EROS) does not fully discuss the potential effects of this drift on NDVI measurements, EROS scientists have concluded that in their judgment, the 2000 orbital drift was not such a significant source of potential error that it would require correction (Carolyn Gacke, USGS, personal communication, 2005; Heinz, 2003: http://www.heinzctr.org/ecosystems/national_technotes/natl_plant_growth_index.shtml). Nonetheless, sources like Nemani et al. (2003) discuss ways to correct NDVI data for satellite drift, should correction be necessary. Technical Supplement for: Nemani, R.R., C.D. Keeling, H. Hashimoto, W.M. Jolly, S.C. Piper, C.J. Tucker, R.B. Myneni and S.W. Running. 2003. Climate-Driven Increases in Global Terrestrial Net Primary Production from 1982 to 1999. Science 300 (June 6, 2003). Technical Supplement located at http://www.ntsg.umt.edu/tops/document/nemani-et-al-supplement.pdf.

Indicator: Threatened and Endangered Species (354)

Congress enacted the Endangered Species Act (ESA) in 1973 to protect endangered and threatened species and the ecosystems on which they depend. The ESA combined and strengthened the provisions of earlier laws, enacted in 1966 and 1969, which provided for a list of endangered species but gave them little meaningful protection.

Under the ESA, a species is considered *endangered* if it is in "danger of extinction throughout all or a significant portion of its range" and *threatened* if it is "likely to become endangered in the foreseeable future." To receive protection under the ESA, a species must be formally listed as threatened or endangered. A species can be simultaneously listed as both threatened and endangered if it is threatened in one part of its range and endangered in another. All species of plants and animals, except pest insects, are eligible for listing.

The decision whether to list a species follows a strict legal process administered by the U.S. Fish and Wildlife Service (USFWS) for terrestrial and freshwater organisms and the National Marine Fisheries Service (NMFS) for marine species. Evaluation of a species as threatened or endangered is based on five factors:

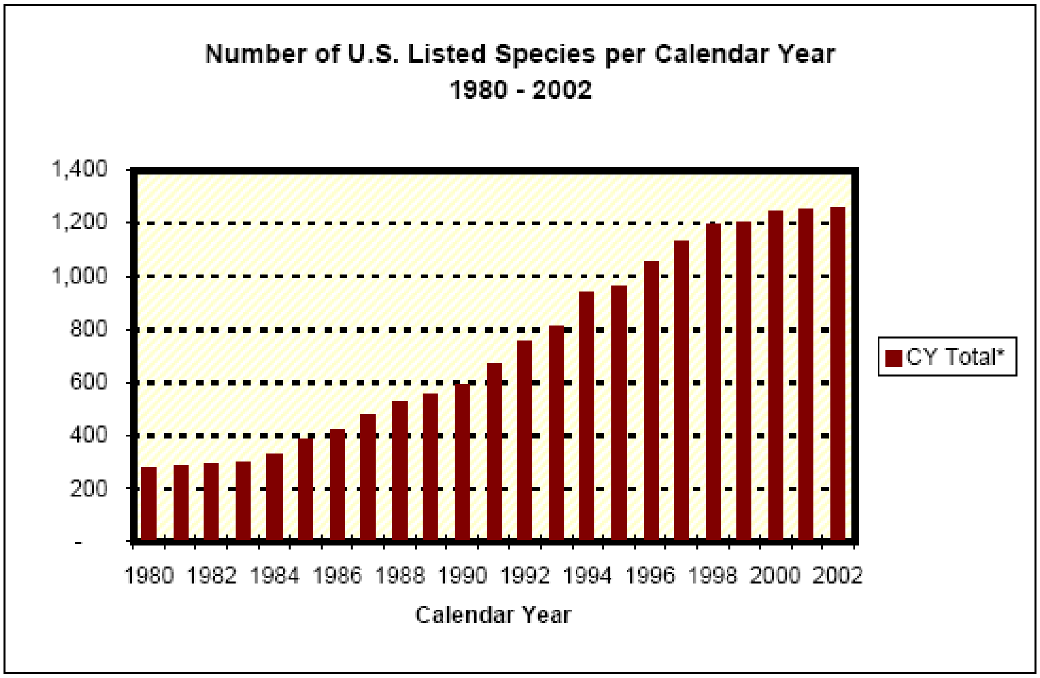
- Is there a present or threatened destruction, modification, or curtailment of the species' habitat or range?
- Is the species subject to overutilization for commercial, recreational, scientific, or educational purposes?
- Is disease or predation a factor?
- Are existing regulatory mechanisms inadequate to protect the species or its habitat?
- Are there other natural or manmade factors affecting the species'survival?

In most cases, the USFWS or NMFS initiates the listing process based on data the agency has collected. In some cases, citizen petitions provide the initial evidence leading to process initiation. The process involves collecting and carefully considering the "best scientific and commercial data available." Listings are made solely on the basis of a species' biological status and threats to its existence. External parties (including the scientific community, state and federal agencies, tribal governments, and the public) provide input and data via public comment and testimony. The USFWS or NMFS decides all listings using sound science and peer review to ensure the accuracy of the best available data. A final ruling on a species' status is required within one year of a species proposal for listing.

The ultimate goal of the ESA is to recover species so they no longer need protection. The status of each listed species is reviewed at least every 5 years to determine if federal protection is still warranted. Species may be delisted (removed from the list altogether) or downlisted (reclassified from "endangered" to "threatened") if threats have been reduced and the population has met its recovery objectives. As of December 31, 2002, 30 species had been delisted. Stresses causing species to be listed include habitat destruction, pollution, introduction of competing non-native species, introduction of exotic diseases and parasites, and commercial exploitation. Therefore, the number of species listed serves as a general indicator of environmental stress.

This indicator is based on USFWS data on the number of species listed each calendar year from 1980 to 2002. The total for each calendar year includes the number carried over from the prior year, as modified during the calendar year by new listings, reclassifications, delistings, new information on taxonomy, and other factors. Species with dual status (i.e., listed as both threatened and endangered) are counted only once. Also, subunits of a single species (e.g., salmon) that have been listed separately as distinct segments are counted only once. A current listing of endangered and threatened species in the United States can be found at the Fish and Wildlife Service's Web site: http://endangered.fws.gov/wildlife.html#Species. The list is updated daily.

What the Data Show



The total number of endangered and threatened species listed in the United States has increased steadily over the 23 years from 1980 to 2002 (Figure 354-1). In calendar year 2002, the total number of species listed as endangered or threatened in the United States was 1,263.

Indicator Limitations

- Not all species on the ESA list are endangered or threatened due to anthropogenically induced stresses. A species can become endangered or threatened due to natural factors. Some species are listed because they have a similarity of appearance to an endangered or threatened species
- The 1973 ESA has been amended on several occasions, most recently in 1988. Some amendments may impact listing activities, possibly causing inconsistencies in listing decisions. For example, a 1982 amendment specified that determinations of species' status were to be made solely based on biological and trade information, without any consideration of possible economic or other effects. The level of appropriation may influence the ability of the USFWS and NMFS to consider species for listing, and thus may affect the number of new species listed each year.
- The ESA was due for reauthorization in 1993, but legislation to reauthorize it has not yet been enacted. Appropriations have continued while Congress considers reauthorization. However, should appropriations cease, then data for this indicator will no longer be available.
- Some listings and delistings result from court orders and other administrative actions.

Data Source

United States Fish and Wildlife Service's Endangered Species Program website:
http://endangered.fws.gov/stats/cy_count2002.pdf

R.O.E. Indicator QA/QC

Data Set Name: THREATENED AND ENDANGERED SPECIES
Indicator Number: 354 (119178)
Data Set Source:
Data Collection Date:
Data Collection Frequency:
Data Set Description: Threatened and Endangered Species
Primary ROE Question: What are the trends in the diversity and biological balance of the Nation's ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

This indicator is not based directly on measurements, but rather on determinations made by federal agencies following a process. The Endangered Species Act of 1973 requires the U.S. Fish and Wildlife Serve (USFWS) and the National Oceanic and Atmospheric Administration's (NOAA's) National Marine Fisheries Service (NMFS) to make biological decisions based upon the best scientific and commercial data available. These decisions involve listing of a species as endangered or threatened, reclassification, and delisting of plant and animal species, and critical habitat designations. The process involves the active solicitation of comments on proposed listing rules and draft recovery plans by the scientific community, state and federal agencies, tribal governments, and other interested parties, including comments on the general information base and the assumptions upon which USFWS and NMFS are basing a biological decision. USFWS and NMFS also solicit expert opinions and analyses on specific questions or assumptions. This solicitation process may take place during a public comment period on any proposed rule or draft recovery plan, during the status review of a species under active consideration for listing, or at any other time deemed necessary to clarify a scientific question. In addition, independent peer review is solicited on listing recommendations and draft recovery plans to ensure the best biological and commercial information is being used in the decision-making process, as well as to ensure that reviews by recognized experts are incorporated into the review process of rulemakings and recovery plans developed in accordance with the requirements of the Endangered Species Act. The Interagency Cooperative Policy for Peer Review in Endangered Species Act Activities is available in its entirety at: http://endangered.fws.gov/policy/pol003.html.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

As stated in T1Q1, the Endangered Species Act of 1973 requires USFWS and NMFS to make listing decisions based upon the best scientific and commercial data available. See http://endangered.fws.gov/policy/pol003.html. Data are held at the field offices of the Fish and Wildlife Service Ecological Services Program, but are not usually available to the public.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

For this indicator, the data (number of species listed each year) are presented without transformation. Regarding how USFWS and the NMFS evaluate the scientific data to make a listing determination, see T1Q1 for a general description of the process. For more information, contact USFWS. Contact information is available at: http://endangered.fws.gov/contacts.html.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

There is no single uniform sampling design or monitoring plan for all species considered for listing or delisting.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Although there is no uniform design, the data upon which decisions are made specifically target species that are or may be threatened or endangered.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

USFWS and NMFS apply the following criteria, based on the best available biological and commercial data, in deciding whether to list a species as endangered or threatened: (1) the present or threatened destruction, modification, or curtailment of the species habitat or range; (2) overutilization for commercial recreational, scientific, or educational purposes; (3) disease or predation; (4) the inadequacy of existing regulatory mechanisms; or (5) other natural manmade factors affective the species survival. (See http://endangered.fws.gov/listing/listing.pdf.) No information is available on the USFWS website about how these criteria were developed or how they are applied.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

USFWS and NMFS receive and use information on the biology, ecology, distribution, abundance, status, and trends of species from a wide variety of sources as part of their responsibility to implement the Endangered Species Act. Some of this information is anecdotal, some of it is oral, and some of it is found in written documents. These documents include status surveys, biological assessments, and other unpublished material from state natural resource agencies and natural heritage programs, tribal governments, other federal agencies, consulting firms, contractors, and individuals associated with professional organizations and higher educational institutions. USFWS and NMFS also use published articles from juried professional journals. The quality of the information contained in these sources can be as variable. As part of their routine activities, USFWS biologists are required to gather, review, and evaluate information from these sources prior to undertaking listing, recovery, consultation, and permitting actions. Further information on ESA information standards can be found online at: http://www.nmfs.noaa.gov/prot_res/readingrm/recoverguide/infostds.PDF

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

All endangered and threatened species lists are available on USFWS Threatened and Endangered Species database System, which can be accessed at: http://endangered.fws.gov/wildlife.html. All lists and reports are updated on a daily basis. Regarding the data used to determine the endangered or threatened status of the listed species, none of this data is provided on the USFWS website.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Data are held at the field offices of the Fish and Wildlife Service Ecological Services Program, but are not usually available to the public to protect species locality and private landowner interests.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Standards for information and peer review can be found at the following website:
http://www.nmfs.noaa.gov/prot_res/readingrm/recoverguide/infostds.PDF
http://www.nmfs.noaa.gov/prot_res/readingrm/recoverguide/peerrvw.PDF General information quality guidelines for the USFWS are available at: http://www.noaanews.noaa.gov/stories/iq.htm General information quality guidelines for NOAA are available at:
http://www.fws.gov/informationquality/topics/FWS%20Information%20Quality%20Guidelines.pdf

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

N/A.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Not on the USFWS website.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

See T4Q2 and T4Q4.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

"Not all species on the ESA list are endangered or threatened due to anthropogenically induced stresses. A species can become endangered or threatened due to natural factors. Also, some species are listed because they have a similarity of appearance to an endangered or threatened species." The 1973 ESA has been amended on several occasions, most recently in 1988. Some amendments may impact listing activities, possibly causing inconsistencies in listing decisions. " The level of appropriation may influence the ability of the USFWS and NMFS to consider species for listing, and thus may affect the number of new species listed each year. The scientists involved in determining a listing vary from one species to the next, as do the data they consider. Thus, inevitably, there may be inconsistencies in the decision-making process.

Indicator: Forest Disturbances: Fire, Insects and Disease (113)

Fires, insects, and disease play key roles in shaping the biotic structure of forest ecosystems (Lorimer, 2001; Seymour et al., 2002). While they all occur naturally, they can be influenced by other variables such as management decisions, air pollutants, and variations in climate. For example, trees weakened by pollutants might be more susceptible to attack by pathogens.

This indicator, developed by the Heinz Center (2003), tracks trends in the occurrences of fires, insect outbreaks, and diseases or parasites. The fire indicator is based on data from the National Interagency Fire Center (NIFC) and the Fire and Aviation Management branch of the U.S. Department of Agriculture (USDA) Forest Service. Together, these sources have compiled national fire acreage statistics for every year since 1916, based on reports from various federal and state agencies. The insect and disease indicators are based on data from the Forest Service Forest Health Monitoring (FHM) program, which is a survey-based program that has operated since the late 1940s. FHM conducts aerial surveys in order to determine the number of acres of forest with visible defoliation or mortality, then conducts additional surveying on the ground as needed to determine the identity of the insect or other parasite causing damage.

What the Data Show

Wildfire acreage has declined from a peak of more than 50 million acres per year in the 1930s (Figure 113-2) to 2 to 7 million acres per year (Figure 113-1), largely due to fire suppression policies (The Heinz Center, 2003). However, there has been a slight increase in fires in recent decades, with 8.4 million acres of forest burned in 2000 (Figure 113-1). Insect damage from five major insect pests affects between 8 and 46 million acres per year (Figure 113-1). The noticeable fluctuations are primarily a result of population cycles of gypsy moth and southern pine beetle (for example, the large spike in 1986 reflects a peak population of southern pine beetle). Data for two major parasites, fusiform rust and dwarf mistletoe, are available only for the past several years, but the total acreage affected is 43 to 44 million acres (Figure 113-1) (The Heinz Center, 2003).

Indicator Limitations

- This indicator does not distinguish between forest fires, other wildfires, and prescribed burns. It also does not track the intensity of the fires.
- Data are not available on forests affected by insects or diseases other than those listed above.
- Some insects can cause widespread damage before it is apparent from aerial surveys.
- Disease data are annual figures, but are based on state surveys that may only take place every 5 to 20 years. Thus, the 2002 disease figures include the most recent survey data from every state, but for some states, these data are as old as the 1980s.

Data Sources

Fire data: (1) Data 1960-present: National Interagency Fire Center (NIFC), http://www.nifc.gov/stats/wildlandfirestats.html. (2) Data 1916-1960: USDA Forest Service, Fire and Aviation Management. NIFC and the Forest Service compiled their annual totals from statistics reported by several state and federal agencies.

Insect and disease data: USDA Forest Service, *Forest Insect and Disease Conditions in the United States – 2003* and similar reports for previous years (http://www.fs.fed.us/foresthealth/current_conditions.shtml). [Pre-1998 insect data are only available as a bar graph; total data availability to be determined, based on ongoing conversations with the Forest Service.]

References

Lorimer, C.G. 2001. Historical and ecological roles of disturbance in eastern North American forests: 9000 years of change. Wildlife Society Bulletin 29: 425-439.

Seymour, R.S., A.S. White, and P.G. deMaynadier. 2002. Natural disturbance regimes in northeastern North America: evaluating silvicultural systems using natural scales and frequencies. Forest Ecology and Management 155: 357-367.

The H. John Heinz III Center for Science, Economics, and the Environment. 2003. The State of the Nation's Ecosystems: Measuring the Lands, Waters, and Living Resources of the United States. New York, NY: Cambridge University Press, September 2002. Web update 2003: http://www.heinzctr.org/ecosystems.

USDA Forest Service. 2004. Forest Insect and Disease Conditions in the United States – 2003. Washington, DC: USDA Forest Service, Forest Health Protection. http://www.fs.fed.us/foresthealth/current_conditions.shtml.

Graphics

Figure 113-1. Fire, insects, and disease: Recent trends (1979-2000)

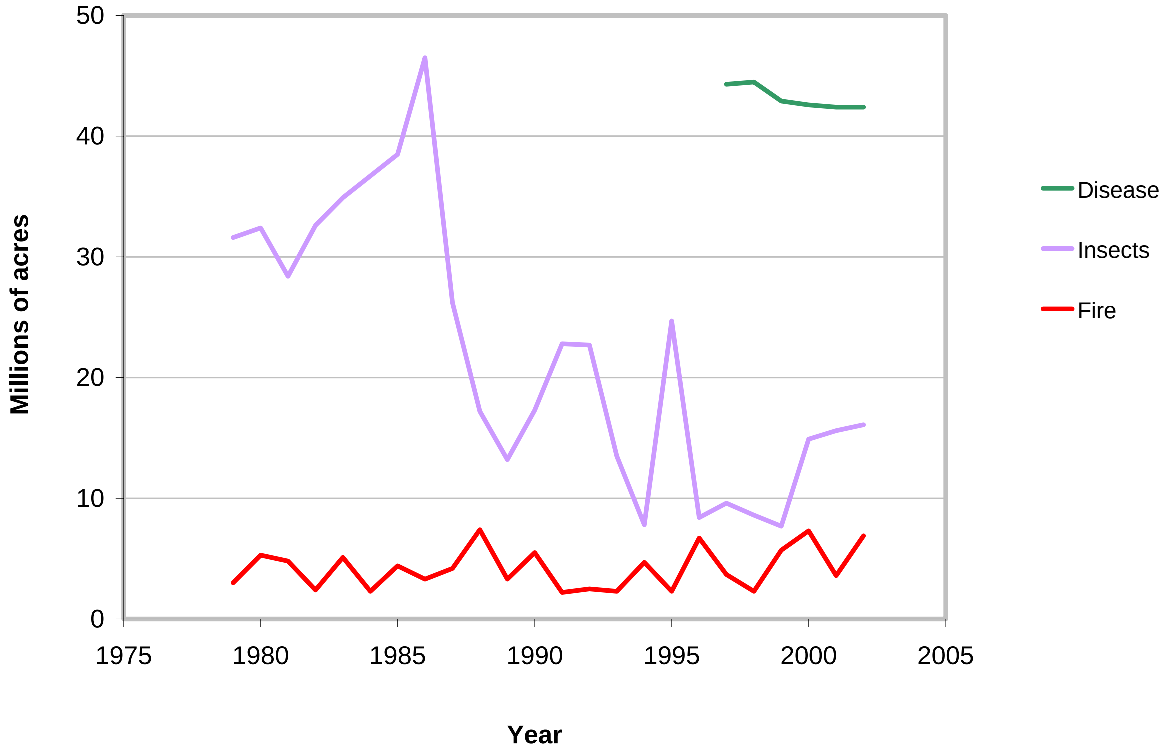
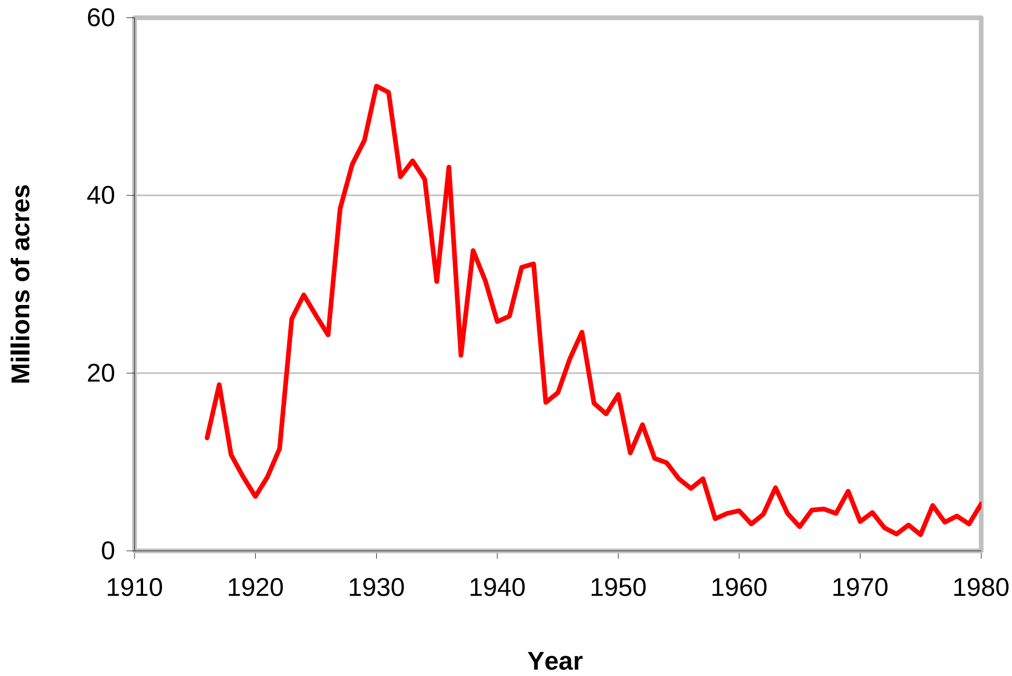


Figure 113-2. Historic wildfire acreage (1916-1980)



R.O.E. Indicator QA/QC

Data Set Name: FOREST DISTURBANCE
Indicator Number: 113 (89664)
Data Set Source: USDA Forest Service
Data Collection Date: irregular: 1916 - 2002
Data Collection Frequency: variable
Data Set Description: Forest Disturbance
Primary ROE Question: What are the trends in the ecological processes that sustain the Nation's ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

(1) Fire data. The Heinz Center (2003) does not present explicit documentation of the methods used to determine the number of acres burned every year. Several federal and state agencies collect fire data independently. Since 1960, the National Interagency Fire Center (NIFC) has compiled these data (NIFC, 2002); older data were compiled by individuals at the Fire and Aviation Management branch of the USDA Forest Service (Forest Service, Andrea Wojtasek and Marian Villasenor, personal communication, 2004). Neither NIFC nor the Forest Service can provide a full accounting for field methods that may have been used for this indicator.

