X. Appendices

The following appendices accompany the report entitled *Approach for Developing a National Atlas of Vulnerabilities for U.S. Water Quality and Aquatic Ecosystems*.

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Appendix A. Bibliography

The literature sources in the following list were reviewed to identify indicators of vulnerability of water quality and aquatic ecosystems. Core Literature studies (i.e., those identified by the Global Change Research Program (GCRP) as starting points for building the comprehensive list of indicators for this study) are identified by a * before the authors' names.

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Appendix B. Comprehensive List of Indicators

The following table lists the 623 indicators gathered from a review of the 86 documents cited in Appendix A. Each indicator was randomly assigned an Indicator ID#. This unique identifier serves as an easy way to identify and refer to the indicator throughout the report. Indicator definitions included in this table were obtained, when possible, from the literature source that identified the indicator. (Note: Some text may be verbatim from the source.). Definitions for some indicators were revised when the data used were different (e.g., more recent) than those cited by the literature. These revised definitions are marked with * in the Indicator Definition column.

The references cited in the Literature Source column refer to the literature source from which the indicator was obtained. Full citations for these references can be found in Appendix A. Some indicators from this list were determined to be duplicates; for these, the ID# of the duplicate indicator is listed in the Duplicate Indicator column. After selection of one indicator for further assessment from each duplicate group, the remaining duplicates were eliminated. Selection of indicators from groups of duplicates was based on completeness of the indicator definition, national (as opposed to regional or local) focus of the literature source, etc. Eliminated duplicate indicators are marked with an ^{X} next to the indicator ID#.

The 53 indicators identified as vulnerability indicators in the report appear in boldface font in this table. (The remaining 559 indicators were considered to be state variables). Of these, the 25 example indicators that were mapped have a **** next to the indicator ID#.

