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 5^{th}-95^{th} 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 1^{st} through 4^{th} 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.

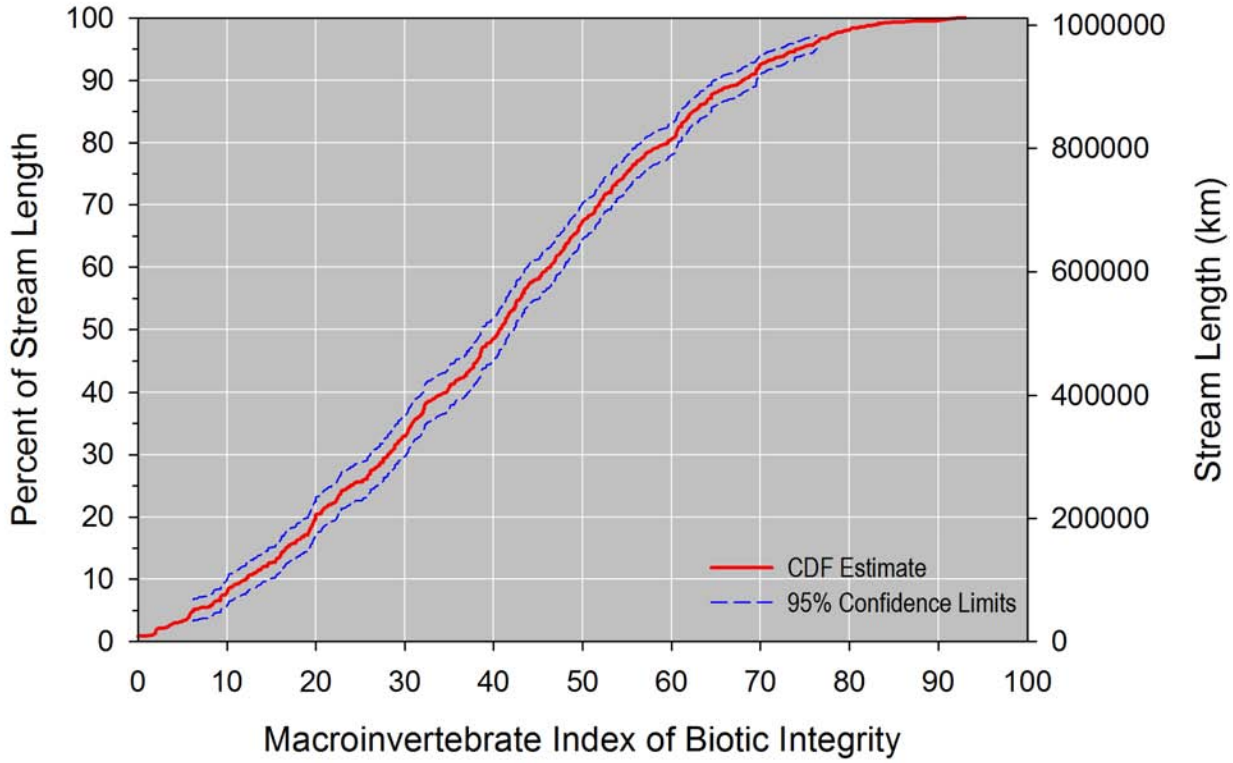
U.S. EPA. 2004. Wadeable Streams Assessment: Benthic Laboratory Methods. U.S. Environmental Protection Agency; Office of Water, Washington D.C. EPA841-B-04-007

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.