(2) Insect data. The USDA Forest Service has collected insect data through aerial surveys conducted by its regional offices under the auspices of its Forest Health Monitoring (FHM) program. These data include the five insects covered under this indicator. FHM conducts the surveys following a set of established guidelines regarding survey timing, flight patterns, and measurement scale (see T3Q1). Since the 1940s, surveying has relied on airborne observers who sketch visible damage onto topographic map templates. Thus, aerial surveying requires a subjective assessment of whether defoliation or mortality is sufficiently visible and severe to constitute a “disturbed area.” Forest Service analysts acknowledge the coarseness of this methodology, but they believe it represents the most economical and efficient way to measure broad trends across the national landscape (http://www.fs.fed.us/r6/nr/fid/as/as-facts.shtml). In some cases, more recent data come from new digital GIS sketching technology that the Forest Service has developed to improve the accuracy of the aerial survey process (http://www.fs.fed.us/r6/nr/fid/as/as-facts.shtml; http://www.fs.fed.us/foresthealth/publications/id/id_tech.html). FHM provides a list of general references at http://fhm.fs.fed.us/fact/index.htm.

FHM supplements aerial survey data with ground surveying data (Forest Service, Ken Stolte, personal communication, 2004). However, for the broad national data in this indicator, ground surveying most likely represents a means of simply confirming the insect(s) to which damage visible from the air can be attributed. This ground surveying is conducted as needed, and does not necessarily follow a standard set of procedures.

Beginning in the late 1990s, FHM ground surveying was incorporated into the Forest Service’s Forest Inventory and Analysis (FIA) ground monitoring program (FHM Fact Sheet: http://www.na.fs.fed.us/spfo/fhm/fact/03/dm.pdf). More documentation of FIA field methods can be found at the links noted under the following section on “disease data.”

(3) Disease data. The Forest Service has collected comprehensive national data for the two major parasites studied under this indicator (fusiform rust and dwarf mistletoe) since 1997. Data for this indicator were collected by FHM prior to the late 1990s (see description of FHM above). Beginning in the late 1990s, disease data were collected through collaboration between FHM and the Forest Service's Forest Inventory and Analysis (FIA) program, which has conducted nationwide ground inventories of forest characteristics (e.g., size, age, density) since the 1940s. FIA collects data from points on a rectangular or hexagonal (since 1998) national grid, following a three-phase approach in which basic measurements take place at many sites, but only a subset of sites (evenly spaced across the grid) are used for more intensive monitoring. Detailed disease data come from the most intensive monitoring (Phase 3) sites, which are spaced at approximately one site per 96,000 acres (http://fia.fs.fed.us/library/fact-sheets/data-collections/Phase2_3.pdf). FIA follows standard methodologies for ground sampling: see http://fia.fs.fed.us/library/field-guides-methods-proc/ (field methods); http://ncrs2.fs.fed.us/4801/fiadb/fiadb_documentation/fiadb_chapter2.htm (plot size and design); and http://fia.fs.fed.us/library/Factsheets/Sampling%20and%20Plot%20Design.doc (plot design). In addition, FHM provides a list of general references supporting its overall program (http://fhm.fs.fed.us/fact/index.htm). A discussion of FIA's scientific validity can be found in a recent special issue of the Journal of Forestry (vol. 97, no. 12, 1999).

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

(1) Fire data. Neither the Heinz Center (2003) nor the Forest Service provides specific information about sampling design. NIFC and Forest Service annual fire summaries are based on reports from a collection of federal and state agencies, and these individual reports are not readily available. (2) Insect data. The Forest Service website contains basic information about the design of the aerial surveys used to assess insect damage (see also T3Q1). Forest Service officials design aerial surveys based on the resolution of the map they wish to obtain (http://www.fs.fed.us/r6/nr/fid/as/as-facts.shtml), and follow specific flight patterns to ensure thorough spatial coverage (http://www.fs.fed.us/r1-r4/spf/fhp/aerial/index.html). FHM employs ground surveying as needed to identify particular insects or other parasites causing damage noted from the air. FHM survey design represents several decades of survey experience. (3) Disease data. Historic disease data were collected by FHM as described above. Recent data were obtained following a standard sample design used by FIA for several decades. FIA s monitoring plan consists of three analytical phases. In Phase 1, the phase of lowest detail, FIA analyzes aerial photographs and satellite imagery to determine general characteristics of forest cover. FIA also uses Phase 1 imagery to plot a grid of locations for ground monitoring in Phase 2. Phase 3 represents a more detailed ground assessment than Phase 2; this monitoring takes place at a subset of Phase 2 locations. Data for this indicator come from Phase 3 sites. FIA has published fact sheets to support and explain its three-tiered sampling methodology: Detailed description of phases: http://fia.fs.fed.us/library/fact-sheets/data-collections/Phase2_3.pdf Sampling and plot design: http://fia.fs.fed.us/library/fact-sheets/data-collections/Sampling and Plot Design.pdf A discussion of the scientific validity of FIA s sample design can be found in a recent special issue of the Journal of Forestry (vol. 97, no. 12, 1999).

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

(1) Fire data. The Heinz Center (2003) and online NIFC materials do not document either the exact nature of raw data or the analytical processes that may be used to transform it. (2) Insect data. Each FHM aerial survey provides a map of insect-damaged areas, which Forest Service

analysts must then transform into figures of total acreage. The digital mapping equipment used to conduct more recent surveys (http://www.fs.fed.us/foresthealth/publications/id/id_tech.html) can calculate acreage automatically. However, most of the insect data included in this indicator are a product of hand-surveying, for which data transformation methods were not identified. [Additional information may be available here, based on ongoing communications with the Forest Service.] (3) Disease data. FIA follows standard statistical protocols to transform ground measurements into values of total acreage. These FIA protocols are supported by sources documented in T3Q1.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The forest disturbance indicator offers a useful assessment of the diversity and biological balance of the nation's forests. While fire, insects, and disease occur naturally, all three of these factors can impact the health of the entire forest ecosystem. (1) Fire data. The fire indicator data represent a compilation of information from several state and federal agencies. According to the Forest Service, these typically include acreage figures reported to the United States Department of Agriculture, Forest Service, by its field offices, the State Forester (or a comparable state official) of each of the 50 states, the officials of Puerto Rico and Guam, the Department of the Interior, and the Tennessee Valley Authority (Forest Service, 1992; full citation below). Thus, the fire component of this indicator includes data from public and private lands in all 50 states. In addition, this component of the indicator includes data from grassland and shrubland fires, which allows it to offer a more complete picture of the total extent of wildfires across the nation (Heinz Center, 2003). Forest Service. 1992. 1980-1994 Wildfire Statistics. USDA Forest Service, State and Private Forestry, Fire and Aviation Management Staff. January 1992. (2) Insect data. The use of aerial survey data ensures that this component of the indicator covers a broad spatial range. Aerial surveying is not an exact measurement, as it has historically required a subjective human judgment of whether an area appears sufficiently damaged to warrant inclusion in a hand-drawn map. Aerial surveying also does not reveal damage from every major insect parasite. However, aerial surveying does represent a simple way to create a broad annual picture of the damage created by certain insects with highly visible defoliation effects including the five major insects for which information is included in this indicator. (3) Disease data. The data available to support this component of the indicator are limited to two plant diseases, with coverage beginning in 1997. Nonetheless, while disease data do not provide a great temporal range or a full accounting of all diseases affecting the nation's forests, this component of the indicator does provide a general picture of recent trends in forest disease, and some basis for comparison with other forms of forest disturbance (fire and insects).

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

This indicator does not demonstrate any bias towards sensitive populations or ecosystems. Because this indicator aims to give an overall picture of forest health in the United States, it is important that the indicator examine sensitive ecosystems in the proportion in which they naturally happen to occur. For this reason, the Forest Service typically conducts aerial surveys (FHM) and ground monitoring (FIA) using a grid-like methodology, so as to give equal weight to equal areas. This indicator presents data in the form of national totals, without any indication of what states or regions might be affected most by any of these forms of disturbance. Thus, this indicator cannot be used to characterize particular regions or ecoregions.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator does not include reference points or baseline values that unambiguously reflect the state of the environment. With no disease data earlier than 1997, this indicator provides no historical basis for comparison of current disease conditions. Insect and forest data cover longer periods of time, but neither of these components includes historical data that can unquestionably be considered representative of a natural or undisturbed state.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

(1) Fire data. Overall fire data represents a compilation of information reported by several government agencies (see T3Q2), each of which may have its own methods of measuring or estimating acreage burned. The National Interagency Fire Center (NIFC) has made summary statistics available to the public for 1960-2003, but the NIFC website does not include any information about measurement or estimation techniques. The Heinz Center obtained historic (1916-present) data from individuals at the Fire and Aviation Management branch of the USDA Forest Service (Forest Service, Andrea Wojtasek and Marian Villasenor, personal communication, 2004), but the Forest Service has not provided direct documentation of sampling or analytical methods either. The Forest Service can provide summary tables, but does not have a full library or record of the many state and federal reports that were consulted at the time annual statistics were compiled. (2) Insect data. The Heinz Center (2003) reports that insect data are derived from aerial surveys. This is consistent with The Forest Service s 2003 Report on Sustainable Forests (technical note for indicator 15: http://www.fs.fed.us/research/sustain/documents/Indicator%2015/Indicator%2015.pdf), which notes that the Forest Service has conducted aerial surveys for insect damage since 1947, with full national coverage beginning around 1979. The Forest Service conducted these surveys through its Forest Health and Monitoring (FHM) Program, which has published a general program description at http://www.na.fs.fed.us/spfo/fhm/fact/03/dm.pdf. FHM has also published a general description of guidelines for aerial detection surveys, including mapping grids (http://www.fs.fed.us/foresthealth/publications/id/id_guidelines.html). More specific documentation may be obtained from each of the Forest Service regional offices, which directly oversee the surveying program (http://www.fs.fed.us/foresthealth/regional_offices.html). Useful information from Forest Service regional sites includes contacts (all regions), a description of survey timing and flight patterns (http://www.fs.fed.us/r1-r4/spf/fhp/aerial/index.html), a discussion of mapping scale (http://www.fs.fed.us/r6/nr/fid/as/as-facts.shtml), and more general surveying guidelines (http://www.fs.fed.us/r5/spf/about/aerial-survey-guidelines.shtml). Aerial data are supplemented by FHM ground surveying in order to identify the parasite(s) responsible for damage that is visible from the air. These ground surveys are basically conducted as needed, not necessarily following a single consistent sampling methodology (Ken Stolte, Forest Service, personal communication, 2004). (3) Disease data. The Forest Service collected data on the two diseases included in this indicator (fusiform rust and dwarf mistletoe) through collaboration between FHM and the Forest Service s Forest Inventory and Analysis (FIA) program, which has conducted nationwide ground inventories of forest characteristics (e.g., size, age, density) since the 1940s. This collaboration began in 1990, as FIA started to incorporate tree health criteria into its nationwide Phase 3 ground monitoring program (http://hrcweb.nevada.edu/forestry/index.html). The disease data for this indicator, with coverage from 1997 to 2002, are the product of FIA s collection methods. FIA collects data from points on a rectangular or hexagonal (since 1998) national grid, following a three-phase approach in which basic measurements take place at many sites, but only a subset of sites (evenly spaced across the grid) are used for more intensive monitoring. Detailed disease data come from the most intensive monitoring (Phase 3) sites. FIA follows standard methodologies for ground sampling: see

http://fia.fs.fed.us/library/field-guides-methods-proc/ (field methods); http://ncrs2.fs.fed.us/4801/fiadb/fiadb_documentation/fiadb_chapter2.htm (plot size and design); and http://fia.fs.fed.us/library/fact-sheets/data-collections/Sampling and Plot

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

(1) Fire data. The Heinz Center (2003) reports that it obtained fire data from several sources: A database maintained by the National Interagency Fire Center (NIFC), located online at http://www.nifc.gov/stats/wildlandfirestats.html. This database lists the total number of acres burned each year from 1960 to 2003. NIFC data represents a compilation of data from several government agencies (USDA Forest Service, Bureau of Land Management, Bureau of Indian Affairs, U.S. Fish and Wildlife Service, National Park Service, and state agencies), but only summary figures are reported in the database, not figures from individual agencies. The U.S. Forest Service. The Fire and Aviation Management branch of the Forest Service has compiled annual fire statistics from reports issued by several state and federal agencies for their respective jurisdictions. A typical list of reporting agencies includes [Forest Service] field offices, the State Forester (or a comparable state official) of each of the 50 states, the officials of Puerto Rico and Guam, the Department of the Interior, and the Tennessee Valley Authority (Forest Service, 1992). Figures are available for 1916-present. Data are not available online, but summary figures may be obtained from Marian Villasenor at Fire and Aviation Management, mvillasenor@fs.fed.us. The Forest Service does not have a full library or record of every state or federal report that was consulted at the time each year s summary statistics were compiled. Forest Service. 1992. 1980-1994 Wildfire Statistics. USDA Forest Service, State and Private Forestry, Fire and Aviation Management Staff. January 1992. (2) The Heinz Center (2003) cites the Forest Service s Forest Health Conditions website (http://www.fs.fed.us/foresthealth/current_conditions.shtml) as a source of recent insect data. This site contains several annual reports, the most recent of which is Forest Insect and Disease Conditions in the United States 2003 (Washington, DC: USDA Forest Service, August 2004), located at http://www.fs.fed.us/foresthealth/publications/annual_i_d_conditions/ConditionsReport_03_final.pdf. This report includes numerical data on annual acreage affected by several insects for the period 1999-2003; for the five insects included in the Heinz indicator, this report also includes bar graphs with annual acreage figures for the period 1979-2003 (1940-2003 for the gypsy moth). The recent reports available online do not provide numerical data for insect acreage prior to 1999. However, the Heinz Center notes that it was able to obtain Insect and Disease Conditions reports from the Forest Service for 1979-83, 1984, 1985, 1986, 1987, 1993, 1997, 1998, and 1999 (Kent Cavender-Bares, Heinz Center, personal communication, 2004). (3) Disease data. The Heinz Center (2003) reports that it obtained 1997-2002 data on the two diseases covered by this indicator (fusiform rust and dwarf mistletoe) from the Forest Health Conditions website (http://www.fs.fed.us/foresthealth/current_conditions.shtml). Data are included within the annual reports posted at this site, as noted above. These reports list acreage affected, not raw data from individual ground monitoring sites. [These reports do not cover every state in every year. This is consistent with the old FIA methodology, where each ground site was only visited every 5 to 10 years. Thus, annual data come from measurements that were not taken every year.] (4) The numerical data represented in the graphics for this indicator may be obtained online from the Heinz Center (http://www.heinzctr.org/ecosystems/forest/datasets/forest_disturbance_recent_trends.shtml; http://www.heinzctr.org/ecosystems/forest/datasets/forest_disturbance_historic_trends.shtml).

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

This indicator s reliance on historical measurements limits reproducibility, even in cases where good documentation of survey design exists. For example, aerial survey results reflect subjective judgments and sketches made in real-time. Thus, insect damage assessments can only be reproduced to the extent that original sketches may still be available for re-analysis. For disease data, FIA describes field sampling methods in great detail. However, FIA and FHM only appear to provide access to metadata (overall acreage affected), not raw data from individual monitoring stations. FIA also maintains the confidentiality of its ground monitoring sites (FIA Fact Sheet: http://fia.fs.fed.us/library/fact-sheets/data-collections/Phase2_3.pdf). In the case of fire data, the Heinz Center and the government agencies that collected the data do not provide online access to raw data or documentation of survey design.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The various agencies responsible for fire data provide no online documentation of collection methods or related quality assurance/quality control procedures. The Forest Service has published general quality control procedures for the aerial surveys used to collect insect data for this indicator (Aerial Survey Standards. Forest Health Monitoring Program, October 1999. http://www.fs.fed.us/foresthealth/publications/id/standards_1099.pdf). This document indicates that more specific QA/QC information can be obtained from Forest Service regional offices, which directly oversee aerial surveys. The website http://www.fs.fed.us/foresthealth/regional_offices.html includes links to regional offices. Although some regional office websites have not posted extensive information about surveying online, all of these sites list contacts who may be able to provide more information. For disease data, several of the Fact Sheets and Field Guides in FIA s online library contain information about quality assurance and quality control in ground sampling (http://fia.fs.fed.us/library/). One document in particular, http://fia.fs.fed.us/library/fact-sheets/data-collections/QA.pdf (FIA Fact Sheet Series: Quality Assurance) provides a thorough discussion of many aspects of the QA/QC process.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

(1) Fire data. This indicator does not require temporal manipulation, since annual figures appear to be derived from annual acreage data reported by state and federal agencies. NIFC and the Forest Service maintain databases of annual summary figures, but these databases do not include information about the spatial aspects of data collection or manipulation. (2) Insect data. This component of the indicator requires no temporal manipulation, as it is reported on an annual basis from full aerial surveys conducted by the Forest Service. This component of the indicator does not require complicated spatial generalization or extrapolation either. The Forest Service surveys all forest area each year, so figures for total acreage basically represent the sum of all its surveys. (3) Disease data. Spatially, FIA uses a set of standard statistical procedures to convert ground measurements into figures of total acreage affected by a particular disease. While this spatial extrapolation does introduce uncertainty into the data, FIA has chosen the number of ground locations (i.e., the size of its probability sample) to ensure that uncertainty remains within a specific range (see T4Q2). Temporally, this component of the indicator represents a great deal of projection, since annual figures are based on state surveys that are only performed every 5 to 20 years. There is no attempt to project year-to-year changes using statistical methods; instead, old

data are just included as is, even if the data may no longer be accurate. This does not appear to be an appropriate method of deriving annual disease figures.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

(1) Fire data. Neither the Heinz Center nor the agencies responsible for collecting or compiling fire data
have published uncertainty data for this component of the indicator. (2) Insect data. The Forest Service does not explicitly quantify the uncertainty associated with its aerial surveying methods, although it does provide a discussion of mapping resolution/scale (http://www.fs.fed.us/r6/nr/fid/as/as-facts.shtml). (3) Disease data. The Forest Service s National Report on Sustainable Forests 2003 (http://www.fs.fed.us/research/sustain) does not present uncertainty measurements for the disease measurements upon which this indicator is based. However, FIA s QA/QC fact sheet specifically mentions that field data are always accompanied by uncertainty measurements (http://fia.fs.fed.us/library/fact-sheets/data-collections/QA.pdf). FIA s database documentation provides a general discussion of error in ground measurements like those used to collect recent (since the late 1990s) insect and disease data for this indicator (http://ncrs2.fs.fed.us/4801/fiadb/fiadb_documentation/fiadb_chapter2.htm). According to this source, FIA designs its inventories to meet specified sampling errors at the 67 percent confidence limit (one standard error). By Forest Service mandate, sampling error for area must not exceed 3% per 1 million acres; aerial design surveys like the one used for this indicator are designed accordingly. This source also quantifies the degree to which error may be magnified on a local scale, suggesting that this indicator is best suited to broad trends on a national scale.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Several sources of uncertainty and variability accompany this indicator, some of which may reduce its utility as a broad, national-level measuring tool. (1) This indicator includes fire data originally collected by several state and federal agencies. The agencies that compiled the data used in this report (NIFC-online; Forest Service-personal communication) do not have extensive information about methods, measuring standards, and the extent (or possible overlap) of the geographic jurisdictions of the various government agencies that collect raw data. There may be significant sources of uncertainty here, but the lack of supporting information makes the impact of this uncertainty difficult to assess. (2) Aerial surveys for insect damage have historically relied on human perception to determine the size of the area deemed disturbed. Because this indicator aims to measure very broad national trends, it does not require exact numbers or a high degree of local detail. The Forest Service's Region 6 website discusses this source of uncertainty (http://www.fs.fed.us/r6/nr/fid/as/as-facts.shtml) and provides a reference containing a more in-depth discussion: Klein, W.H., S. Tunnock, J.G.D. Ward, and J.A.E. Knopf. 1983. Aerial Sketchmapping. In: Forest Insect and Disease Survey Methods Manual, USDA Forest Service, Forest Pest Management, Methods Application Group, Davis, Calif., 15 pp. (3) By deriving a national acreage figure from ground samples conducted several miles apart (one sample per 96,000 acres, following a grid), FIA s Phase 3 sampling methodology may introduce uncertainty into recent data, particularly on a local scale (see T4Q2). FIA designs its procedures to keep error within specific bounds. However, because annual figures for the disease indicator are derived from non-annual state survey data (the 2003 disease data include information from some FIA state surveys that were conducted as early as the 1980s), the reported totals are actually of rather limited utility as a metric of true year-to-year trends. (4) The main source of variability in this indicator is natural. Fires can vary with weather patterns (e.g., droughts, lightning). Insects and diseases may fluctuate based on natural population cycles; for example, the Heinz Center (2003) attributes much of the insect variability over the last 20 years to population cycles involving the gypsy moth and southern pine beetle. However, this natural variability does not diminish the utility of the indicator. Instead, it provides one explanation for some of the year-to-year variations apparent in the indicator graphic.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

(1) This indicator does not differentiate among true wildfires and prescribed burns. [However, NIFC does have figures for prescribed burn acreage for the period 1995-2000 (http://www.nifc.gov/stats/).] (2) This indicator requires some simplification: an area is either disturbed or not disturbed. In the case of fire, the indicator cannot account for the intensity of fire damage. For insects and disease, the indicator cannot quantify how heavily an area has been affected; it can only report how many acres have either met a Forest Service threshold for the percentage of trees damaged, or just shown evidence that a particular parasite is present (in the case of ground surveying for disease). (3) Data are limited to five insects and two diseases. Thus, this indicator does not represent the full extent to which the nation's forests are affected by insects and disease. In particular, this indicator does not quantify damage associated with the hemlock wooly adelgid, whose damage may not be detected through aerial surveys until several years after the damage has occurred (Heinz Report, 2003). (4) The indicator only includes disease data from 1997 to 2002. Thus, it currently lacks a historical baseline for comparison of recent trends in disease prevalence. (5) Annual disease data are based on non-annual state surveys. Insect data may be similarly limited, since historically, FHM has not had a consistent methodology for completing a full national aerial survey every year. Some state surveys were last completed in the late 1980s or early 1990s. This may represent a significant limitation to this indicator.