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
1**	**Acid Neutralizing Capacity (ANC)**	**Percent of streams with low acid-neutralizing capacity (ANC) i.e., below 100 milliequivalents/liter. ANC is a measure of the water's ability to buffer additional acid deposition or drainage from acid mines.***	**USEPA, 2006b.**	
2	Agricultural Inputs - Durable Goods (Units of durable goods per unit of output)	Tractors are an example of durable goods. This indicator reports the amount of inputs used to produce one unit of output, with 1975 as the base year. For example, all fertilizers used on U.S. farms were divided by all agricultural outputs — even if different amounts of fertilizer were used to produce each commodity. So, for any input, the index value for a given year describes whether more or less of that input was used to produce a unit of output in that year than in 1975.	Heinz Center, 2002; Heinz Center, 2008	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
3	Agricultural Inputs - Energy (Units of energy per unit of output)	This indicator reports the amount of energy inputs used to produce one unit of output, with 1975 as the base year. For example, all fertilizers used on U.S. farms were divided by all agricultural outputs — even if different amounts of fertilizer were used to produce each commodity. So, for any input, the index value for a given year describes whether more or less of that input was used to produce a unit of output in that year than in 1975.	Heinz Center, 2002; Heinz Center, 2008	
4	Agricultural Inputs - Fertilizers (Units of fertilizers per unit of output)	This indicator reports the amount of fertilizer inputs used to produce one unit of output, with 1975 as the base year. For example, all fertilizers used on U.S. farms were divided by all agricultural outputs — even if different amounts of fertilizer were used to produce each commodity. So, for any input, the index value for a given year describes whether more or less of that input was used to produce a unit of output in that year than in 1975.	Heinz Center, 2002; Heinz Center, 2008	
5	Agricultural Inputs - Labor (Units of labor per unit of output)	This indicator reports the amount of labor inputs used to produce one unit of output, with 1975 as the base year. For example, all fertilizers used on U.S. farms were divided by all agricultural outputs — even if different amounts of fertilizer were used to produce each commodity. So, for any input, the index value for a given year describes whether more or less of that input was used to produce a unit of output in that year than in 1975.	Heinz Center, 2002; Heinz Center, 2008	
6	Agricultural Inputs - Land (Units of land per unit of output)	This indicator reports the amount of land inputs used to produce one unit of output, with 1975 as the base year. For example, all fertilizers used on U.S. farms were divided by all agricultural outputs — even if different amounts of fertilizer were used to produce each commodity. So, for any input, the index value for a given year describes whether more or less of that input was used to produce a unit of output in that year than in 1975.	Heinz Center, 2002; Heinz Center, 2008	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
7	Agricultural Inputs - Pesticides (Units of pesticides per unit of output)	This indicator reports the amount of pesticide inputs used to produce one unit of output, with 1975 as the base year. For example, all fertilizers used on U.S. farms were divided by all agricultural outputs — even if different amounts of fertilizer were used to produce each commodity. So, for any input, the index value for a given year describes whether more or less of that input was used to produce a unit of output in that year than in 1975.	Heinz Center, 2002; Heinz Center, 2008	
8	Agricultural Outputs - Crops (Units of output per year)	The indicator reports agricultural outputs over time, with 1975 as the base year.	Heinz Center, 2002; Heinz Center, 2008	
9	Agricultural Outputs - Meat, Dairy, Eggs, and Other Products (Units of output per year)	The indicator reports U.S. agricultural outputs over time, with 1975 as the base year.	Heinz Center, 2002; Heinz Center, 2008	
10	Agricultural Outputs - Total (Units of output per year)	The indicator reports U.S. agricultural outputs over time, with 1975 as the base year.	Heinz Center, 2002; Heinz Center, 2008	
11	Agricultural products (economic production)	This indicator reports the production of food and fiber and the withdrawals of water (agricultural products), using an index with 1980 as the base year.	Heinz Center, 2002; Heinz Center, 2008	
12	Agricultural water use share	Agricultural sector withdrawals (QWag) as a share of total average annual withdrawals. Method of calculation: QWag/QW	Hurd et al., 1998.	
13	Air Quality - High Ozone Levels: At least 1 day per year (Percent of urban/suburban air monitoring stations with 1 day exceedance)	This indicator reports the percentage of air pollution monitoring stations in urban and suburban areas with “high” ozone concentrations at least 1 day a year. Ground-level ozone is considered high when the 8-hour average concentration exceeds 0.08 parts per million (ppm).	Heinz Center, 2002; Heinz Center, 2008	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
14	Air Quality - High Ozone Levels: At least 2 days per year (Percent of urban/suburban air monitoring stations with 2 day exceedance)	This indicator reports the percentage of air pollution monitoring stations in urban and suburban areas with "high" ozone concentrations at least 2 days a year. Ground-level ozone is considered high when the 8-hour average concentration exceeds 0.08 parts per million (ppm).	Heinz Center, 2002; Heinz Center, 2008	
15	Air Quality - High Ozone Levels: At least 3 days per year (Percent of urban/suburban air monitoring stations with 3 day exceedance)	This indicator reports the percentage of air pollution monitoring stations in urban and suburban areas with "high" ozone concentrations at least 3 days a year. Ground-level ozone is considered high when the 8-hour average concentration exceeds 0.08 parts per million (ppm).	Heinz Center, 2002; Heinz Center, 2008	