Indicator: Changing Stream Flows (029)

Flow is a critical aspect of the physical structure of stream ecosystems (Poff and Allan, 1995; Robinson et al., 2002). Low flows define the smallest area available to stream biota during the year. Even though riparian vegetation and aquatic life in ephemeral streams in arid and semi-arid regions have evolved to complete their life histories during periods when water is available, extended periods of no-flow can significantly impact their survival (Fisher, 1995). High flows shape the stream channel and clear silt and debris from the stream, and some fish species depend on high flows for spawning. The timing of high and low flows also influences many ecological processes. Changes in flow can be caused by dams, water withdrawals, groundwater pumping (which can alter baseflow), and changes in land cover (e.g., deforestation or urbanization) or climate (Calow and Petts, 1992).

This indicator, which combines two indicators reported on by The Heinz Center (2002), reports on trends in two aspects of stream flow in the lower 48 states:

- **Flow magnitude and timing:** The percentage of streams or rivers with major changes in the magnitude or timing of their average annual 1-day high flows or 7-day low flows in the decades, 1970s, 1980s, and 1990s, compared to a reference period from 1930 to 1949. This indicator is based on 867 stream gauging sites with at least 20 years of discharge records within the target dates 1930 to 1949, and all 30 years of records for the 1970s, 1980s, and 1990s.

- **No-flow periods**: The percentage of streams in primarily grassland and shrubland watersheds in which no-flow periods occurred during the 1950s, 1960s, 1970s, 1980s, and 1990s; and the percentage of these streams in which the duration of no-flow periods during each of these decades represents an increase or decrease of more than 50% compared to the 50-year average (1950-1999). This indicator is based on 408 gauging sites in primarily grassland/shrubland watersheds in the contiguous 48 states, but the second component (duration of no-flow periods) only considers a subset of 143 sites that had at least one no-flow day between 1950 and 1999.

What the Data Show

More than half of the streams and rivers showed changes of 75% or more in their high or low flows or a shift of 60 days or more in the timing of their high or low flows, compared to the period 1930-1949 (Figure 029-1). This percentage increased from 55% in the 1970s to 61% in the 1990s. The corresponding statistics for streams and rivers showing changes of 25-75% in their high or low flows or a shift of 30-60 days in the timing of their high or low flows are 35% and 30% in the 1970s and 1990s, respectively. Only 10% of the streams and rivers had alterations of flow of less than 25% or timing of fewer than 30 days, compared to the 1930-1949 period (http://www.heinzctr.org/ecosystems/fr_water/strm_flows.shtml).

Approximately one-third of the streams and rivers showed increases, decreases, and/or changes in timing of their average annual 7-day low flows, compared to the 1930-1949 period, with a slight increase in those exhibiting higher low flows (37% in the 1990s compared to 31% in the 1970s) (Figure 029-2). The percentage of streams with increases in high flow also increased, from 12% in the 1970s and 1980s to 31% in the 1990s. There was no discernable trend in decreasing high or low flows over the same time period. Figure 029-2 shows a slight upward trend in the percentage of streams and rivers showing changes in the timing of high flows, from 41% in the 1970s to 47% in the 1980s and 1990s. A similar trend is evident in the timing of low flows: 32% of streams showed significant changes in timing during the 1990s, up from 27% in the 1970s.

Overall, the percentage of streams and rivers experiencing periods of no flow decreased from 24% in the 1950s to 14% in the 1990s across grassland and shrubland regions of the United States (Figure 029-3).

Among streams experiencing periods of no flow, the duration of these periods also decreased between the 1950s and 1990s (Figure 029-4). In the 1950s, 38% of these streams and rivers experienced no-flow periods that were at least 50% longer than their long-term average (1950-1999). By the 1990s, only 10% of streams fell into this category. The percentage of streams with no-flow periods at least 50% shorter than their long-term average increased from 23% in the 1950s to 63% in the 1990s.

Taken together, these indicators point to increases in high and low flows in streams and rivers between the 1950s and the 1990s, with streams and rivers in grassland and shrubland regions experiencing fewer or shorter no-flow periods. The 1980s were a relatively wet period, featuring some of the smallest percentages of no-flow periods during the 50-year period of record.

Indicator Limitations

- The "magnitude and timing" component of this indicator compares stream flows in the decades from 1970 to 1999 with a baseline period, 1930-1949. Many dams and other waterworks had already been constructed by 1930, and this baseline period was characterized by low rainfall in some parts of the country. However, a similar analysis based on data from 506 watersheds (Forest Service, 2004) showed a tendency toward higher high- and low-flow rates in the decades of the 1940s, 1950's and 1960s compared to the earlier period 1879-1929.

- The "dry periods" component of this indicator compares stream flows in the decades from 1950 to 1999 with average stream flow over the full 50-year period. Like the baseline discussed above, this long-term average does not represent the "natural state" of stream flow because it postdates anthropogenic changes such as urbanization, construction of dams, etc.

- Although the sites analyzed here are spread widely throughout the U.S., gauge placement by the USGS is not a random process. Gauges are generally placed on larger, perennial streams and rivers, and changes seen in these larger systems may differ from those seen in smaller streams and rivers.

Data Sources

Data for this indicator came from the U.S. Geological Survey gauging station network, http://waterdata.usgs.gov/nwis. Analysis was conducted for the Heinz Center by David Raff and N. LeRoy Poff, Colorado State University (Raff and Poff, 2001; Raff, Howard, and Poff, 2001).

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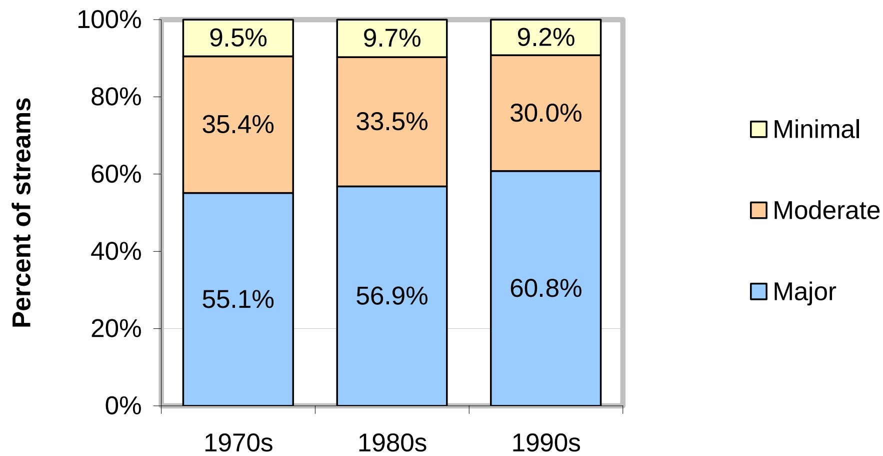
Graphics

Figure 029-1. Alteration of key flow characteristics (compared with 1930-1949)



Major: more than 75% increase or decrease in flow, or more than a 60-day change in timing of low or high flow.
Moderate: between 25% and 75% increase or decrease in flow, or a 30- to 60-day change in timing of low or high flow.
Minimal/stable: less than 25% increase or decrease in flow, or less than 30-day change in timing of low or high flow.

Figure 029-2. Major changes in high and low flow (compared with 1930-1949)

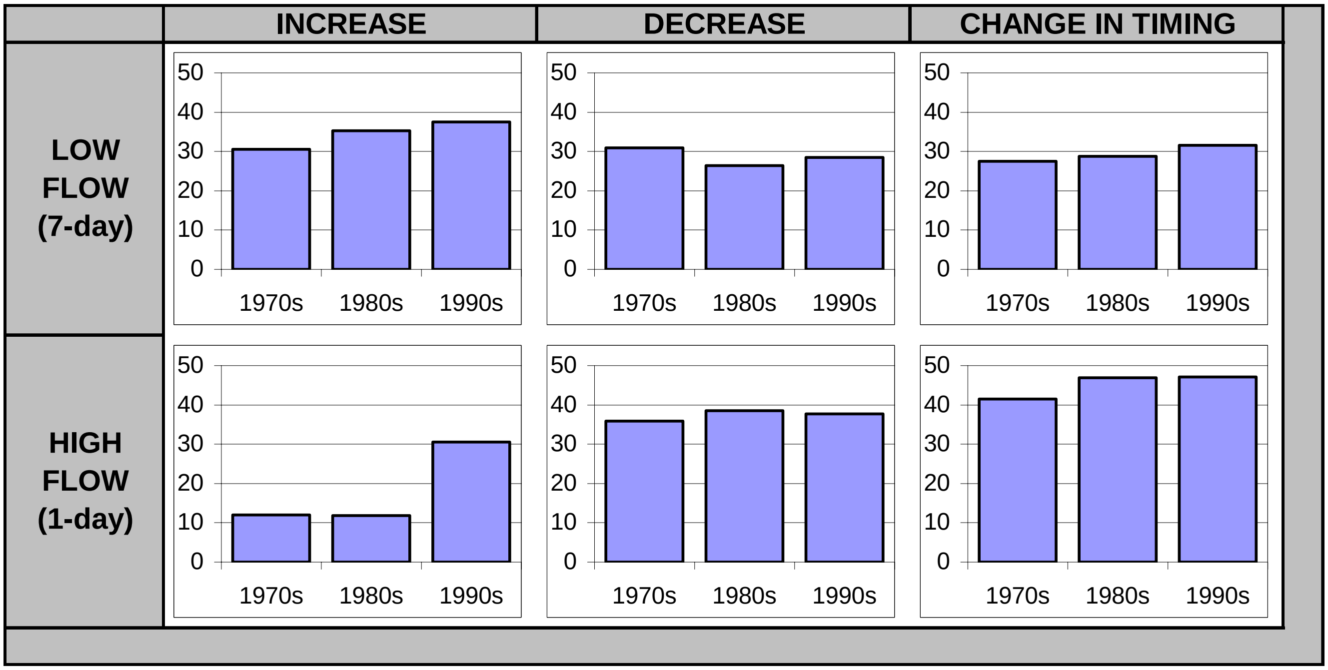


Figure 029-3. Percentage of grassland/shrubland streams experiencing periods of no flow

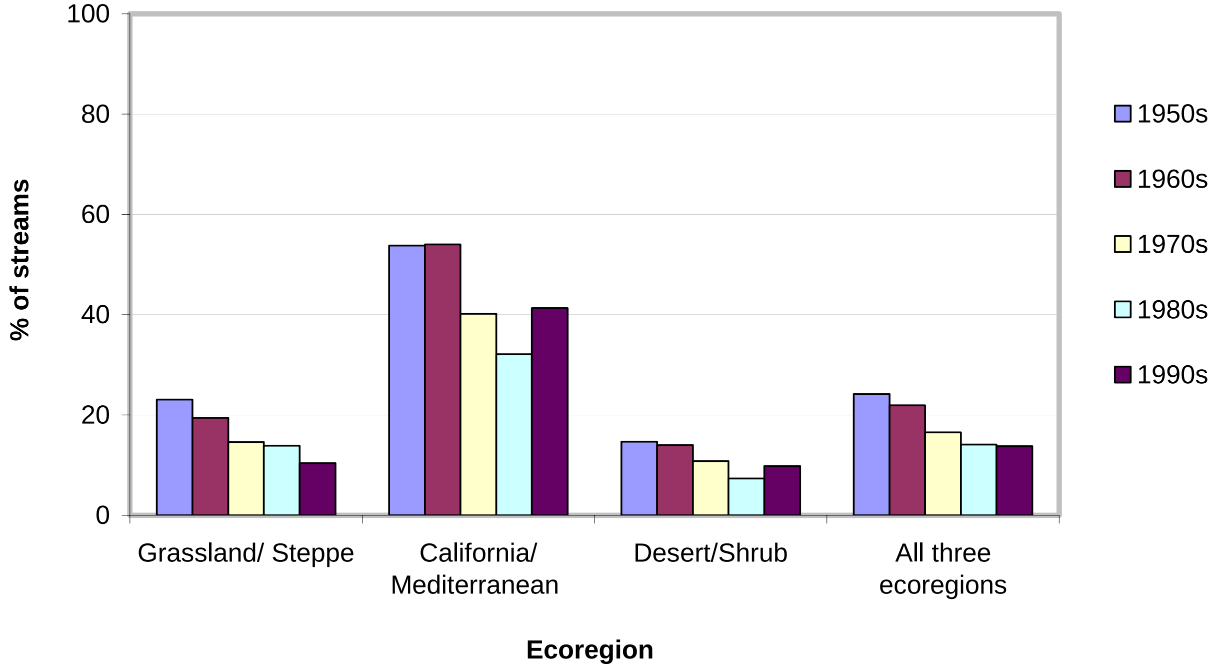
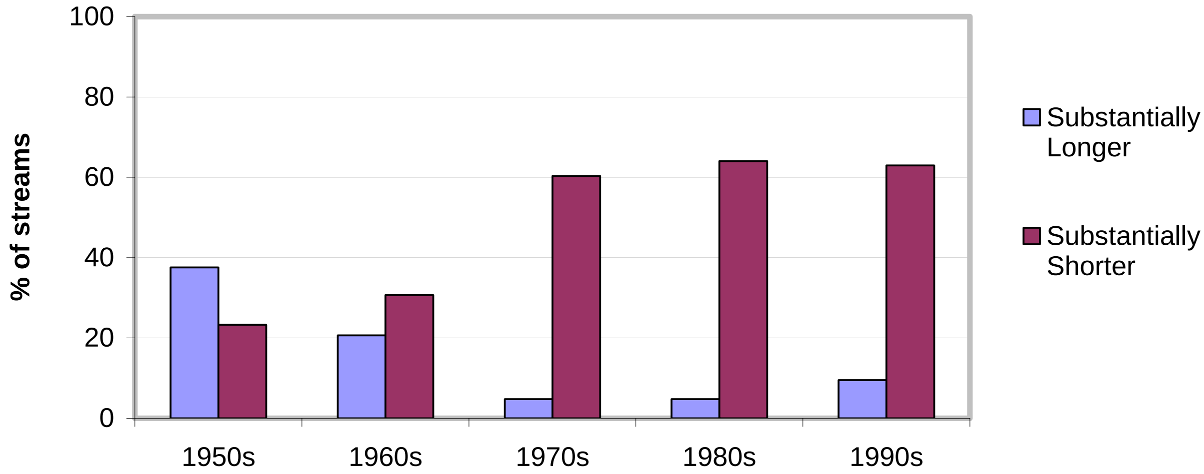


Figure 029-4. Duration of no-flow periods in intermittent streams* (compared to 50-year average, 1950-1999)



*For this analysis, an "intermittent" stream is any stream having at least one day of no flow between 1950 and 1999. A total of 143 grassland/shrubland streams met this criterion. Percentages reported in this chart are out of these 143 "intermittent" streams, not out of the full set of 408 grassland/shrubland streams.

A no-flow period is considered "substantially longer" if it is at least twice as long as the 50-year average for a given stream, and "substantially shorter" if it is 50% or less of the 50-year average. A decade without any no-flow days qualifies as "substantially shorter."

R.O.E. Indicator QA/QC

Data Set Name: CHANGING STREAMFLOWS
Indicator Number: 029 (89605)
Data Set Source: U.S. Geologic Survey
Data Collection Date: regular: 1949-1999
Data Collection Frequency: daily
Data Set Description: Combine: Changing Streamflows 029, Number/duration of dry stream flow periods in grasslands/shrublands 030, and Streamflow extremes in forest watersheds 343
Primary ROE Question: What are the trends in the critical physical and chemical attributes of the Nation's ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. This indicator, which combines two Heinz Center (2002) indicators -- changing stream flows ("magnitude and timing") and dry periods in grassland/shrubland streams -- is derived from stream gauge measurements conducted by the U.S. Geological Survey (USGS) in the lower 48 states. USGS stream gauges at hundreds of locations collect raw data on either water depth or discharge volume (flow volume per second). If the equipment is not present to measure discharge directly (using a current meter), then depth is transformed into volumetric discharge using analytical methods described in T1Q3. USGS has been collecting stream gauge data since the late 1800s. Documentation of standard USGS field sampling procedures can be found online at http://water.usgs.gov/pubs/twri/.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. USGS's network of stream gauging stations is designed to provide a comprehensive inventory of streamflow throughout the lower 48 states. USGS currently collects data from over 7,000 continuous monitoring stations (http://water.usgs.gov/wid/html/SG.html). Gauges are not placed randomly but are sited so as to capture information from relatively large, perennial streams and rivers (Heinz Center, 2002). Measurements are taken multiple times per day. For its "magnitude and timing" indicator, the Heinz Center used a subset of 867 stream gauging sites, chosen because each site met two basic criteria for data availability: (1) daily data for each year from 1970 to1999; and (2) daily data from 1930 to 1949, to serve as a baseline for comparison. (http://www.heinzctr.org/ecosystems/fr_water_technotes/fr_water_chg_strm_flows.shtml). [Note: The baseline may actually be any 20-year period within 4 years of the target period (1930-1949). This source of uncertainty is discussed in T4Q3.] The resulting 867-site sample is distributed across the entire 48 conterminous states, but with a higher density in the Northeast and Mid-Atlantic States, the Rocky Mountains, and the Pacific Northwest (Raff, D., and N. Poff 2001. Final Report on Hydrologic Alteration of Rivers and Streams in support of the State of the Nation's Ecosystems Project for The H. John Heinz III Center. Colorado State University.) For its "dry periods" indicator, The Heinz Center selected two subsets of USGS measuring sites for analysis, one for each graphic. For its comparison of "Streams that have Zero-Flow Periods," the Heinz Center looked at all USGS measuring sites that had a complete 50-year record (October 1949 to September 1999) and were located within 4-digit Hydrologic Unit Code (HUC4) watersheds containing 50 percent or greater grass/shrub cover, corresponding with National Land Cover Dataset (NLCD) classes 31, 51, and 71 (http://landcover.usgs.gov/classes.asp). A total of

408 stream gauges met the criteria for "Streams that have Zero-Flow Periods." In their analysis of "Duration of Zero-Flow Periods," the Heinz Center included only those grassland/shrubland streams that had at least one day of zero flow during the 50-year period of interest -- a total of 143 data points out of the original 408. The Heinz Center does not discuss the spatial distribution of selected sites. However, the original analysis of the data includes a discussion of how data points are distributed among different "ecoregions" (Raff, D., S. Howard, and N. Poff 2001. Report on Hydrologic Alteration of Rivers and Streams in Predominantly Grassland and Shrubland Ecosystems in support of the State of the Nation's Ecosystems Project for The H. John Heinz III Center. Colorado State University.; Raff, D. 2001. Addendum to Report on Hydrologic Alteration of Rivers and Streams in Predominantly Grassland and Shrubland Ecosystems in support of the State of the Nation's Ecosystems Project for The H. John Heinz III Center. Colorado State University.) For a definition of ecoregions, see http://www.fs.fed.us/colorimagemap/ecoreg1_divisions.html.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The conceptual model used in transforming raw streamflow data into indicator data consists of two basic steps. The first step is conducted by USGS and involves the conversion of depth measurements to discharge data, reported in units of volume of water per second (daily averages). USGS describes conversion techniques at http://water.usgs.gov/pubs/twri/ (specific reference: Book 3, Chapter A10). This step is only necessary for those measuring sites that lack equipment to directly measure discharge (e.g., a current meter). Site-specific particulars on location and method of discharge measurement are available from USGS's site inventory (http://waterdata.usgs.gov/nwis/si). The second step is the analysis conducted by the Heinz Center in compiling its indicators. These steps are outlined in the Heinz report and in the underlying reports by Raff and Poff (2001) and Raff, Howard, and Poff (2001). Data for "magnitude and timing" are evaluated using Indicators of Hydrologic Alteration (IHA) software produced by the Nature Conservancy together with Smythe Scientific Software. Using this software, each decadal streamflow value is classified into one of three categories, based on the degree by which it differs from the 20-year baseline for the stream in question. Data are also categorized by the degree to which timing of peak streamflow has changed in relation to the baseline average. The IHA software is available from http://www.freshwaters.org/tools; this website also lists several peer-reviewed papers that support the IHA methodology. The rubric for final stream classification (three categories, based on the degree of deviation from the baseline) is located at http://www.heinzctr.org/ecosystems/fr_water_technotes/fr_water_chg_strm_flows.shtml. For the "dry periods" indicator, daily flow data from each stream were analyzed to determine: (1) whether the stream has experienced at least one zero-flow day over the course of the year; and (2) the duration of the zero-flow period (in days). For the latter quantity, each stream is compared with its 50-year average in order to classify a given year's dry period as either substantially longer than average (100 percent or greater increase), substantially shorter (50 percent or greater decrease), or neither. In both cases, annual data are averaged over the course of a decade. In addition, in compiling the zero-flow data, data points are sorted by land cover type and "ecoregion." The former designation comes from the National Land Cover Dataset (NLCD) and is used to select only sites with greater than 50 percent grass/shrub cover. The NLCD combines information from Landsat imagery and various government agencies and is documented at http://landcover.usgs.gov. The Bailey "ecoregion" designation used to break data down by ecosystem type is documented by: Bailey, R.G. 1995. Description of the ecoregions of the United States. 2nd ed. rev. and expanded (1st ed. 1980). Misc. Publ. No. 1391 (rev). Washington, DC: USDA Forest Service.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

This indicator is conceptually appropriate for assessing the physical health of the nation's ecosystems. It is also well designed to report on broad trends in streamflow patterns, as each of the component indicators groups data by decade, and each includes a baseline for comparison. For "changing streamflows," the 867-site sample is distributed across the entire 48 conterminous states, but with a higher density in the Northeast and Mid-Atlantic States, the Rocky Mountains, and the Pacific Northwest (Raff, D., and N. Poff 2001, Final Report on Hydrologic Alteration of Rivers and Streams in support of the State of the Nation's Ecosystems Project for The H. John Heinz III Center. Colorado State University). It is not clear whether this data set captures a significant percentage of the nation's total streamflow. USGS stream gauges are not placed at random; in general, they are sited on relatively large, perennial streams (Heinz Center, 2002). USGS does document the locations of its full inventory of gauging sites (http://nwis.waterdata.usgs.gov/nwis/si). The data set for "dry periods" is thorough in temporal terms: 50 years of daily average measurements, October 1949 to September 1999. Spatially, this component of the indicator includes 408 data points for one graphic ("Streams That Have Zero-Flow Periods") and 143 for the other ("Duration of Zero-Flow Periods"). While these numbers may appear small, they do represent the full extent of USGS data available to characterize grassland/shrubland streams and grassland/shrubland streams with a history of zero-flow periods, respectively. Sample design lacks some transparency, as neither the Heinz Center nor the underlying analysis discusses whether the geographic distribution of data points is sufficient to characterize broad, national-scale trends for grassland/shrubland streams (Raff, D., S. Howard, and N. Poff 2001. Report on Hydrologic Alteration of Rivers and Streams in Predominantly Grassland and Shrubland Ecosystems in support of the State of the Nation's Ecosystems Project for The H. John Heinz III Center. Colorado State University). However, the paper by Raff, Howard, and Poff (2001) notes that data points are well distributed among several different ecoregions.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

Sampling for "magnitude and timing" is not designed to give any special preference to streams that happen to contain sensitive populations or ecosystems, as this indicator is a composite of 867 streams that were chosen for data availability, not sensitivity characteristics. Sampling for "dry periods" is specifically designed to represent sensitive populations and ecosystems. Every stream in this indicator data set was chosen because of the type of ecosystem it supports (grassland/shrubland), while streams were included in the "Duration of Zero-Flow" graphic only if they had at least one day of zero flow during the 50-year sampling period. More than just changes in flow, the actual drying up of streams places great stress on any population that lives in the water. Thus every stream in this sample has populations and ecosystems that are sensitive to this stressor. In addition, changes in the duration of zero-flow periods can affect populations that have adapted their life cycles to specific drying-and-wetting regimes, and remain very sensitive to alterations in those regimes (Heinz Center, 2002).

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Neither of the components of this stream flow indicator has an established reference point that unambiguously reflects the state of the environment. Both indicator components make use of a baseline average, but only to facilitate comparison. For "dry periods," the baseline for each stream is the mean number of annual zero-flow days, calculated over the 50-year sampling period. For "magnitude and timing," the baseline for each stream is 20 years of continuous measurements taking place primarily during the 1930s and 1940s. In the latter case, the baseline happens to be a period of historically low rainfall across much of the United States, including the period known as the "Dust Bowl" (Heinz Center, 2002). For both indicator components, the baseline period occurred after many significant human modifications had already been made to streams across the nation (e.g., dams and irrigation systems) (Heinz Center, 2002). Thus, neither baseline can be considered representative of an unmodified "natural state" of stream flow patterns.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Sampling and analytical procedures are well documented. Sample collection methodology is documented in USGS procedural manuals: depth (stage) gauging (http://water.usgs.gov/pubs/twri/twri3-A6/ and http://water.usgs.gov/pubs/twri/twri3a7/); conversion of depth to discharge (http://water.usgs.gov/pubs/twri/twri3-a1/ and http://water.usgs.gov/pubs/twri/twri3-a10/); direct measurement of discharge (http://water.usgs.gov/pubs/twri/twri3a8/). Analysis of "changing stream flow" data is described briefly by the Heinz Center, at http://www.heinzctr.org/ecosystems/fr_water_technotes/fr_water_chg_strm_flows.shtml, and in greater depth within the references cited by the organization that developed the software used for this analysis (http://www.freshwaters.org/tools). For the "dry periods" data, a basic description of analytical procedures is given in the Heinz report (http://www.heinzctr.org/ecosystems/grass_technotes/grass_dry_prds_strms.shtml). The "ecoregions" categorization methodology is discussed in: Bailey, R.G. 1995. Description of the ecoregions of the United States. 2nd ed. rev. and expanded (1st ed. 1980). Misc. Publ. No. 1391 (rev). Washington, DC: USDA Forest Service. Analysis of both indicator components was conducted by David Raff, Department of Civil Engineering, Colorado State University, and N. LeRoy Poff, Department of Biology, Colorado State University. Their reports detail the criteria for data selection and the steps of their analysis. Raff, D., and N. Poff 2001, Final Report on Hydrologic Alteration of Rivers and Streams in support of the State of the Nation's Ecosystems Project for The H. John Heinz III Center. Colorado State University. Raff, D., S. Howard, and N. Poff 2001. Report on Hydrologic Alteration of Rivers and Streams in Predominantly Grassland and Shrubland Ecosystems in support of the State of the Nation's Ecosystems Project for The H. John Heinz III Center. Colorado State University. Raff, D. 2001. Addendum to Report on Hydrologic Alteration of Rivers and Streams in Predominantly Grassland and Shrubland Ecosystems in support of the State of the Nation's Ecosystems Project for The H. John Heinz III Center. Colorado State University.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Discharge data for all of USGS's stream gauge locations can be obtained online at http://nwis.waterdata.usgs.gov/usa/nwis/discharge. Some of these locations have been monitored since the late 19th century, but for others, data are only available for recent decades. At some locations, USGS does not measure discharge directly. Here, USGS calculates daily discharge using measurements of stream depth, which are also available online (http://nwis.waterdata.usgs.gov/usa/nwis/measurements). USGS publishes a full inventory of its monitoring sites, including exact location and the types of measuring equipment in use (http://waterdata.usgs.gov/nwis/si). The land cover data used to choose sites for "dry period" analysis can be obtained from an NLCD (National Land Cover Dataset) website administered by

USGS's Earth Resources Observations Systems (EROS): http://landcover.usgs.gov. "Ecoregions" are defined and delineated at http://www.fs.fed.us/colorimage map/ecoreg1_divisions.html. The Heinz Center has not published the exact list of stream gauging sites included in either of its streamflow indicators, but the underlying analyses by Raff and Poff (see T3Q1 for citations) offer thorough descriptions of the criteria used in querying USGS data for inclusion. Complete analytical output can also be found in the Raff and Poff reports cited in T3Q1. The Heinz Center has published the numerical data from the graphs in the 2002 Heinz Report:
1.http://www.heinzctr.org/ecosystems/fr_water/datasets/freshwater_changing_stream_flow_characteristics.shtml;
2.http://www.heinzctr.org/ecosystems/fr_water/datasets/freshwater_changing_stream_low_flow.shtml;
3.http://www.heinzctr.org/ecosystems/fr_water/datasets/freshwater_changing_stream_high_flow.shtml;
4. http://www.heinzctr.org/ecosystems/grass/datasets/grass-shrub_perennial_zero_flow_periods.shtml;
5.http://www.heinzctr.org/ecosystems/grass/datasets/grass-shrub_perennial_duration_zero_flow_periods.shtml

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

In general terms, the study design is sufficiently well documented to allow both components of this indicator to be reproduced. Using USGS discharge data as a starting point, the methodology involves selecting data points that meet certain criteria (see T1Q3), calculating average values and percent changes, and then classifying data by either the degree of change or the physical "ecoregion" represented. The IHA software program used by Heinz may be obtained free online, making re-analysis even easier. Because the Heinz Center has not provided specific information about which USGS gauging stations were included in either of their analyses, it may be difficult to reproduce the Heinz Center's figures exactly. However, it may be possible to reproduce the list of data points included in each analysis using query criteria from the Raff and Poff reports (see T3Q1) and information from the NLCD.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The USGS procedural manuals cited in T3Q1 provide detailed technical information about collection equipment. These manuals do not specifically discuss QA/QC, but another USGS publication provides very thorough coverage of both accuracy and QA/QC for stream stage and discharge equipment (Rantz et al., "Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge," http://water.usgs.gov/pubs/wsp/wsp2175/pdf/WSP2175_vol1a.pdf). QA/QC procedures for the analytical stages used in creating this indicator are not documented in the Heinz Report or the Raff and Poff reports (citations in T3Q1).

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

This indicator does not require any projection of data beyond the temporal bounds of the measuring periods, because all of the streams chosen for analysis have daily flow data for the entire period of measurement. The main sources of temporal generalization are the simple process of averaging daily figures to get yearly or decadal mean values (for "magnitude and timing") and the similarly simple process of summing the number of zero-flow days to get annual and consecutive-day values (for "dry periods"). This generalization reduces the influence of outlier values by smoothing the data set over longer time periods, and provides a means for easy graphical analysis. No statistical procedures have been used either to portray data beyond the spatial extent of sampling or to generalize the data spatially. The only possible example of spatial generalization related to this indicator is if the observer interprets the data to be quantitatively representative of either the nation as a whole or the individual "ecoregions" by which the data may be divided.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

The Heinz Report does not provide any quantification of uncertainties associated with this indicator, either in the original data set or in the analytical output. For raw discharge measurements, USGS has published a general online reference devoted to the calculation of error (Sauer and Meyer 1992, "Determination of error in individual discharge measurements," http://pubs.er.usgs.gov/pubs/ofr/ofr92144). The Raff and Poff report for "magnitude and timing" (2001) includes a chart of 95 percent confidence intervals for each of the final outputs. The Raff and Poff report for "dry periods" does not include a similar analysis. An uncertainty measurement has been published for the National Land Cover Dataset (NLCD), which is used to screen stream gauging points for inclusion in the "dry periods" analysis. According to the Heinz Center, the NLCD has 80 percent or higher accuracy for the eastern United States, while the western United States is still under review. A detailed discussion of error in the NLCD can be found at http://landcover.usgs.gov/accuracy. No similar information is immediately available in reference to the delineation of "ecoregions," but such information may be included in the original document that developed this approach: Bailey, R.G. 1995. Description of the ecoregions of the United States. 2nd ed. rev. and expanded (1st ed. 1980). Misc. Publ. No. 1391 (rev). Washington, DC: USDA Forest Service.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

As noted in T4Q2, uncertainty is explicitly quantified for "magnitude and timing." Confidence intervals are not so large that they drastically reduce the utility of the indicator, but they do suggest that this indicator should be taken more as evidence of general trends than as an exact set of numbers. The Heinz Center and the underlying data report do not quantify uncertainty for "dry periods," although this uncertainty might be expected to be larger than error for "magnitude and timing," since the data set is smaller. Variability is not quantified, but it is expected that streamflow will vary on a daily or even hourly basis. USGS handles this variability by making measurements several times a day and then reporting a daily average. However, additional uncertainty in the Heinz Center's "magnitude and timing" indicator may limit the utility of comparing modern data to baseline values. The Heinz Center compares streamflow with a baseline that is not consistent across all gauging stations. While all stations have a 20-year baseline, this 20-consecutive-year period is not specifically defined as 1930-1949. Instead, periods used may deviate from this standard period by up to 4 years, depending on data availability.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

(1) This indicator measures environmental condition, not the causes of that condition. The 1980s appear to be marked by higher streamflows and fewer streams with zero flow, but it is not known whether this is a result of high precipitation, changes in precipitation patterns, changes in plant communities, changes in water management policies (e.g., diversion for irrigation), development, or a combination of factors. (2) The "magnitude and timing" indicator compares streamflows in decades 1970-1999 to a baseline period, 1930-1949. In some parts of the country, this period saw rainfall well below longer-term averages (Heinz Center, 2002). In addition, many dams, water works, and other forms of human interference with streamflow were introduced during or prior to this baseline period. As such, baseline values do not necessarily represent a "normal" or "natural" state. (3) Gauge placement is not a random process. USGS gauges are generally placed on larger, perennial streams and rivers (Heinz Center, 2002). Thus, small or intermittent streams may be underrepresented or undercounted. Changes observed in the larger streams may differ from those seen in smaller rivers or streams. (4) Some bodies of water have gauges operated by other entities like the U.S. Army Corps of Engineers (USACE), but only data from USGS gauges were used in calculating this indicator (Heinz Center, 2002). The Heinz Center does not discuss the extent to which USACE gauges may represent waterways that are already measured by USGS gauges.

Indicator: Carbon Storage in Forests (116)

After carbon dioxide is converted into organic matter by photosynthesis, carbon is stored in forests for a period of time in a variety of forms before it is ultimately returned to the atmosphere through the respiration and decomposition of plants, animals, and the paper and wood products that result from tree harvest. A substantial pool of carbon is stored in woody biomass (roots, trunks, and branches). Another portion eventually ends up as organic matter in the upper soil horizons. Carbon storage in forest biomass and forest soils is an essential physical and chemical attribute of stable forest ecosystems.

This indicator, developed by the USDA Forest Service (USDA, 2004), tracks carbon storage in the pools of living and dead biomass in forests in the conterminous 48 states. The carbon pools for this indicator are estimated using USDA Forest Service Forest Inventory and Analysis (FIA) data from five historical periods (circa 1953, 1963, 1977, 1987, and 1997). These data cover 37 states, mostly east of the Mississippi, in the Rocky Mountains, or on the Pacific Coast (Smith et al., 2001). Alaska and Hawaii are not included because of limited historical data. Carbon storage is estimated by the FIA program using on-the ground measurements of tree trunk size from many forest sites and statistical models that show the relationship between trunk size and the weight of branches, leaves, coarse roots (>0.1 inch in diameter), and forest floor litter, combined with estimates of forest land area obtained from aerial photographs and satellite imagery. These values are converted into carbon storages based on the results of previous field studies (Smith and Heath, 2002; Smith et al., 2003; Birdsey, 1996). Forest floor litter includes all dead organic matter above the mineral soil horizons, including litter, humus, small twigs, and coarse woody debris (branches and logs greater than 1.0 inches in diameter lying on the forest floor). Organic carbon in soil is not included.

What the Data Show

The change in carbon inventories from year to year represents the net growth of trees, minus the amount of carbon removed in harvested timber. The average rates of net carbon storage in forests increased between the 1950s and the 1980s, but declined somewhat during the 1990s (Figure 116-1). This trend varies among regions of the country, but net storage has been positive in all regions during the past two decades (Figure 116-2).

The rate of storage for the last period of record (1987-1996) decreased to 135 MtC/yr, with declining sequestration evident in live, dead, and understory pools. This decline is thought to be due to a combination of increased harvests relative to growth, more accurate data, and better accounting of emissions from dead wood (USDA, 2004).

The Northern region is sequestering the greatest amount of carbon, followed by the Rocky Mountain region (Figure 116-2). The trend of decreasing sequestration in the South is due to the increase in harvesting relative to growth. Some of the harvested carbon is sequestered in wood products (USDA, 2004).

Indicator Limitations

- The data include only forest classified as “timberland,” which excludes about one-third of U.S. forest land cover. Historical data from Alaska and Hawaii are insufficient for inclusion in this indicator.
- Data are derived from state inventories that do not correspond exactly to the decades identified in Figure 116-1.
- Carbon stored in soil is not included.

- Carbon pools are not measured, but are estimated based on inventory-to-carbon relationships developed with information from ecological studies

These limitations are discussed in detail in Smith and Heath (2000, 2001) and Heath and Smith (2000).

Data Sources

The data sources for this indicator were the Forest Inventory and Analysis, U.S. Department of Agriculture (1979-1995); *and Data Report; A Supplement to the National Report on Sustainable Forests, 2003* U.S. Department of Agriculture, Forest Service (2004). http://www.fs.fed.us/research/sustain/one_pagers/indicator%2027.pdf, http://www.fs.fed.us/research/sustain/documents/Indicator%2027/c5i27.pdf.

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USDA Forest Service. 2004. National Report on Sustainable Forests – 2003. Washington, DC: USDA Forest Service. http://www.fs.fed.us/research/sustain/.

Graphics

Figure 116-1. Average annual net forest carbon storage (Mt/yr) by component, 1953-1996

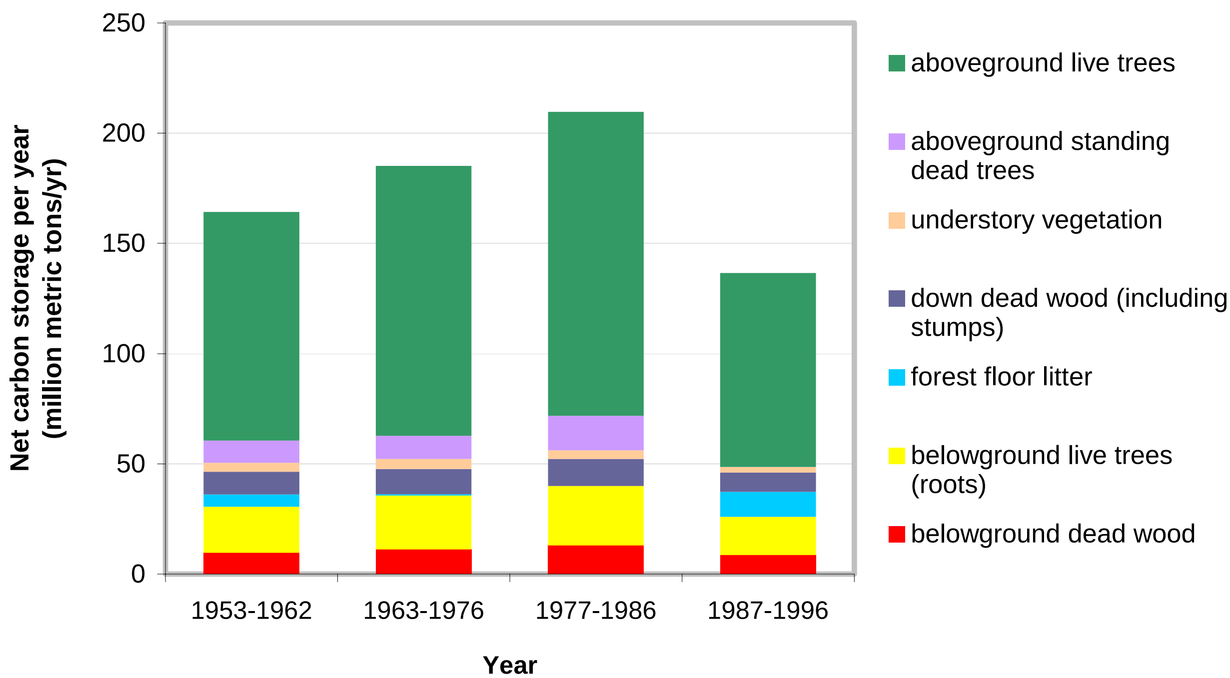
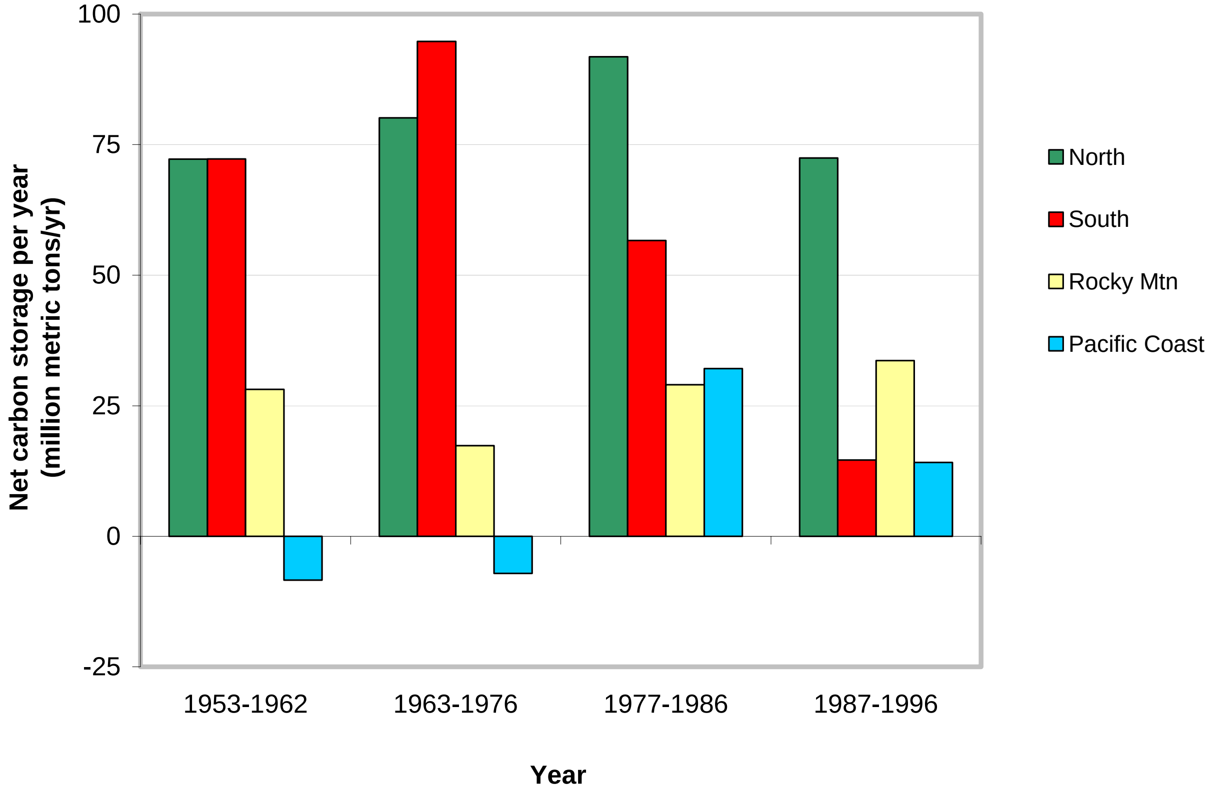