16	Air Quality - High Ozone Levels: At least 4 days per year (Percent of urban/suburban air monitoring stations with 4 day exceedance)	This indicator reports the percentage of air pollution monitoring stations in urban and suburban areas with "high" ozone concentrations at least 4 days a year. Ground-level ozone is considered high when the 8-hour average concentration exceeds 0.08 parts per million (ppm).	Heinz Center, 2002; Heinz Center, 2008	
17	**Altered Freshwater Ecosystems (percent miles changed)**	**This indicator of alteration reports the percentage of:**	**Heinz Center, 2002; Heinz Center, 2008**	
18	Ambient toxicity (chemical concentration)	Metals, pesticides, PCBs, and organic contaminants.	USEPA, 2006a.	
19	Animal Deaths and Deformities (events)	This indicator reports on unusual mortality events for waterfowl, fish, amphibians, and mammals, and on deformity events for amphibians. Only data on waterfowl mortality can be reported at this time.	Heinz Center, 2002; Heinz Center, 2008	
20	Aquatic life mobility	N/A	MEA, 2005c.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
21	Areas with depleted oxygen (percent monthly exposure)	The percentage of brackish water exposed to a range of oxygen concentrations for at least 1 month will be reported as anoxic (no oxygen), hypoxic (>0 and <2 parts per million [ppm]), low (2–4 ppm), or sufficient (>4 ppm).	Heinz Center, 2002; Heinz Center, 2008	
22**	**At-Risk Freshwater Plant Communities (% area at risk)**	**This indicator reports on the percentage of wetland and riparian plant communities that are at risk of extinction. These status ranks are based on such factors as the remaining number and condition of occurrences of the community, the remaining acreage, and the severity of threats to the community type.***	**Heinz Center, 2002; Heinz Center, 2008**	**467**
23	At-Risk Native Forest Species (Percent of all forest species that are at risk)	This indicator reports on the relative risk of extinction of native forest species. The risk categories are based on such factors as the number and condition of individuals and populations, the area occupied by the species, population trends, and known threats. Degrees of risk reported here range from very high ("critically imperiled" species are often found in five or fewer places or have experienced very steep declines) to moderate ("vulnerable" species are often found in fewer than 80 places or have recently experienced widespread declines). In all cases, a wide variety of factors contribute to the overall ratings. "Forest species" live in forests during at least part of their life and depend on forest habitats for survival.	Heinz Center, 2002; Heinz Center, 2008	
24**	**At-Risk Native Freshwater Species (relative rank)**	**This indicator reports on percentage of native freshwater species that are at risk of extinction. The risk categories are based on such factors as the number and condition of individuals and populations, the area occupied by the species, population trends, and known threats.***	**Heinz Center, 2002; Heinz Center, 2008**	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
25	At-Risk Native Grassland and Shrubland Species - By Category (Percent of all at-risk species in a certain category)	Categories include: Extinct, Critically Imperiled, Imperiled, Vulnerable, and All At-Risk. This indicator reports on the status of native grassland and shrubland species with respect to their relative risk of extinction. These status ranks are based on multiple factors: the number and condition of individuals and populations, the area occupied by the species, population trends, and known threats. Degrees of risk reported here range from very high ("critically imperiled" species often are found in five or fewer places or have experienced very steep declines) to moderate ("vulnerable" species often are found in fewer than 80 places or have recently experienced widespread declines). In all cases, a wide variety of factors contribute to overall ratings. "Grassland and shrubland species" live in these habitats during at least part of their life cycle and depend on them for survival.	Heinz Center, 2002; Heinz Center, 2008	
26	At-Risk Native Grassland and Shrubland Species - By Region (Percent of all at-risk species in a certain region)	Regions include: Northeast/Mid-Atlantic, Southeast, Midwest, Southwest, Rocky Mountain, Pacific Coast, and Hawaii. This indicator reports on the status of native grassland and shrubland species with respect to their relative risk of extinction. These status ranks are based on multiple factors: the number and condition of individuals and populations, the area occupied by the species, population trends, and known threats. Degrees of risk reported here range from very high ("critically imperiled" species often are found in five or fewer places or have experienced very steep declines) to moderate ("vulnerable" species often are found in fewer than 80 places or have recently experienced widespread declines). In all cases, a wide variety of factors contribute to overall ratings. "Grassland and shrubland species" live in these habitats during at least part of their life cycle and depend on them for survival.	Heinz Center, 2002; Heinz Center, 2008	
27	**At-Risk native marine species (relative risk)**	**Relative risk of extinction of native marine species, both plants and animals. The risk categories are based on such factors as the number and condition of individuals and populations, the area occupied by the species, population trends, and known threats.**	**Heinz Center, 2002; Heinz Center, 2008**	
28	At-Risk native species (relative rank)	This indicator reports on the relative risk of extinction of native plant and animal species.	Heinz Center, 2002; Heinz Center, 2008	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
29	Bay grasses	N/A	Chesapeake Bay Program, 2008.	
30	Beach closings (driven by bacterial contamination)	Measure of bacterial contamination.	USEPA, 1995.	
31	Benthic Index (several)	Shannon-Weiner Diversity Index, and other Indices.	USEPA, 2006a.	
32[X]	Benthic Macroinvertebrates	Benthic communities are largely composed of macroinvertebrates, such as annelids, mollusks, and crustaceans. These organisms 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, and birds.	USEPA, 2008b.	461, 33
33[X]	Benthic organisms (abundance, diversity)	Benthic abundance, species richness/diversity.	Hayslip et al., 2006.	32, 461