Figure 116-2. Average annual net forest carbon storage (Mt/yr) by region, 1953-1996



R.O.E. Indicator QA/QC

Data Set Name: CARBON STORAGE IN FORESTS
Indicator Number: 116 (89663)
Data Set Source: U.S. Department of Agriculture
Data Collection Date: Irregular: 1953, 1963, 1977, 1987, 1997
Data Collection Frequency: variable
Data Set Description: Carbon Storage in Forests
Primary ROE Question: What are the trends in the critical physical and chemical attributes of the Nation's ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The U.S. Department of Agriculture (USDA) Forest Service's Forest Inventory and Analysis (FIA) Program developed this indicator from field measurements of on-ground tree diameter taken throughout the lower 48 states (USDA 2004). FIA describes current (2004) field data collection methodology in procedural manuals available online (http://fia.fs.fed.us/library/field-guides-methods-proc/). These manuals do not include explicit scientific or peer-reviewed support for tree diameter measurement. However, FIA has always employed a consistent methodology for measuring diameter: 4.5 feet from the ground, measured on the uphill side of the tree if it is on a slope. FIA also has a consistent (albeit complicated) way of measuring trees with multiple trunks (Linda Heath, Forest Service, personal communication, 2004). Calculations of total carbon storage require estimations of forest land area, which the Forest Service obtained through analysis of aerial photographs and satellite imagery. Smith et al. (2001) provides documentation of this process. While the Forest Service does not provide explicit scientific support for this methodology, government agencies regularly use aerial image analysis in their efforts to classify land uses, most notably in the National Land Cover Dataset (NLCD), available from USGS.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

The Forest Service does not present full information about historic sampling design online. FIA methodologies have varied from year to year and from region to region, at least in terms of overall sample grids (Forest Service, Ken Stolte, personal communication, 2004). However, current FIA sampling procedures provide useful information about the general principles by which the FIA program has operated through the years. FIA's current (2004) sampling plan consists of three analytical phases. In Phase 1, the phase of lowest detail, FIA analyzes aerial photographs and satellite imagery to determine general characteristics of forest cover. FIA also uses Phase 1 imagery to plot a grid of locations for ground monitoring in Phase 2. Phase 3 represents a more detailed ground assessment than Phase 2; this monitoring takes place at a subset of Phase 2 locations. FIA has published fact sheets to support and explain this three-tiered sampling methodology: a detailed description of phases (http://fia.fs.fed.us/library/fact-sheets/data-collections/Phase2_3.pdf) and sampling and plot design (http://fia.fs.fed.us/library/fact-sheets/data-collections/Sampling and Plot Design.pdf). According to a general description of the FIA Program at http://fia.fs.fed.us/library/fact-sheets/data-collections/FIA_Data_Collection.pdf, Phase 2 consists of approximately one ground site per 6,000 acres, where data collectors make basic observations about forest characteristics (e.g., age and density) as well as basic measurements like tree diameter. Phase 3 consists of one site per

96,000 acres, where researchers gather more detailed measurements (e.g., tree damage from ground-level ozone) (http://fia.fs.fed.us/library/fact-sheets/data-collections/Phase2_3.pdf). Although FIA presents no documentation to confirm that the FIA program operated under these procedures when it conducted earlier measurements (data for this indicator dates back to 1953), other sources do confirm that FIA has consistently used a similar multi-tiered approach. As noted in Draft ROE/03, p. B-39, FIA has historically monitored about 450,000 Phase 2 sites (roughly every 3 miles), and approximately 125,000 Phase 3 sites. The measurements used to construct this indicator most likely would have come from Phase 2 sites. FIA has documented temporal aspects of sample design, but does not present explicit scientific support. However, additional scientific support for FIA methods may be found in a special issue of the Journal of Forestry (vol.7, no. 12, 1999).

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The Forest Service estimates carbon storage from measurements of tree diameter using a series of statistical models that are supported by scientific/peer-reviewed literature (see T3Q1 for complete references). (1) This indicator requires the use of statistical models that show the relationship between trunk size and the weight and volume of branches, leaves, and coarse roots. For this step, the Forest Service uses species-specific "taper models." While models varied over time and from one FIA region to another (Linda Heath, Forest Service, personal communication, 2004), a good general reference for these models is: Hansen, Mark. 2003. Volume and biomass estimation in FIA: national consistency vs. regional accuracy. pp. 109-120. In: McRoberts, R.E., and others. Proceedings of the third annual forest inventory and analysis symposium; 2001 October 17-19; Traverse City, MI. Gen Tech Rep NC-230. St. Paul MN: US Dept of Agriculture, Forest Service, North Central Research Station. 208 pp. (http://ncrs.fs.fed.us/pubs). (2) The Forest Service uses live-tree volumes to estimate carbon reservoirs, following equations derived from ecological studies and described by Smith et al. (2003). The Forest Service estimates carbon in the forest floor using additional models that account for forest area, type, and age (Smith and Heath, 2002). Carbon in understory vegetation is estimated using equations given in Birdsey (1996). In general, the process of converting forest inventory data to carbon through biometrical models is supported by forest scientists as a standard analytical approach (IPCC, 1997; Barford et al., 2001; full citations in T3Q1). (3) The Forest Service divides carbon reservoirs into specific types (e.g., understory, down dead, forest floor) based on standards documented by Smith et al. (2001). For example, Smith et al. defined forest floor litter as all dead organic matter residing above the mineral soil horizons, and considered roots a part of the live tree if they met a basic size criterion (>0.1 inches in diameter).

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

This indicator provides useful information about the function and sustainability of the nation's ecosystems, as net storage of carbon in forests is considered a proxy for forest productivity. The sampling design enables this indicator to represent trends over a relatively large time period, rather than year-to-year. FIA data collection has historically taken place at multi-year intervals (Ken Stolte, Forest Service, personal communication, 2004), and thus far, the data used to generate this indicator represent only five general periods of measurement (circa 1953, 1963, 1977, 1987, and 1997). However, the years chosen for analysis are sufficiently well spaced to enable inter-decadal comparisons. The design also allows for representation of general trends across the lower 48 states (Alaska and Hawaii lack the same level of FIA historical coverage), with one notable limitation: the FIA Program has historically measured only forest land classified as "timberland," which encompasses only two-thirds of the forest area of the lower 48 states. However, within this two-thirds of forest land, FIA samples are collected with uniform spacing and relatively high resolution. FIA Phase 2 and Phase 3 ground measurements are conducted at sites chosen following a grid or hexagon pattern, so as to present results that are well distributed in space (see T1Q2 for discussion of sampling phases). Thus, results may be broken down by region or by forest type. FIA design has varied over time and from region to region, but general principles appear to have remained fairly consistent (e.g., the multi-tiered methodology). Currently, the Forest Service's Forest Inventory and Analysis (FIA) Program assesses approximately 450,000 sites in Phase 2 and 125,000 sites in Phase 3 (see T3Q1 for documentation of FIA field methods), although it may visit a given site only every 5 or 10 years (in some cases, up to 20 years between visits). While the Forest Service (2004) does not discuss spatial sample size for this indicator's data set, descriptions of FIA methodology classify tree diameter as a Phase 2 measurement, suggesting that sample size may be closer to 450,000 sites. Likewise, Phase 2 investigations also record general characteristics used in some of the biomass models, such as forest age and forest type. In addition, FIA treats each site with a high level of detail, as described in the documentation for its database of recent measurements (http://ncrs2.fs.fed.us/4801/fiadb/fiadb_documentation/fiadb_chapter2.htm).

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The sampling design does not include any special effort to represent sensitive populations or ecosystems. This indicator is designed to offer a very general representation of overall trends in forest growth. While particular forest types are identified during data collection, it is with the intention of ensuring that the statistical methods applied in data transformation are appropriate to the species in question (e.g. ratios of carbon storage to trunk diameter in oak-hickory forest versus scrub pine forest). Nonetheless, the availability of forest type data presents an opportunity for analysis of growth within specific forest types, including those that may be relatively sensitive to environmental stressors.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

No. However, by its nature, this indicator compares trends in carbon storage and forest growth against what is essentially a reference condition: the condition of no net growth, or zero net carbon storage.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The Forest Service's FIA Program developed this indicator from field measurements of tree diameter (USDA Forest Service, 2004). FIA describes current (2004) data collection methodology at (http://fia.fs.fed.us/library/field-guides-methods-proc/). FIA also has documented some specific sampling procedures (e.g., the size of sample plots) for data collected in the 1990s and stored in its online database (http://ncrs2.fs.fed.us/4801/fiadb/fiadb_documentation/fiadb_chapter2.htm). While these references do not discuss the full historical range of FIA sampling, they represent the best available online documentation of data collection methods that may have been used by FIA in earlier monitoring studies that contributed to this indicator. The Forest Service cites several analytical methods in its National Report on Sustainable Forests -- 2003 (Washington, DC: USDA FS-766. February 2004.), which is the primary source of data for this indicator (http://www.fs.fed.us/research/sustain/documents/Indicator%2026/c5i26.pdf): Species-specific methods of calculating tree volume from trunk diameter have been used in: Smith, W.B., Vissage, J.S., Darr, D.R., Sheffield, R.M. 2001. Forest resources of the United States, 1997. General Technical Report NC-219. St. Paul, MN: USDA Forest Service, North Central Forest Experiment Station. 191 pp. Models have changed over time, and have often differed from one FIA region to another (Linda Heath, Forest Service, personal communication, 2004). However, a good general reference for these models is: Hansen, Mark. 2003. Volume and biomass estimation in FIA: national consistency vs. regional accuracy. pp. 109-120. In: McRoberts, R.E., and others. Proceedings of the third annual forest inventory and analysis symposium; 2001 October 17-19; Traverse City, MI. Gen Tech Rep NC-230. St. Paul MN: US Dept of Agriculture, Forest Service, North Central Research Station. 208 pp. (http://ncrs.fs.fed.us/pubs). Estimation of carbon in live trees, based on volume, is documented in: Smith, J.E., Heath, L.S., Jenkins, J.C. 2003. Forest volume-to-biomass models and estimates of mass for live and standing dead trees of U.S. forests. Gen. Tech. Rep. NE-298. Newtown Square, PA: USDA Forest Service, Northeastern Research Station. 57 pp. Estimation of carbon in the forest floor, based on forest age and type: Smith, J.E., and Heath, L.S. 2002. Estimators of forest floor carbon for United States forests. Res. Pap. NE-722. Newtown Square, PA: USDA Forest Service, Northeastern Research Station. 37 pp. Carbon in understory vegetation, based on forest age and type: Birdsey, R.A. 1996. Carbon storage for major forest types and regions in the conterminous United States. In: Sampson, R.N., Hair, D., eds. Forests and global change, volume 2: forest management opportunities for mitigating carbon emissions. Washington, DC: American Forests: 1-25, 261-308. More information on carbon storage models: Birdsey, R.A. 1992. Carbon storage and accumulation in United States forest ecosystems. Gen. Tech. Rep. WO-59. Washington, DC: USDA Forest Service. 51 pp. Additional documentation (support for the use of biometric methods of estimating carbon storage): (1) Intergovernmental Panel on Climate Change (IPCC). 1997. Revised 1996 Guidelines for national greenhouse gas inventories, vol. 1-3. Paris: IPCC/OECD/IEA. 650 pp. http://www.ipcc.ch/pub/guide.htm. (2) Barford, C.C., Wofsy, S.C., Goulden, M.L. [and others]. 2001. Factors controlling long- and short-term sequestration of atmospheric CO_2 in a mid-latitude forest. Science 294: 1688-1691.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

In Forest Resources of the United States, 1997, Smith et al. (2001) presents aggregate figures of timber volume by state and forest type. This includes historical data for 1953, 1963, 1977, 1987, and 1997. However, due to the fact that data collection occurred in different states in different years, the data represent the most recent data available as of a given year (e.g., "as of 1953"), and not necessarily the data collected within any specific one-year time frame. Smith et al. (2001) does not include either the full set of volume data (by measuring location or by county) or the raw diameter data used for volume calculations. The Forest Service's online FIA database contains detailed datasets by state from the late 1970s through 2003. These datasets include raw data from individual FIA plots (tree diameter, etc.), which were used to generate the most recent aggregate figures (e.g., "forest conditions as of 1997") in Smith et al. (2001). Older aggregate figures in Smith et al. (2001) were based on similar datasets, but these older datasets are not available online. Database location: http://fia.fs.fed.us/tools-data/data/. Some historical data may also be obtained indirectly through FIA's online "map-maker" system, which depicts historical data from individual sampling plots (without revealing exact coordinates of sites, which are kept confidential to protect property rights). The Forest Service does not provide online access to the output of the models it used to calculate the amount of carbon contained within the various components of the forest (live trees, forest floor, etc.). However, these data may be obtained from Linda Heath, who co-authored the National Report on Sustainable Forests - 2003 (lheath@fs.fed.us).

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The reproducibility of this survey is inherently limited, as it relies upon historical data as a basis for evaluating trends over time. FIA survey design has changed greatly through the years, and documentation of historic sampling may be difficult to find (Linda Heath and Ken Stolte, Forest Service, personal communication, 2004). Nonetheless, the Forest Service (2004) has provided complete documentation of current analytical methods. Therefore, it should at least be possible to reproduce the steps by which volume data were converted to tons of carbon for the recent Report on Sustainable Forests -- 2003. The Forest Service keeps sampling locations confidential in order to protect the identity of property owners (FIA Fact Sheet: http://fia.fs.fed.us/library/fact-sheets/data-collections/Phase2_3.pdf), precluding direct access to the underlying data.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Several of the Fact Sheets and Field Guides in FIA's online library contain information about quality assurance and quality control of data (http://fia.fs.fed.us/library/). One document in particular, http://fia.fs.fed.us/library/fact-sheets/data-collections/QA.pdf, provides a thorough discussion of many aspects of the QA/QC process as it relates to field measurements.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

This indicator requires a great deal of spatial extrapolation, but statistical projections appear to have been employed appropriately. FIA designed its sampling procedure to include enough sampling points to derive an overall result with a particular level of uncertainty and confidence (see T4Q2). Aerial imagery helps ensure that measurements are extrapolated to the appropriate forest area and that generalizations account for the appropriate forest type. Projections are not extended beyond the spatial bounds of the inventory. Thus, FIA does not attempt to provide data for Alaska, Hawaii, or non-timber forest in the lower 48 states (see T4Q4). This indicator does not require temporal extrapolation or generalization, aside from the fact that data are grouped by decade (roughly).

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

The Forest Service's Report on Sustainable Forests -- 2003 does not present uncertainty measurements for the tree measurements upon which this indicator is based. However, FIA's QA/QC fact sheet specifically mentions that field data are always accompanied by uncertainty measurements (http://fia.fs.fed.us/library/fact-sheets/data-collections/QA.pdf). Discussions of uncertainty in forest carbon estimates can be found in two Forest Service publications: Heath, L.S.; Smith, J.E. 2000. An assessment of uncertainty in forest carbon budget projections. Environmental Science & Policy. 3: 73-82. Smith, J.E.; Heath, L.S. 2000. Considerations for interpreting probabilistic estimates of uncertainty of forest carbon. In: Joyce, L.A.; Birdsey, R., eds. The Impact of climate change on America's forests. Gen. Tech. Rep. RMRS-59. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station: 102-111. FIA's database documentation (http://ncrs2.fs.fed.us/4801/fiadb/fiadb_documentation/fiadb_chapter2.htm) also presents a more general discussion of error in FIA analyses. According to this source, FIA inventories are commonly designed to meet specified sampling errors at the 67 percent confidence limit (one standard error). By Forest Service mandate, sampling error for area must not exceed 3% per 1 million acres; surveys like the one used for this indicator are designed accordingly. For volume and net annual growth, error should be within 5% (Eastern U.S.) or 10% (Western U.S.) per 1 billion cubic feet of growing stock, although these figures are not mandated. This source also quantifies the degree to which error may be magnified on a local scale, suggesting that an indicator like this one is best applied to changes on a regional or national scale.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

To the extent that this indicator is used to evaluate general national trends, uncertainty and variability should not diminish its utility. Sampling is sufficiently broad and thorough to account for much of the natural variability in tree growth, and according to FIA, error is lowest when this indicator is considered on a large spatial scale -- either national, or a few large regions (FIA database documentation, http://ncrs2.fs.fed.us/4801/fiadb/fiadb_documentation/fiadb_chapter2.htm). If methods of sampling and extrapolation remain consistent over time and space, this indicator should allow regional and inter-decadal comparisons. Nonetheless, the numerical value of this indicator represents several layers of statistical inference whose uncertainties may compound one another. In addition, FIA does not measure every plot during every calendar year, a possible source of temporal uncertainty. Historically, FIA has inventoried different states in different years, and it may only inventory the same state every fifth or tenth year (source: various FIA documents linked from FIA's website, http://fia.fs.fed.us/). In some cases, the interval may even be as great as 20 years (Forest Service, Ken Stolte, personal communication, 2004). The National Report on Sustainable Forests -- 2003 (USDA Forest Service, 2004) classifies data as belonging to five base years (1953, 1963, 1977, 1987, 1997), but not all measurements were actually made in these years. For example, the 1953 dataset does not just include data from states that FIA analyzed in 1953. Instead, this dataset covers all states, using the most recent measurements that were available in 1953. FIA methods have varied over time and between regions -- including criteria like minimum tree size for measurement and the degree to which sample design includes relatively inaccessible areas (Linda Heath, Forest Service, personal communication, 2004). Considering these additional sources of uncertainty, the carbon storage indicator is probably best suited to remain an indicator of general spatial and temporal trends, rather than a specific numerical indicator of forest growth rates. A useful discussion of assumptions in this indicator appears in: Birdsey, R.A. and Heath, L.S. 2001. Forest inventory data, models, and assumptions for monitoring carbon flux. P. 125-135. In: Lal, R., ed. Soil Carbon Sequestration and the Greenhouse Effect. SSSA Special publication No. 57. Soil Science Society of America, Inc. Madison, WI. 236 pp.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

There are several limitations. (1) This indicator does not cover all forest land in the United States. Alaska and Hawaii are excluded entirely because of limited historical data, while land in the other 48 states is only counted if it is classified as "timberland" (about two-thirds of total forest land in the lower 48). Thus, this indicator excludes national park land and other protected or reserved land, or roughly one-third of forest land cover in the lower 48 states. (2) Certain forest types may be underrepresented. In particular, this indicator may under-count western pinyon and juniper forests (Houghton et al., 1999; full citation below). Classification as "forest" is dependent on aerial imagery, so it is possible that some very thin or marginal forest land may not be counted.

[Houghton, R.A., Hackler, J.L., Lawrence, K.T. 1999. The U.S. carbon budget: contributions from land-use change. Science 285: 574-578.] (3) The model may not accurately reflect a large increase in the volume of dead wood in certain forest areas due to increased fire suppression in recent years (Houghton et al., 1999). (4) This indicator does not include any accounting of carbon in soil, another carbon sink. According to the Heinz Center (personal communication, 2004), there simply are not enough data available to characterize soil carbon for the same historical range as the rest of this indicator. (5) Data have improved dramatically since the 1950s. Linda Heath of the Forest Service (personal communication, 2004) notes that for early years (1953, 1963, etc.), the best volume data available for the National Report on Sustainable Forests -- 2003 were aggregate tree volumes for each state, not records of individual trees or plots. Thus, the recent decrease in carbon sequestration (evident in the graphic for this indicator) may actually be a reflection of better data rather than exact trends.

Indicator: Sea Level (353)

The status of the coastline is an important aspect of the ecological and economic balance of the U.S. One element of that balance is the level of the sea relative to the land. Coastal areas in the U.S. host a rich set of natural and economic resources and include some of the most developed and rapidly growing population centers in the nation. More than 100 million people globally live within 1 meter of the mean sea level and more than 40% of the U.S. population lives in watersheds along U.S. ocean coasts. Changing sea levels have the potential to impact U.S. coasts in numerous ways, such as inundating low lying wetlands and dry lands, eroding beaches, increasing coastal flooding, and increasing the salinity of estuaries and aquifers, all with human and ecological consequences.

A number of factors affect sea level including but not limited to changes in sea temperature, salinity, and total water volume and mass (e.g. from melting glaciers or changes in the amount of water stored on land). Sea-surface height moves up with warming sea temperatures and down with cooling. In addition, because saltwater takes up more volume than an equivalent mass of freshwater, the freshening of the oceans from melting ice and snow results in small reductions in sea level and volume. Changes in the total volume and mass of ocean water also result from the melting (or accumulation) of Antarctic and Greenland ice sheets, melting of non-polar glaciers, and changes in the amount of water stored in lakes, rivers and groundwater. Observed sea level changes reflect seasonality as well as longer-term variability, such as “El Nino,” and potentially climate change. As such, global average sea level is one indicator of the physical and climatic stability of our environment.

This indicator presents trends in relative sea level along the US coast based on tidal gauge data, and absolute sea level trends derived from satellite data. Relative sea level rise is defined as global (eustatic) sea level rise plus land subsidence (or minus land uplift), whereas absolute sea level represents only the change in sea height. Tidal gauge station measurements and analysis are from the National Water Level Observation Network (NWLON), operated by the Center for Operational Oceanographic Products and Services (CO-OPS), a component of the National Ocean Service (NOS). The NWLON is composed of approximately 175 long-term, continuously operating stations located along the United States coast, including the Great Lakes and islands in the Atlantic and Pacific Oceans (Smith, 1980; Gill and Schultz, 2001). Tidal gauges have been used to monitor sea levels, including tides, for many decades, with the New York and San Francisco stations dating back to 1856 and 1854, respectively (CO-OPS 2001). Satellite data are from NASA’s Ocean TOPography EXperiment (TOPEX/Poseidon spacecraft) which uses radar to map the precise features of the oceans’ surface, and the “Jason” satellite which monitors ocean circulation. The two satellites operate in tandem, using radar altimetry to collect sea surface height data from all the world's oceans. These satellite measurements have been available since 1993 and provide a reference by which changes in regional ocean height can be determined regardless of changes in land height.

What the Data Show

The tidal gauge measurements at stations along the US coasts (Figure 353.1) show that, in many locations, relative sea levels (combined land and sea movement) have been rising, typically at rates of 1.5-3 millimeters (mm) per year (6-12 inches per century). Sea level is rising more rapidly (3-4 mm/yr) along the mid-Atlantic coast from North Carolina to New Jersey. At some locations, rates are much higher, such as at several stations in Louisiana on the Gulf of Mexico, with rates of 5-10 mm per year. At the same time, other locations, such as along the southern coast of Alaska, show rates of relative sea level *drop* of over 16 mm per year. Average relative sea level rise was not calculated because the tidal gauge stations are not spatially representative and therefore such a measure is not meaningful.

Measurement of absolute sea heights is the principal way to understand the relative importance of the location of land (e.g. uplift and subsidence) versus sea level changes. Satellite measurements available since 1993 from NASA's TOPEX/Poseidon and Jason missions allow reliable estimates of global mean change in sea level – independent of land movements - over the past 12 years (Figure 353.2). The amount and direction of change vary greatly but tend to show the greatest increase along the Atlantic coast and the central Pacific, and the greatest decrease along the Pacific coast of the U.S.

The long-term, land-based tidal gauges over the past century indicate a global mean sea level rise of about 1.5-2.0 millimeters per year (mm/yr). In the last 12 years, global mean sea level appears to have risen by more than half to about 3 mm/yr (.12 inches per year). Satellite measurements similarly suggest that GSLR has been about 2.9 mm yr^{-1} $\pm$ 0.4 mm/yr^{-1} over the past 12 years (Figure 353.3) (Leuliette et al. 2004).

In sum, this indicator shows that relative sea levels have been rising along much of the U.S.' coasts, although in some locations, relative sea levels are falling. The relative change is caused by rising and falling of land due to geologic and human factors, as well as by global sea level rise which is not evenly distributed around the globe. The relative contributions of these factors depend on the specific location and cannot be generalized for relative sea level change. However, both tidal gauge data and satellite data indicate that global mean sea level has been rising and appear to have accelerated in the past couple of decades.

Indicator Limitations

- An estimated 50 to 60 years of data are required for obtaining linear mean sea level trends having a 1 mm/yr precision with a 95% statistical confidence interval.
- Tidal gauge measurements do not represent more generalized (i.e. average) relative sea level change along US coasts (or globally).
- Tidal gauge measurements do not indicate whether changes in relative sea level are due to changing water level or land level.
- Satellite data are not available for a long enough time series to be able to separate out medium-term variability from long-term change.
- Satellite data are not horizontally precise enough to resolve SLR for small water bodies, such as many estuaries, or for localized interests (such as a particular harbor or beach).

Data Sources

The data sources for this indicator include: the National Water Level Observation Network's tidal gauge monitoring network (http://140.90.121.76/sltrends/sltrends.shtml), and satellite measurements from NASA's Ocean TOPography EXperiment and Jason satellite (http://topex-www.jpl.nasa.gov/science/data.html).

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Vaughan, David G. "How Does the Antarctic Ice Sheet Affect Sea Level Rise?" SCIENCE VOL 308 24 JUNE 2005

Graphics

Figure 353.1
Mean Relative Sea Level Trends along US Coasts from 1950 to 1999
from Tidal Gauge Measurements

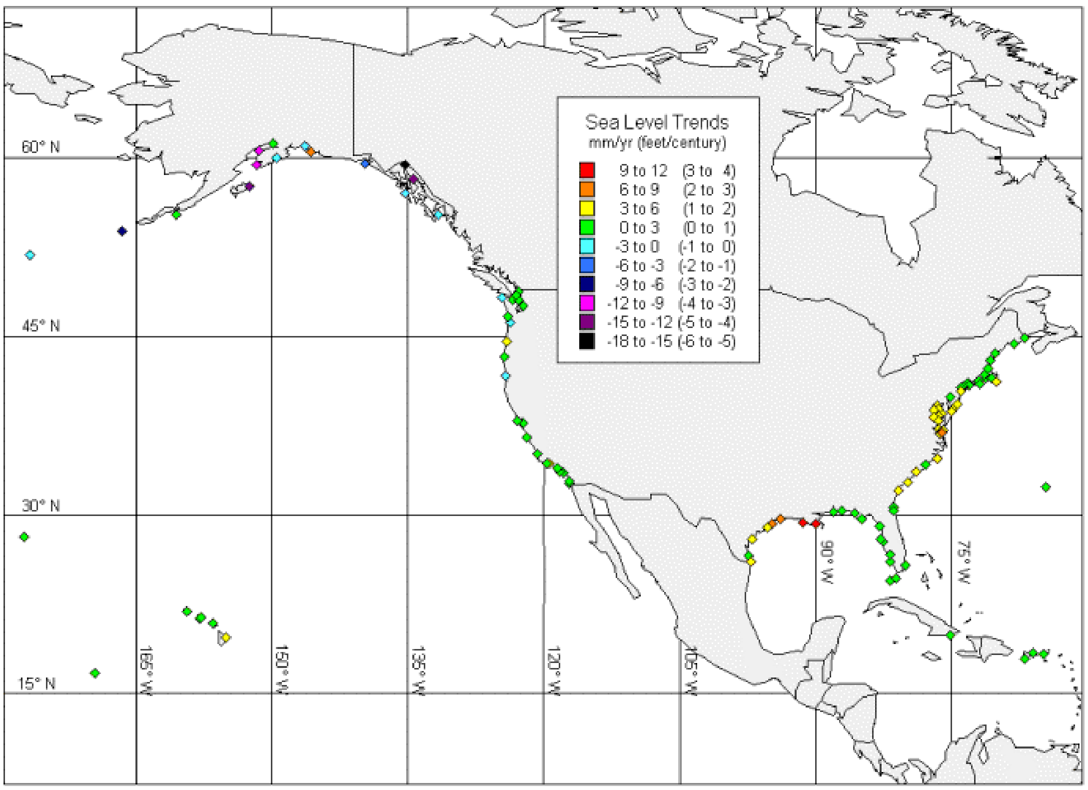


Figure 353.2
Change in Absolute Sea Level Along US Coasts from 1993 – 2005
From Satellite Measurements

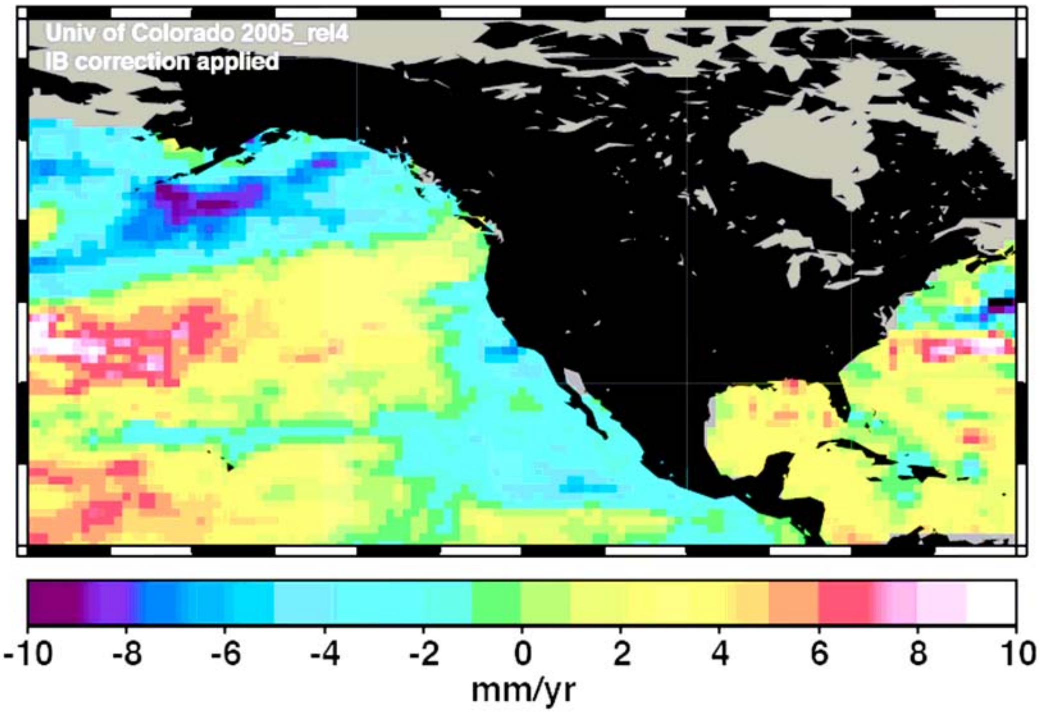
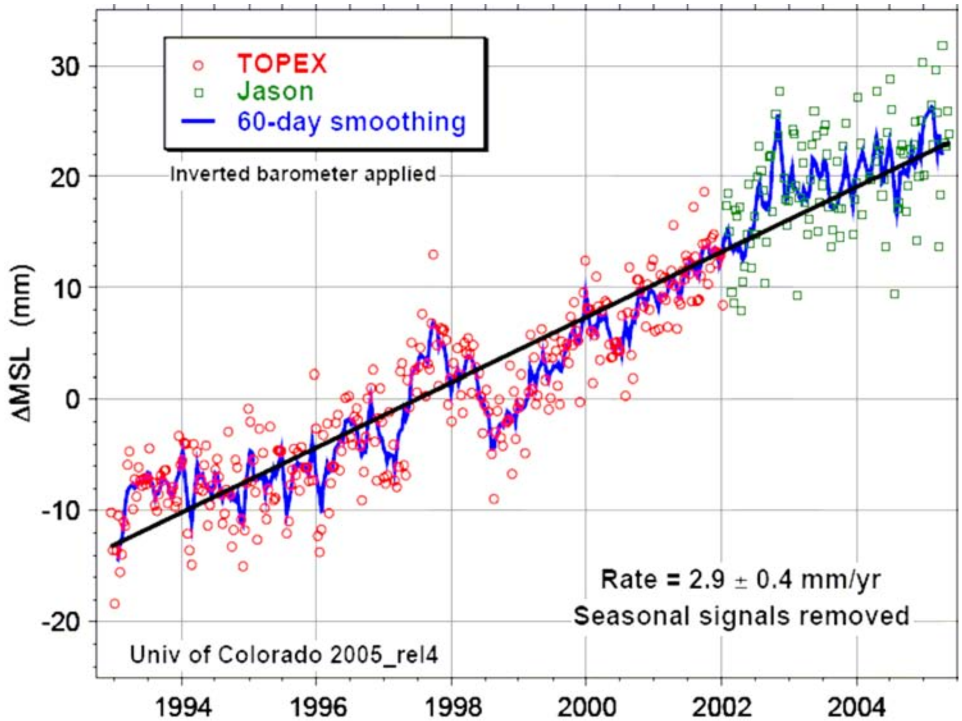


Figure 353.3
GLOBAL MEAN SEA LEVEL RISE FROM SATELLITE DATA
1993-2005



R.O.E. Indicator QA/QC

Data Set Name: SEA LEVEL
Indicator Number: 353 (139048)
Data Set Source:
Data Collection Date:
Data Collection Frequency:
Data Set Description: Sea Level
Primary ROE Question: What are the trends in the critical physical and chemical attributes of the Nation's ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes, the tidal gauge measurements are fairly accurate, and some, such as the San Francisco station, have been operating for more than a century. As a total measure of the relative change of sea levels to the land surface, the tidal gauges are very reliable. With 50 years of data, precision in determining the mean sea level change can be to the 1 mm/year level with a 95% level of confidence. However, the measurements include both the change in the absolute sea surface height, as well as changes in land levels. Land surfaces move up or down in many locations around the world, both due to natural geologic processes, such as those playing out in this post-glacial period, as well as human activities that in some cases, cause ground to sink (e.g. from the weight of human structures, or extraction of groundwater or oil that supported the surface). Thus, the tidal gauges are reliable as measures of the relative change in levels of sea to adjoining land surface. However, it is not possible to understand what is causing sea level changes and relative contributions with tidal gauge data alone. Satellite measurements of land and sea surface heights (altimetry) began several decades ago. But the launch of the TOPEX/Poseidon mission in 1992, and subsequent analyses, have allowed very precise and reliable measurements of changes in absolute sea heights from 1993 to the present (as in Figure 344-1). Moreover, the satellite altimetry has revealed that global sea levels are not evenly distributed around the globe, but can increase several times more than the mean in some locations (Cazenave and Narem 2004). Factors that lead to change in sea levels include: the astronomical tide, changes in atmospheric pressure, wind, river discharge, ocean circulation, changes in water density (e.g. from temperature and salinity), and added or extracted water volume due to the melting of ice or storage of water on land in reservoirs or evaporated with agricultural irrigation.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Over time: yes; Over space: not for the tidal gauge data, which are neither comprehensive nor spatially representative, but yes for satellite data, which are globally comprehensive. The National Water Level Observation Network (NWLON) is operated by the Center for

Operational Oceanographic Products and Services (CO-OPS), a component of the National Ocean Service (NOS). The NWLON is composed of approximately 175 long term, continuously-operating stations located along the United States coast, including the Great Lakes and islands in the Atlantic and Pacific Oceans. Extensive discussion of this network, and of the tidal gauge data analysis can be found in NOAA CO-OPS 2001 in the list of references, and at http://140.90.121.76/publications/techrpt36doc.pdf. Additional sources are available from the CO-OPS web site at: The sampling at tidal gauge stations is representative of changes at each location, but not of broad changes over larger spaces and time. The challenge of using tidal gauge measurements for drawing conclusions about changes in global means has lead to controversy since about 2001, as attention to the lack of representative stations has lead to questioning and reanalysis of the global means. Fortunately, a long enough time series of global satellite altimetry data has become available for providing very accurate and reliable measurements that are representative globally and since 1993. This is not a long enough time period for assessing multi-decadal trends and their causes, making it necessary to continue the tidal gauge measurements for decades more and for calibration and comparison with the satellite data. The two data sets together provide good representativeness, although all uncertainties will not be eliminated regarding the various contributions to changes in particular locations for many years. Longer discussion and history of the debate can be found in Cazenave and Nerem (2004). A summary of the methods for calibrating satellite data is found at: http://www.csr.utexas.edu/gmsl/calibration.html . A more extensive discussion is available in Leuliette, Nerem and Mitchum (2004) for TOPEX/Poseidon data and in Chambers et al. (2003) for Jason data.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

Yes. The challenges of using tidal gauge data, as presented in this indicator, is well described in “Sea Level As an Indicator of Climate and Global Change “ by Bruce B. Parker, available at: http://140.90.121.76/sltrends/mtsparker.html. Further discussion is available at: http://www.co-ops.nos.noaa.gov/pub.html - sltrends. Moreover, the availability for over a decade of precise and reliable satellite measurements complements and enriches the tidal gauge measurement data set. In tandem, the tidal gauge and satellite measurements provide both long-term and spatially sound measures of sea level rise. Since 2001, there has been some disagreement and debate over the reliability of the tidal gauge data and estimates of global sea level rise trends from it (Cabanes et al. 2001). However, further research both with comparisons of satellite data with tidal gauge measurements, and improved estimates of contributions to sea level rise by sources other than thermal expansion – and by Alaska glaciers in particular, have largely resolved the question (Cazenave 2004; Miller et al. 2004). This work has in large part closed the gap between “top-down” and “bottom-up” measurements of sea level change, although further improvements are expected as more measurements and longer time series become available.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The tidal gauge data are fairly well distributed along US coastlines, covering all 50 States and some Territories (e.g. Puerto Rico). The show clear regional similarities and differences, and provide a useful picture of overall trends and distinctions in relative sea levels. Sea level change is an important indicator of physical changes affecting ecosystem condition of many habitats and population centers in the US, and is also an important indicator itself of impacts of changes in ocean temperatures (which may be partially attributable to climate change). The tidal gauge data are critical, because of their available for over a century in some locations, to understanding long-term variability and change. They are supported by satellite data that are more precise and help to sort out among the potential contributions to changes in relative sea level. The satellite data coming from TOPEX/Poseidon are measurements of global mean sea level variations at 10 day intervals with a precision of 4 mm, more than sufficient to detect the very low frequency (VLF) changes associated with climate change given a sufficiently long time series and accurate monitoring of the instrument calibration. More importantly, TOPEX/Poseidon makes it possible to geographically map the spatial variations of VLF sea level (Nerem et al., 1999; Cabanes et al., 2001), though a better characterization and understanding of these patterns is still sought. It is difficult to detect the geographic "fingerprint" of long-term climate change signals using altimeter data from a single satellite mission such as TOPEX/Poseidon, because the mission length will probably be insufficient to easily differentiate these signals from inter-annual and decadal variations. Therefore, a multi-decadal time series of sea level derived from several altimeter missions will likely be required. As the TOPEX/Poseidon mission generates a longer time series, much better separation of the interannual, decadal, and secular sea level signals will be possible. (from: http://sealevel.jpl.nasa.gov/science/invest-nerem.html)

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The tidal gauge data are not representative of sensitive populations or ecosystems, but because of their locations tend to represent important human utilities for understanding tidal and coastal changes. However, in tandem with the more recent satellite measurements of TOPEX/Poseidon and Jason, comprehensive measurement of sea level height of all US coastlines are available, and in the future, geodetic and other methods for precisely determining land changes will provide comprehensive information. In combination with the multi-decadal time series of tidal gauge measurements, a robust picture of changes in relative sea levels, its causes and implications will be available.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

There are no unambiguous reference points, thresholds or ranges of value for this indicator, although anomalies are often measured against a recent multi-decadal period designated as a “normal.” However, these “normal” values change as trends evolve, as well as from place to place. In addition, the implications of the indicator may also be determined by the rate of change, which is sensitive to the time period chosen to determine the average or “normal.” Tide gauge data are an important resource, not only for instrument calibration, but also for tying different altimeter missions together, and understanding the sea level variations observed in the relatively short altimetry record in the context of the tide gauge observations of sea level rise over the last century [Mitchum, 1997].

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

The tidal gauge data and their manipulation and analysis to provide the station data for this indicator are available in NOAA CO-OPS (2001), available on the worldwide web at http://www.co-ops.nos.noaa.gov/pub.html - sltrends. The satellite data are available from NASA and from various research institutes that perform calibrations, analyses and other manipulations to make them easier to interpret or use. The NASA website at http://topex-www.jpl.nasa.gov/science/data.html provides links to the various research centers. The documentation for the data manipulations is available from each of the research institutes and must be read carefully before use. A principal site for the TOPEX/Poseidon data sets is at http://podaac.jpl.nasa.gov/cgi-bin/dcatalog/fam_summary.pl?ost+topex and for Jason at http://sealevel.jpl.nasa.gov/science/jason1-quick-look/ . The data set and analysis used specifically for the figure presented with this indicator as contextual detail is described in Leuliette et al. (2004) and at http://sealevel.colorado.edu/documents.html.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes, the tidal gauge data are available online at: http://www.co-ops.nos.noaa.gov/sltrends/sltrends.shtml The satellite data are available online at: http://sealevel.colorado.edu/results.html

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

The tidal gauge data themselves cannot be reproduced, but the analysis and interpretation of them can be from data provided by NOAA. The analysis of satellite data can, and have, been reproduced, which has led to improvements and high level of confidence in the associated measurements of sea level rise. Discussion of this is found in Cazenave (2004) and Miller et al. (2004).]

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The tidal gauge data and their manipulation and analysis to provide the station data for this indicator are available in NOAA CO-OPS (2001), available on the worldwide web at http://www.co-ops.nos.noaa.gov/pub.html - sltrends . Various publications available through that website describe the QA/QC procedures for tidal gauge data. The satellite data are available from NASA and from various research institutes that perform calibrations, analyses and other manipulations to make them easier to interpret or use. The NASA website at http://topex-www.jpl.nasa.gov/science/data.html provides links to the various research centers. The documentation for the data manipulations is available from each of the research institutes and must be read carefully before use. A principal site for the TOPEX/Poseidon data sets is at http://podaac.jpl.nasa.gov/cgi-bin/dcatalog/fam_summary.pl?ost+topexand for Jason at http://sealevel.jpl.nasa.gov/science/jason1-quick-look/. The data set and analysis used specifically for the figure presented with this indicator as contextual detail is described in Leuliette et al. (2004) and at http://sealevel.colorado.edu/documents.html.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes, although some of the data interpretations are not without controversy. However, the reproduction and recalculation of analyses, sometimes using alternative methods, has led to increased confidence in the research results.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes. For tidal gauge data, these are available in NOAA CO-OPS (2001) among other sources. For satellite data, uncertainty is provided and discussed in Leuliette et al. (2004).

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

No. The complementarity of the tidal gauge data and the satellite data provide a reliable indicator of sea level rise generally, although with considerable spatial variation. The data sets are providing a much improved picture and understanding of the degree and causes of the variability, which will continue to improve over coming decades. The conclusions that may be drawn regarding sea level rise are robust. However, while confidence has decreased and grown again in assessment of the contributions to sea level rise, complete understanding of sources, variability and trends will continue to evolve for at least several years. A good discussion of these is provided by Cazenave and Nerem (2004).

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

No biases have been identified for the tidal gauge data in representing relative sea level change at individual sites. However, an estimated 50 to 60 years of data are required for obtaining linear mean sea level trends having a 1 mm/yr precision with a 95% statistical confidence interval. Also, the variability of change among stations and the lack of comprehensive or representative tidal gauges mean that are not distributed well to represent more generalized (i.e. average) relative sea level change along US coasts (or globally) and have limitations in sorting out sea level rise from rising or falling land.

Understanding the causes of relative sea level change is important for addressing adverse consequences of relative sea level change. Considerable controversy arose, for example, in 2001, when Cabanes (2001) published an analysis contending that averaging tidal gauge data provided estimates of global mean sea level rise that were double the “true” increase (Cabanes, 2001). Complementary satellite data are instrumental in providing precise and reliable measures of sea level height, and in the near future, of land level changes. However, they are not available for a long enough time series to be able to separate out medium-term variability from long-term change. As a set, the complementary tidal gauge and satellite measures are strong and reliable.

Indicator: Sea Surface Temperature (344)

Sea surface temperature (SST) is a critical physical attribute of coastal ecological systems. Water temperature directly affects process rates, water column stability, and the species of plants (such as algae, seagrasses, marsh plants, and mangroves) and animals (microscopic animals, larger invertebrates, fish, and mammals) that live in a particular region. Increases in temperature are thought to be associated with the degradation of coral reefs (bleaching) and may increase the frequency or extent of blooms of harmful algae. On longer time scales (decades to centuries), such changes may be related to decreases in the supply of nutrients to surface waters from the deep sea and a cascade of effects from decreases in primary production to declines in fish production. Changes in temperature may result from long-term cycles in ocean circulation or secular trends in climate (Committee on the Bering Sea Ecosystem et al., 1996).

This indicator, developed by the National Ocean Service of the National Oceanographic and Atmospheric Administration (NOAA) (The Heinz Center 2002) describes whether SST is above or below average. The indicator tracks how much regional average temperatures in any given year deviate from the average for a 14-year period of record for waters within 25 miles of the coast.

Data from 1985 through 1998 were obtained using Advanced Very High Resolution Radiometers onboard several NOAA Polar Orbiting Environmental Satellites. Data were acquired on a grid of square pixels nominally 10 kilometers (about 6 miles) on a side. Both day and nighttime data were processed to remove clouds using an “erosion filter,” and averaged to produce monthly means, which then were averaged to produce seasonal means.

To calculate the index: (1) the seasonal average SST of near-shore water (shoreline out to 25 miles) was calculated for the warmest season in each region (termed the “seasonal mean maximum”), which typically occurred during summer or fall; (2) the long-term mean (during the warmest seasons) for the period of observation (1985–1998) was calculated; and (3) the long-term mean was then subtracted from the seasonal mean maxima. Values greater than zero are positive “anomalies” (i.e., deviations from the long-term average), and those less than zero are negative anomalies. Systematic errors are rare in such analyses, and the source data (daily averages from NOAA satellites) are expected to be within 0.3 to 0.5^{o}C of actual temperatures. Annual anomalies should be even more accurate, because averaging data reduces overall uncertainty. A “1.1”index score means that the SST for that region in that year was 10 percent warmer than the 14-year average for that region. The indicator defines “average SST” for a region as the average temperature for the warmest season in that region.

What the Data Show

While SST varies noticeably from year to year, and there are individual reports of gradually increasing temperatures in several of these ocean regions (Barry et al., 1995; Levitus et al., 2000), the index shows no noticeable trends (Figure 344-1).

Indicator Limitations

- At the time the Heinz Center compiled this indicator, complete data were not available for 1996 and 1997.

- SST data are available back to 1979, but the data are not yet comparable to the series beginning in 1985.

Data Sources

Data are available from NASA at http://podaac.jpl.nasa.gov/sst/.

References

Barry, J.P., C.H. Baxter, R.D. Sagarin, and S.E. Gilman. 1995. Climate-related, long-term faunal changes in a California rocky intertidal community. Science 267:672–675.

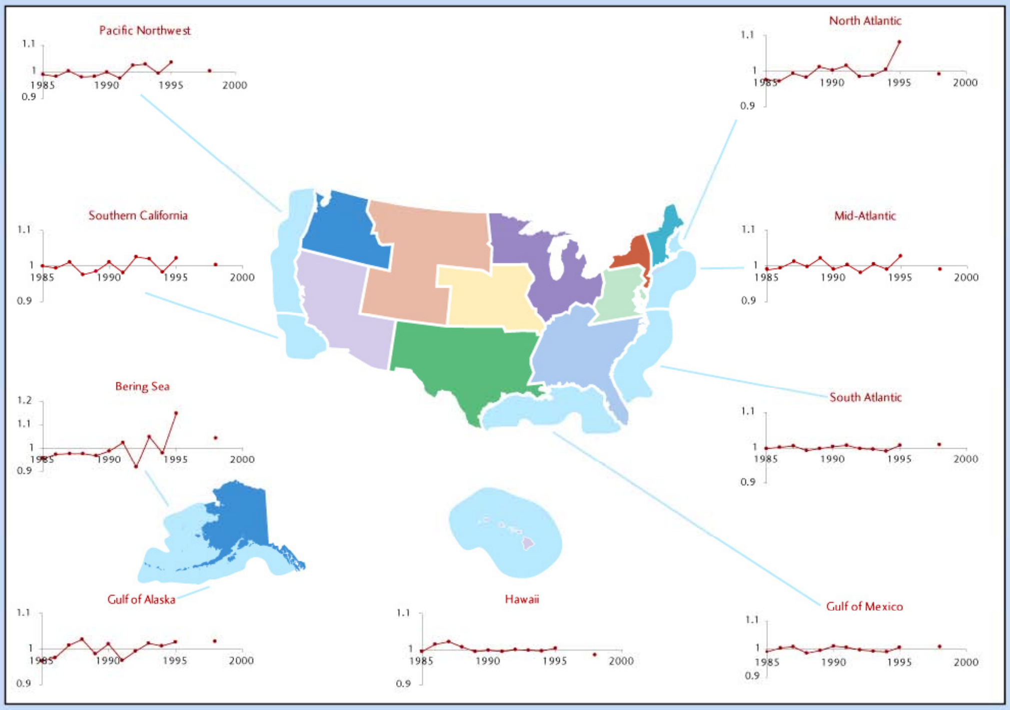
Committee on the Bering Sea Ecosystem, Polar Research Board, Commission on Geosciences, Environment and Resources, and National Research Council. The Bering Sea Ecosystem. 1996. National Academy Press, Washington, D.C. pp. 196-237.

Levitus, S., J.I. Antonov, T.P. Boyer, and C. Stephens. 2000. Warming of the world ocean. Science 287:2225–2229.

Graphics

Figure 344-1. Sea surface temperatures, 1985-1998

Figure 344-1: Sea surface temperatures, 1985-1998 (anomalies calculated from data in degrees C)



Source: The Heinz Center. The State of the Nation's Ecosystems. 2002.
Data from NOAA/NASA (AVHRR Pathfinder satellite data)
Coverage: waters within 25 miles of U.S. coast, not including estuaries

Note: 1996, 1997, and some post–1998 data are expected to be available following the Heinz Center's online update in late 2005.

R.O.E. Indicator QA/QC

Data Set Name: SEA SURFACE TEMPERATURE
Indicator Number: 344 (139049)
Data Set Source:
Data Collection Date:
Data Collection Frequency:
Data Set Description: Sea Surface Temperature
Primary ROE Question: What are the trends in the critical physical and chemical attributes of the Nation's ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

This indicator uses measurements of sea surface temperature (SST) made with satellite technology. The National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautical and Space Administration (NASA) collected these data in a joint effort using Advanced Very High Resolution Radiometers (AVHRR) onboard several of NOAA s Polar Orbiting Environmental Satellites. The 5-channel AVHRR specifically measures the infrared (thermal) radiation given off by the surface layer of the ocean, which is a direct reflection of water temperature. NASA s Jet Propulsion Laboratory (JPL) provides an online user s guide with detailed information about SST data collection equipment and methodology (http://podaac.jpl.nasa.gov/pub/sea_surface_temperature/avhrr/pathfinder/doc/usr_gde4_0_toc.html). This document includes supporting references. Supplementary documentation sites: (1) Main SST data site: http://podaac.jpl.nasa.gov/sst/ (2) Various SST data user s guides: http://podaac.jpl.nasa.gov/sst/sst_doc.html (3) Additional documentation of AVHRR Pathfinder data products: http://podaac.jpl.nasa.gov/cgi-bin/dcatalog/fam_summary.pl?sst+pfsst). These websites also include a link to several supporting references (http://podaac.jpl.nasa.gov/sst/sst_ref.html).

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

The sampling design for this indicator has been carefully developed over the years to collect high-quality data at high resolution, both spatially and temporally. NOAA s satellites collect data using a grid, where each data point or pixel represents a square of ocean surface that nominally measures between 9 and 10 kilometers (km) on a side. NOAA also collects data at other resolutions ranging from 18 km to 4 km, but the Heinz Center (2002) uses the 9-10 km data for this indicator (http://www.heinzctr.org/ecosystems/coastal_technotes/coasts_sea_srf_temp.shtml). NOAA s data set covers the world s ocean surface in its entirety, which allows this indicator to include all U.S. coastal waters, from the Bering Sea to the Gulf of Mexico. NOAA s satellites cover the entire grid on a daily basis. The sampling plan includes a systematic means of detecting data points that happen to be obscured by clouds, since these cannot be included in the final data set (clouds block the infrared radiation emitted by the ocean surface). The Jet Propulsion Laboratory s SST website discusses sample design and provides a list of references that offer more detailed support of NOAA s SST monitoring plan (sample design at http://podaac.jpl.nasa.gov/cgi-bin/dcatalog/fam_summary.pl?sst+pfsst; references at http://podaac.jpl.nasa.gov/sst/sst_ref.html).

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The analytical model for this indicator, which is an index of the annual deviation of SST above or below a long-term average, consists of three main steps: (1) Conversion of raw thermal data to SSTs. NOAA performs this conversion based on models that show the relationship between water temperature and the thermal properties observed by satellite. NASA s online SST data user s guide describes this algorithm in detail (http://podaac.jpl.nasa.gov/pub/sea_surface_temperature/avhrr/pathfinder/doc/usr_gde4_0_toc.html). NOAA and NASA note that algorithms for converting satellite data to SSTs have improved since the first year of data included in this indicator (1985) (http://podaac.jpl.nasa.gov/sst/), and they have taken steps to ensure that the full historic SST dataset reflects the most up-to-date methodology. According to the data website: This dataset represents a historical reprocessing of the entire AVHRR time series using consistent SST algorithms, improved satellite and inter-satellite calibration, quality control and cloud detection (http://podaac.jpl.nasa.gov/sst/). NOAA and NASA specifically cite the work of the project s algorithm team, headed by Professor Robert Evans at the University of Miami Rosenstiel School of Marine and Atmospheric Sciences. (2) Calculation of seasonal means. NOAA divided SST data pixels from near-shore U.S. waters (up to 25 miles offshore) into 9 geographic regions. From daily SST data, NOAA calculated mean SST values for the warmest season in each year (summer or fall, depending on the region). These annual values are labeled seasonal mean maxima. From these data the Heinz Center calculated a long-term mean for each geographic region, consisting of the average of all seasonal mean maxima over the full period of observation (currently, 1985-1998) (Heinz Center, 2002). Climate researchers commonly convert daily SST data into seasonal, annual, and long-term means in order to evaluate inter-annual trends; this implies general acceptance of the data manipulation steps involved in the creation of this indicator by the scientific community. (3) Creation of an index to depict variation from the long-term mean. For each geographic region, the Heinz Center (2002) reports this indicator in terms of an anomaly that is, the percentage by which each year s seasonal mean maximum deviates from the long-term mean. The Heinz Center (2002) sets up the index so that the long-term mean receives a value of 1. If one year receives a value of 0.9, it means that the anomaly is 0.1, and for the year in question, the SST is 10 percent cooler than average. By emphasizing relative rather than absolute temperatures, this reporting method allows data from several regions to be compared on the same graph, even if their average temperatures differ greatly in absolute terms. The scientific community commonly uses this type of index to quantify relative changes in SST (for example, see the various climate databases compiled by Columbia University s

Lamont-Doherty Earth Observatory at http://ingrid.ldeo.columbia.edu/).

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

This indicator documents an important physical attribute of the nation s coastal ocean ecosystems. As discussed in the Heinz Center s 2002 report (http://www.heinzctr.org/ecosystems/coastal/sea_surf_temp.shtml), changes in SST can cause coral bleaching and changes in algal blooms, and long-term SST shifts can lead to large changes in nutrient cycling and food chain dynamics (The Bering Sea Ecosystem. Commission on Geosciences, Environment and Resources (CGER), Polar Research Board (PRB), 1996. pp. 196-237). This data set covers U.S. coastal waters with sufficient frequency and resolution to ensure that overall averages are not inappropriately distorted by singular events or missing data due to occasional cloud cover. NOAA collects samples as points on a grid of squares, each 9-10 km on a side. Satellite orbiting patterns ensure that measurements can be taken day and night for every location on the grid. The Heinz Center s (2002) SST indicator includes complete data from 1985 to 1995 and complete data from 1998. [The next web update of the Heinz Report is expected to occur in late 2005, and should incorporate full SST data from 1996, 1997, and 1999-2003.]

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

This indicator offers a broad overview of sea-surface temperature (SST). By design, it does not focus on any one sensitive population. However, because NOAA s analysis divides data by geographic region, it may be possible to assess SST threats to particular populations of concern.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

A defined baseline is used to generate the SST index for this indicator: the long-term mean of warm seasons from 1985 to 1998 (14 years), which serves as a basis for the graphical representation of relative shifts in SST. Because paleo-climatological evidence shows that air and sea surface temperatures have varied throughout geological time (McElroy, 2002), it is not possible to compare recent SST trends with any background data that specifically represents a natural state. McElroy, M. B. The Atmospheric Environment: Effects of Human Activity. Princeton University Press. 2002.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

(1) Data collection. NOAA and NASA collected raw satellite imagery using the Advanced Very High Resolution Radiometers (AVHRR) onboard several of NOAA s Polar Orbiting Environmental Satellites. The 5-channel AVHRR specifically measures the infrared (thermal) radiation given off by the surface layer of the ocean, which is a direct reflection of water temperature. NASA s Jet Propulsion Laboratory provides an

online user s guide with detailed information about data collection equipment and methodology (http://podaac.jpl.nasa.gov/pub/sea_surface_temperature/avhrr/pathfinder/doc/usr_gde4_0_toc.html; specifically, see Appendix A). Earlier editions of the user s guide are posted at http://podaac.jpl.nasa.gov/sst/sst_doc.html. Supplementary documentation sites: - Main SST data site: http://podaac.jpl.nasa.gov/sst/ - Additional documentation on Pathfinder AVHRR data: http://podaac.jpl.nasa.gov/cgi-bin/dcatalog/fam_summary.pl?sst+pfsst). (2) Conversion of raw thermal data to SST. NOAA performs this conversion based on models that show the relationship between water temperature and the thermal properties observed by satellite. The current SST data user s guide describes this algorithm in detail (http://podaac.jpl.nasa.gov/pub/sea_surface_temperature/avhrr/pathfinder/doc/usr_gde4_0_toc.html; specifically, see the section entitled Algorithms and Data Processing). Although processing algorithms have changed since the onset of data collection (1985), NOAA and NASA report that the full SST dataset now reflects the most up-to-date methodology. According to the data website: This dataset represents a historical reprocessing of the entire AVHRR time series using consistent SST algorithms, improved satellite and inter-satellite calibration, quality control and cloud detection (http://podaac.jpl.nasa.gov/sst/). (3) Calculation of seasonal means. NOAA divided SST data from near-shore U.S. waters (up to 25 miles offshore) into 9 geographic regions. From daily SST data, NOAA calculated mean SST values for the warmest season in each year (summer or fall, depending on the region). These annual values are labeled seasonal mean maxima. The Heinz Center used these data to calculated a long-term mean for each geographic region, consisting of the average of all seasonal mean maxima over the full period of observation (currently, 1985-1998). The Heinz Center provides a general description of mathematical processes in the 2002 technical note for this indicator (http://www.heinzctr.org/ecosystems/coastal_technotes/coasts_sea_srf_temp.shtml). According to the Heinz Center s (2002) general description of coastal indicators, NOAA divided data pixels in accordance with regions as defined under EPA s Environmental Monitoring and Assessment Program, which match the regions established under public law 101-593 for regional marine research (http://www.heinzctr.org/ecosystems/coastal/intro4.shtml). The Heinz Center s description includes a map delineating these regions. (4) Creation of an index to depict variation from the long-term mean. For each geographic region, the Heinz Center (2002) reports this indicator in terms of an anomaly that is, the percentage by which each year s seasonal mean maximum deviates from the long-term mean. The Heinz Center documents the basis of this index within its 2002 report.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

NOAA and NASA allow free online access to the full global SST dataset derived from its AVHRR satellite imagery. Data are available at http://podaac.jpl.nasa.gov/cgi-bin/dcatalog/fam_summary.pl?avhrr+pfsst; this site can also be accessed through links from the main SST website, located at http://podaac.jpl.nasa.gov/sst/. These sites currently contain daily, 8-day average, and monthly data from 1985 to June 2003 (as of

December 2004). NOAA and NASA do not provide online access to the raw thermal imagery collected by the AVHRR equipment. However, NOAA maintains these raw data, as it reports that it recently revisited raw data to re-calculate historic SSTs using an improved algorithm (see also T1Q3 and T3Q1). Neither the Heinz Center nor NOAA/NASA provides online access to the specific subset of SST data points included in this indicator. However, NOAA can provide such metadata upon request, including SST by pixels (within 25 miles of the U.S. coast), SST by region, and seasonal mean maxima by region. For data requests or questions, a good contact at NOAA is Rick Stumpf (Richard.Stumpf@noaa.gov). The Heinz Center has published the exact numerical data that are represented in the graphics for this indicator: http://www.heinzctr.org/ecosystems/coastal/datasets/sst_west.shtml; http://www.heinzctr.org/ecosystems/coastal/datasets/sst_east.shtml.

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Although historical data cannot be re-collected, NOAA has provided sufficient documentation of processing algorithms to allow full reproduction of SST figures from the raw data. The Heinz Center (2002) also presents information to enable seasonal means, long-term means, and overall SST indices to be reproduced. Geographic data sorting can be reproduced using the regional delineation discussed at http://www.heinzctr.org/ecosystems/coastal/intro4.shtml.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

NOAA and NASA document quality assurance and quality control procedures for AVHRR satellite imagery in the current SST data user s guide (http://podaac.jpl.nasa.gov/pub/sea_surface_temperature/avhrr/pathfinder/doc/usr_gde4_0_toc.html; other user s guides linked from http://podaac.jpl.nasa.gov/sst/sst_doc.html). The user s guide includes an appendix specifically devoted to quality flagging of data points.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

In developing this indicator, the Heinz Center (2002) has not made any effort to portray data beyond the spatial and temporal range of the chosen data subset. This indicator involves both spatial and temporal generalization, but in both forms, generalization essentially amounts to calculating averages. Spatially, the figures reported by this indicator represent averages by geographic region. Temporally, this indicator requires that SST data be averaged across the warmest season in each year. This represents a mathematical way to generalize broad trends within the data, as this indicator aims to do.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

NOAA and NASA currently report that they expect temperatures to be measured within 0.3 to 0.5 degrees Celsius of actual values (http://podaac.jpl.nasa.gov/sst/). According to Richard Stumpf of NOAA (personal communication, 2005), the following statement best describes this uncertainty: The source daily data for the monthly means has an accuracy of 0.3 to 0.5 degrees C. According to the current SST data user s guide, NOAA is still in the process of determining the accuracy of its data (http://podaac.jpl.nasa.gov/pub/sea_surface_temperature/avhrr/pathfinder/doc/usr_gde4_0_toc.html; see section 2.2, Accuracy of AVHRR-derived SSTs, which includes supporting references). However, a future revision of uncertainty figures should not negatively impact this indicator, because NOAA anticipates that its recalculations will reveal an actual uncertainty that is lower than the figure currently reported (Richard Stumpf, NOAA, personal communication, 2005).

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

SST data naturally include day-to-day variability, but the Heinz Center has designed this indicator to reflect broader trends. Seasonal averaging reduces the impact of day-to-day variability. NOAA and NASA report uncertainty of 0.3 to 0.5 degrees Celsius in their SST data, which reflects the high precision and accuracy of NOAA s technologically advanced measuring equipment (http://podaac.jpl.nasa.gov/sst/). Cloud cover represents the main source of unquantified uncertainty in the raw satellite data. However, NOAA and NASA have a set of standard QA/QC procedures to filter out data tainted by clouds (see T3Q4). Thus, this uncertainty should not affect the utility of the processed SST data or the overall indicator. The SST data website notes two additional sources of error within NOAA s AVHRR survey (http://podaac.jpl.nasa.gov/sst/sst_prob.html), but they do not affect the utility of the indicator, as noted in the descriptions that follow: (1) In some locations, the Pathfinder processing algorithm incorrectly flags coastal ocean pixels as land. However, the largest of these areas are concentrated around South America and Australia, not the United States. NOAA has processed all SST data using the same algorithm. Thus, at worst, this error means that a few small areas very close to the shore have consistently been excluded from the data set. This does not introduce any year-to-year uncertainty into the SST indicator. (2) NOAA has identified some errors in SST at high latitudes, particularly SST measured below 6 degrees Celsius (specifically due to low brightness temperatures in channel 4 of the AVHRR on the NOAA-14 satellite). More information on this error can be found in Podesta et al. (2003). However, the SST indicator measures relative temperature change, not absolute temperature. Because this indicator also focuses on warm-season temperatures, this error, at worst, would affect data from far northern areas like the Bering Sea, and does not represent a major source of uncertainty. Podestá, G.P., M. Arbelo, R. Evans, K. Kilpatrick, V. Halliwell and J. Brown. 2003. Errors in high-latitude SSTs and other geophysical products linked to NOAA-14 AVHRR channel 4 problem. Geophysical Research Letters 30 (11): 1548

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

(1) Measures effects, not causes. Trends in this indicator do not necessarily implicate global climate change of anthropogenic or non-anthropogenic origin. Naturally occurring climate oscillations can cause noticeable fluctuations in sea surface temperature in U.S. coastal waters (see information and references related to the Pacific Decadal Oscillation, given on the website of the University of Washington s Joint Institute for the Study of the Atmosphere and Ocean: http://www.jisao.washington.edu/pdo/). (2) Limited to SSTs from warmest season only. By measuring temperature changes during only one season, this indicator may not address the full range of ways in which temperature changes can impact the health of the nation s coastal ecosystems. For example, warming in the cool season might allow a population to survive when otherwise, it would have died off or migrated to warmer waters. Warming and cooling in all seasons may affect nutrient cycling and migration patterns (Hayward, 1996; Blackbourn, 1987). Blackbourn D.J. 1987. Sea Surface Temperature and the Pre-Season Prediction of Return Timing in Fraser River Sockeye Salmon (Oncorhynchus nerka). In Smith HD., Margolis L., & Wood CC. [Ed.] Sockeye Salmon (Oncorhynchus nerka) Population, Biology, and Future Management. Canadian Special Publication of Fisheries and Aquatic Sciences, # 96. Hayward, T.L. 1996. Meeting Report: Long-term change in the North Pacific. CalCOFI Rep., Vol. 37. http://www.calcofi.org/newhome/publications/CalCOFI_Reports/v37/pdfs/Vol_37_Hayward.pdf (3) Data limitations. As currently presented by the Heinz Center (2002), this indicator covers the period 1985-1998, and it lacks any data for 1996 and 1997. According to the Heinz Center (2002), data are available for the period 1979-1984, but they are not sufficiently comprehensive to be included in this indicator. [The next web update of the Heinz Report is expected to occur in late 2005, and should incorporate full SST data available from NOAA/NASA for 1996, 1997, and 1999-2003.]

Indicator: US and Global Mean Temperature and Precipitation (351)

Air temperature and precipitation are the two main properties of climate and the most easily measured, directly observable, and geographically consistent indicators of climate change. Both indicators significantly impact ecological condition and human health.

Trends in global temperature and precipitation provide a context for interpreting trends in temperature and precipitation in the U.S. Instrumental records from land stations and ships indicate that global mean surface temperature warmed by about 0.6ºC +/- 0.2ºC during the 20th century (Figure 351-1, bottom). The warming trend is spatially widespread and is consistent with the global retreat of mountain glaciers, reduction in snow-cover extent, the earlier spring melting of ice on rivers and lakes, and increases in sea-surface temperatures and ocean heat content (NRC, 2001). Global mean precipitation also has increased (Figure 351-2, bottom). Precipitation over land has increased by about 2 percent globally since 1901, but the trends vary spatially and temporally. For example, instrumental records show a 5 to 10 percent increase in precipitation over land in northern mid-high latitudes, except over eastern Asia. In contrast, land-surface precipitation over the sub-tropics decreased about 3 percent during the 20th century, a trend that has weakened in recent decades (IPCC, 2001).

This indicator shows trends in actual temperatures and temperature anomalies and trends in precipitation and precipitation anomalies based on instrumental records of temperature and precipitation over the United States from 1901 to the present (with the exception of Alaska and Hawaii, where records began in 1918 and 1905, respectively).

Temperature anomalies (in degrees centigrade) represent the difference between the average temperature for a given month and the 1961-1990 mean. Precipitation anomalies represent the difference between the total precipitation for a given month and the 1961-1990 mean. The precipitation anomalies are converted to percent departures from average using the 1961-1990 means. Annual time series reflect the average (temperature anomaly) or total (precipitation anomaly) of the monthly time series.

What the Data Show

Across the contiguous United States, temperatures rose linearly at a rate of 0.06°C (0.1°F) per decade since 1901, increasing to 0.33°C (0.6°F) per decade since 1976 (Figure 351-1). The last five five-year periods (1999–2003, 1998–2002, 1997–2001, 1996–2000,1995–99) were the warmest in the last 109 yr of national records (compared to the 1961-1990 mean). The most recent six-year-(1998–2003), seven-year (1997–2003), eight-year (1996–2003), nine-year (1995–2003), and ten-year (1994–2003) periods also are the warmest on record for the United States (Levinson and Waple, 2004).

Most regions of the US have warmed by at least 0.6ºC (1ºF) since 1901 although the Southeast (climate region 2) has cooled (Figure 351-1). Warming in excess 1°C (1.8°F) has occurred in the West (climate region 8) and Alaska (climate region 10).

Total annual precipitation over the contiguous U.S has increased by 6.1 percent in the last century, although there is significant regional variability (Figure 351-2). (The precipitation trend based on linear regression shows an increase in precipitation of 4.5 mm/decade.) Precipitation has increased by at least 10% in the East North Central (climate region 5) and the South (climate region 4). Decreases in precipitation have been observed in the Southwest (climate region 7) and Hawaii (climate region 11).

Indicator Limitations

- Biases may have occurred as a result of changes over time in instrumentation, measuring techniques, and the exposure and location of the instruments.

- Uncertainites in both the temperature and precipitation data increase as one goes back in time, particularly in the west, where there are fewer stations early in the record.

Data Sources

The US Historical Climate Network (USHCN)

- NOAA's National Climate Data Center (NCDC): http://www.ncdc.noaa.gov/oa/climate/research/ushcn/ushcn.html

- DOE's Carbon Dioxide Information and Analysis Center (CDIAC): http://cdiac.ornl.gov/r3d/ushcn/ushcn.html#TOP

References

IPCC, 2001a: Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 881pp.

NRC (National Research Council), 2001. Climate Change Science: An Analysis of Some Key Questions. Committee on the Science of Climate Change. National Academy Press, Washington, DC, 29 pp.

Levinson, D. H., and A. M. Waple, 2004: State of the Climate 2003. *Bull. Amer. Meteor. Soc.*, **85** (June), S1–S72.

Graphics

Figure 351-1: **Annual Mean Temperature Anomalies 1901-2003**

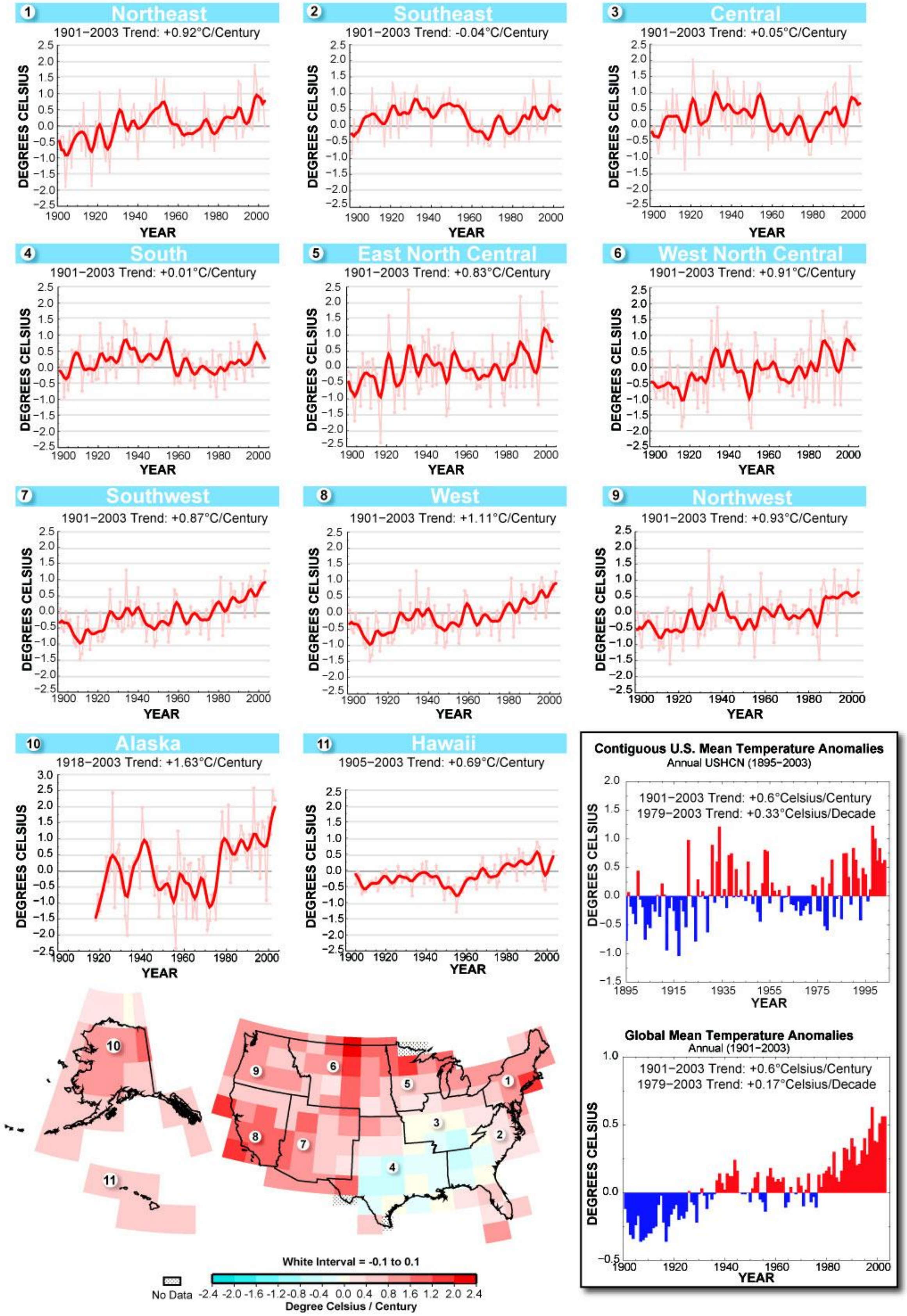
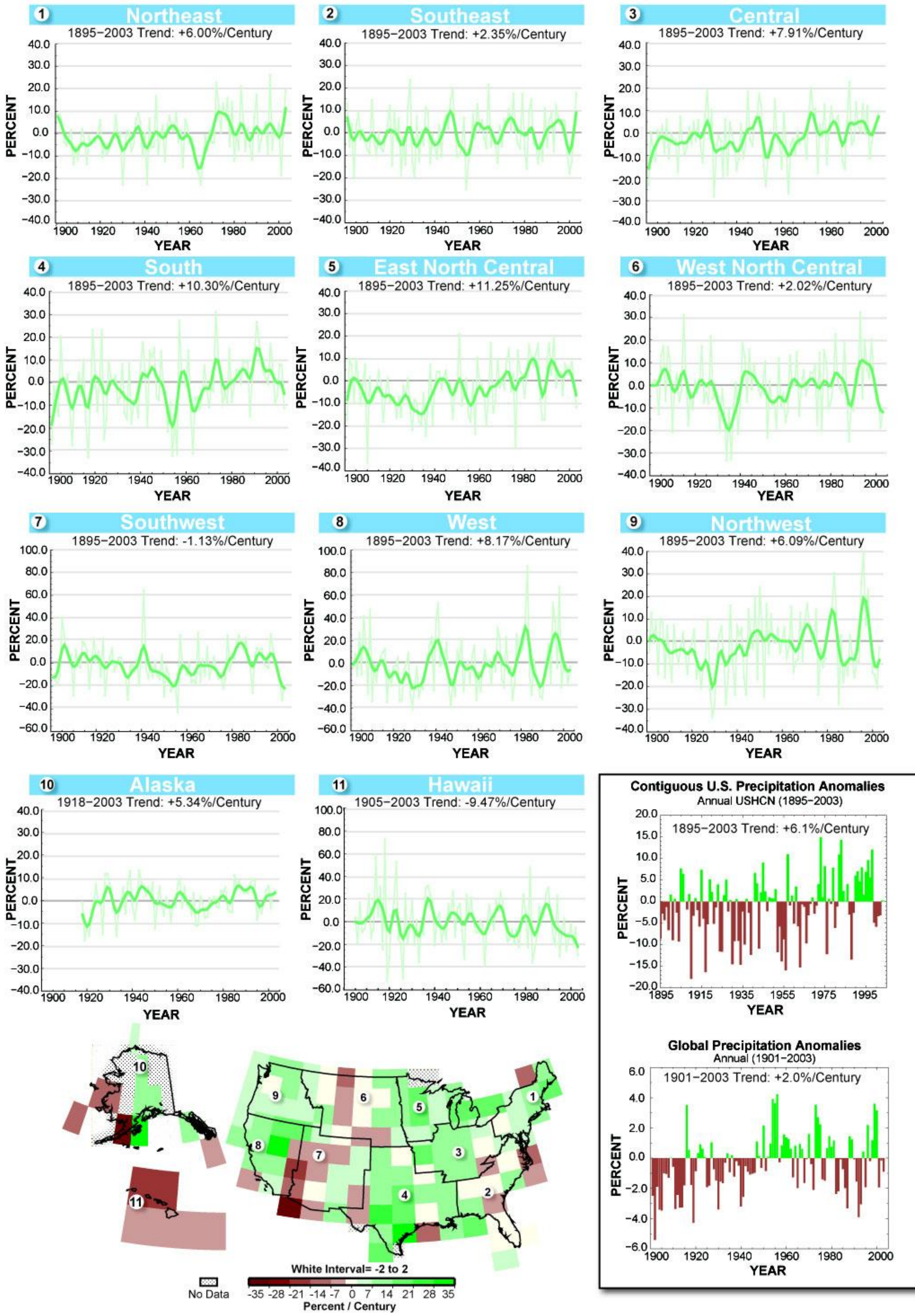


Figure 351-2: Annual Precipitation Anomalies 1895-2003



R.O.E. Indicator QA/QC

Data Set Name: U.S. AND GLOBAL MEAN TEMPERATURE AND PRECIPITATION
Indicator Number: 351 (114471)
Data Set Source: The U.S. Historical Climate Network and Global Historical Climate Network
Data Collection Date: 1901-2003
Data Collection Frequency: monthly
Data Set Description: Changes/Trends in Anomalies of US and Global Mean Temperature and Precipitation
Primary ROE Question: What are the trends in the critical physical and chemical attributes of the Nation's ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Yes. The U.S. Historical Climatology Network (USHCN, Karl et al. 1990) is a high-quality moderate sized data set of monthly averaged maximum, minimum, and mean temperature and total monthly precipitation developed to assist in the detection of regional climate change.

References: http://www.ncdc.noaa.gov/oa/climate/research/ushcn/ushcn.html and http://cdiac.esd.ornl.gov/epubs/ndp019/ndp019.html

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Yes. One of the objectives in establishing the U.S. HCN was to detect secular changes of regional rather than local climate. Therefore, only those stations that were not believed to be influenced to any substantial degree by artificial changes of local environments were included in the network. Some of the stations in the U.S. HCN are first order weather stations, but the majority were selected from U.S. cooperative weather stations (approximately 5000 in the United States). To be included in the U.S. HCN, a station had to be active (in 1987), have at least 80 years of mean monthly temperature and total monthly precipitation data, and have experienced few station changes. An additional criterion that was used in selecting the 1221 U.S. HCN stations, which sometimes compromised the preceding criteria, was the desire to have a uniform distribution of stations across the United States.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?
Yes. These data have been adjusted to remove biases introduced by station moves, instrument changes, time-of-observation differences, and urbanization effects.

References: - Easterling, D.R., and T.C. Peterson, 1995: A new method of detecting undocumented discontinuities in climatological time series, Int. J. of Climatol., 15, 369-377. - Karl, and C.N. Williams, 1987: An approach to adjusting climatological time series for discontinous inhomogeneities. J. Climate Appl. Meteor., 26, 1744-1763. - Karl, C.N. Williams Jr., and P.J. Young, 1986: A model to estimate the time of observation bias associated with monthly mean maximum, minimum, and mean temperatures for the United States J. Climate Appl. Meteor., 25, 145-160. - Karl, H. Diaz, and G. Kukla, 1988: Urbanization: Its detection in the U.S. climate record. J. Climate Appl. Meteor., 1, 1099-1123. - Quayle, R.G., D.R. Easterling, T.R. Karl, and P.Y. Hughes, 1991: Effects of recent thermometer changes in the cooperative station network. Bull. Amer. Meteor. Soc., 72, 1718-1723.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The indicator provides a century long record of observed temperatures and precipitation throughout the United States. The USHCN is comprised of 1221 high-quality stations from the U.S. Cooperative Observing Network within the 48 contiguous United States. The data set is comprised of monthly averaged maximum, minimum, and mean temperature and total monthly precipitation. The data for Alaska and Hawaii originate from the Global Historical Climate Network dataset (GHCN) (comprised of over 14,000 individual station monthly records) which undergoes the same quality control measures as the USHCN. However these data are analyzed to produce 5x5 degree grid box data, whereas it was determined that a 2.5 degrees X 3.5 degree grid box was optimal for analysis of the USHCN data within the contiguous U.S. See: http://www.ncdc.noaa.gov/oa/climate/research/ushcn/gridbox.html

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The network covers the entire United States, including sensitive populations and ecosystems.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

The mean temperature and precipitation trends provide an unambiguous indicator of climate change in the United States.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

See: http://www.ncdc.noaa.gov/oa/climate/research/ushcn/ushcn.html

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

The USHCN was developed and is maintained at NOAA's National Climatic Data Center (NCDC) and the Carbon Dioxide Information and Analysis Center (CDIAC) of Oak Ridge National Laboratory through a cooperative agreement between the NCDC and the U.S. Department of Energy. Currently it is distributed by NCDC and by CDIAC on various computer media including anonymous ftp. There are no confidentiality issues that may limit accessibility. Link to data online: ftp://ftp.ncdc.noaa.gov/pub/data/ushcn/
http://cdiac.esd.ornl.gov/epubs/ndp019/ushcn_r3.html

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

Yes. Appropriate README files are appended to the data so that they are discernible for analysis. See: ftp://ftp.ncdc.noaa.gov/pub/data/ushcn/README.TXT
T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Both the National Climatic Data Center and the Carbon Dioxide Information and Analysis Center publish extensive documentation about the USHCN dataset. See:
http://www.ncdc.noaa.gov/oa/climate/research/ushcn/ushcn.html and
http://cdiac.esd.ornl.gov/epubs/ndp019/ndp019.html

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Anomalies and Trends for the contiguous US were calculated from the US Historical Climatology Network database (Karl et al. 1990). The Anomaly Method was used for calculating station anomalies (base period 1961-1990 minimum 25 of 30 years of data required) on a month by month basis, and the station anomalies were then averaged within 3.5X2.5 degree grid cells. In obtaining regional time series, the grid cell anomalies were averaged (using cosine weighting) across all grid cells within regions. For grid cells that were only partially contained within a region, the grid cell anomaly was also weighted by the proportion of the grid cell within the region. Annual time series are the average (temperature) or total (precipitation) of the monthly time series. Precipitation anomalies were converted to percent departures from average using the 1961-1990 means. Grid cell trends were calculated using least squares regression after the annual time series were computed for each grid box. The Global Historical Climatology Network database (Peterson and Vose, 1997) was the source of data for Alaska and Hawaii anomaly and trend calculations as well as for global calculations. The global temperature temperature trends were taken from the merged land air and sea surface temperature dataset consisting of a combination of GHCN and COADS data. Global precipitation is from GHCN only. Station anomalies for precipitation were calculated using the Anomaly Method (base period 1961-1990 minimum 25 of 30 years of data required), while station temperature anomalies were calculated using the First Difference Method (Peterson et al. 1998) on a month by month basis. Station anomalies for precipitation and temperature were averaged within 5X5 degree grid cells and the monthly grid cell values averaged (temperature) or totaled (precipitation) into annual anomalies. Precipitation anomalies were converted to percent departures from average using the 1961-1990 means. Statewide and global time series and grid cell trends were calculated in the manner described for the contiguous US. Trends were calculated only in those grid cells for which there were at least 68 years of data in the 103-year period. A summary of the data set and methods (for the Global data, i.e. Alaska and Hawaii) used in development can be found at http://www.ncdc.noaa.gov/gcag/gcagmerged.html

Additional references: - Karl, T.R., C.N. Williams, Jr., F.T. Quinlan, and T.A. Boden, 1990: United States Historical Climatology Network (HCN) Serial Temperature and Precipitation Data, Environmental Science Division, Publication No. 3404, Carbon Dioxide Information and Analysis Center, Oak Ridge National Laboratory, Oak Ridge, TN, 389 pp. - Peterson, T.C., T.R. Karl, P.F. Jamason, R. Knight, and D.R. Easterling, 1998: The first difference method: maximizing station density for the calculation of long-term global temperature change. Journal of Geophysical Research, Atmospheres , 103 (D20), 25967-25974. - Peterson, T.C., and R.S. Vose, 1997: An overview of the Global Historical Climatology Network temperature data base. Bulletin of the American Meteorological Society , 78 (12), 2837-2849.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Not presently. During the first half of 2005, it is likely that NOAA's National Climatic Data Center will begin putting error bars on temperature time series, but techniques for doing this for precipitation have not been developed.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Balling and Idso (2002) compare the USHCN data with several surface and upper-air datasets and show that the effects of the various USHCN adjustments produce a significantly more positive, and likely spurious, trend in the USHCN data. However, in a subsequent analysis Vose et al. (2003) found that USHCN station history information is reasonably complete and that the bias adjustment models have low residual errors. References: Balling Jr., R.C. and Idso, C.D. 2002. Analysis of adjustments to the United States Historical Climatology Network (USHCN) temperature database. Geophysical Research Letters R. S. Vose, C. N. Williams Jr., T. C. Peterson, T. R. Karl, and D. R. Easterling, 2003: An evaluation of the time of observation bias adjustment in the U.S. Historical Climatology Network. Geophysical Research Letters.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

There are data gaps, particularly in the earlier years of the time series that increase the uncertainty but these are not sufficient to mislead the user about the fundamental trends.