34	Bottom habitat (diversity, abundance, biomass)	Attainment of the benthic restoration goal was determined by examining: benthic biodiversity measures, measures of assemblage abundance and biomass, life history strategy measures, activity beneath the sediment surface, and feeding guild measures.	Chesapeake Bay Program, 2008.	
35	Carbon Storage - Forests (Weight of carbon stored over time)	This indicator reports how much carbon—an essential component of all organisms—is stored in forests, including trees, soil, and plant litter on the forest floor, and in wood products.	Heinz Center, 2002; Heinz Center, 2008	36, 617
36[X]	Carbon Storage - Grasslands/Shrublands (Weight of carbon stored over time)	This indicator will report the total amount of carbon stored in soil and plants in grasslands and shrublands.	Heinz Center, 2002; Heinz Center, 2008	35, 617
37	Chemical contaminants (exceedence of regulatory value)	Metals, PCBs, tributyltin, and priority organics found exceeding total maximum daily loads (TMDLs).	Chesapeake Bay Program, 2008.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
38	Chemical Contamination in Urban Streams - Contaminant Occurrence (Number of contaminants detected)	This indicator reports on contaminants found in urban and suburban streams. Compounds reported here include many pesticides, select pesticide breakdown products, ammonia, and nitrate (because nitrate and ammonia occur naturally, they are not included in the graphs showing contaminant occurrence).	Heinz Center, 2002; Heinz Center, 2008	
39	Chemical Contamination in Urban Streams - Contaminant Concentrations above Standards or Guidelines (Percent sites with exceedances)	This indicator reports on contaminants found in urban and suburban streams. Compounds reported here include many pesticides, select pesticide breakdown products, ammonia, and nitrate (because nitrate and ammonia occur naturally, they are not included in the graphs showing contaminant occurrence).	Heinz Center, 2002; Heinz Center, 2008	
40	Chemical Contamination in Urban/Suburban Soils	This indicator reports on contaminants found in urban and suburban soils. Compounds reported here include many pesticides, selected pesticide breakdown products, ammonia, and nitrate (because nitrate and ammonia occur naturally, they are not included in the graphs showing contaminant occurrence).	Heinz Center, 2002; Heinz Center, 2008	
41[x]	Chlorophyll a	N/A	Chesapeake Bay Program, 2008.	42
42	Chlorophyll a (surface concentration)	Good: Surface concentrations are less than 5 µg/L (less than 0.5 µg/L for tropical ecosystems). Fair: Surface concentrations are between 5 µg/L and 20 µg/L (between 0.5 µg/L and 1 µg/L for tropical ecosystems). Poor: Surface concentrations are greater than 20 µg/L (greater than 1 µg/L for tropical ecosystems).	USEPA, 2006a.	41
43	Chlorophyll concentrations (within 25 miles of shore)	Chlorophyll concentration in estuaries and ocean waters within 25 miles of shore. For ocean waters, the indicator reports the average value for the season with the highest concentration, for each region. For estuaries, the indicator reports the percentage of area in three ranges: below 5 parts per billion (ppb), between 5 and 20 ppb, and above 20 ppb, using data for the season with the highest average concentration.	Heinz Center, 2002; Heinz Center, 2008	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
44	Climate, storm, and extreme event variability	Climate fluctuations, mostly related to flood and drought events.	Gleick and Adams, 2000.	
45	Coastal Bird Populations (2 indicator species)	Indicators consist of two birds (piping plover and least tern) that inhabit Long Island Sound beaches, plus wading birds that forage in tidal marshes.	Long Island Sound Study, 2008.	46
46[X]	Coastal birds	N/A	MEA, 2005b.	45
47	Coastal erosion (managed vs. unmanaged area)	How much of the U.S. coast is managed in an attempt to control erosion and how much remains in a "natural" state, with no erosion control. For unmanaged areas, the indicator reports what fraction is eroding, accreting (gaining land area), or stable.	Heinz Center, 2002; Heinz Center, 2008	
48[X]	Coastal Fish Tissue Contaminants	N/A	USEPA, 2008b.	58, 99, 579
49	Coastal land loss	N/A	Twilley et al., 2001.	
50[X]	Coastal Sediment Quality	N/A	USEPA, 2008b.	250
51**	**Coastal Vulnerability Index (to sea level rise)**	**Index of coastal ecosystem vulnerability to sea level rise. he index allows the six physical variables to be related in a quantifiable manner that expresses the relative vulnerability of the coast to physical changes due to sea-level rise. This method yields numerical data that cannot be equated directly with particular physical effects. It does, however, highlight those regions where the various effects of sea-level rise might be the greatest. The six variables are: a = Geomorphology; b = Coastal Slope (%); c = Relative sea-level change (mm/year); d = Shoreline erosion/accretion (m/year); e = Mean tide average (m); e = Mean wave height (m). Once each section of coastline is assigned a risk value based on each specific data variable, the coastal vulnerability index is calculated as the square root of the geometric mean, or the square root of the product of the ranked variables divided by the total number of variables as: CVI = [(a*b*c*d*e*f*)/6)]^1/2. ***	**Day et al., 2005.**	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
52	Coastal wetlands (extent/acreage)	Acreage of coastal habitats whose defining feature is that they are composed of living organisms (such as seagrasses, mangrove forests, and coastal wetlands) or are built by them (such as coral reefs or shellfish beds).	Heinz Center, 2002; Heinz Center, 2008	53
53[x]	Coasts and Oceans (extent/acreage)	This indicator presents the area coastal land as a percentage of the total U.S. land area, for the most recent 50-year period and compared to presettlement estimates.	Heinz Center, 2002; Heinz Center, 2008	52
54	Commercial fish and shellfish landings (weight)	Reports the weight of fish, shellfish, and other products taken from U.S. waters. Landings, plus certain aquaculture harvests, are shown for five regions that cover all waters out to the 200-mile territorial limit.	Heinz Center, 2002; Heinz Center, 2008	
55	**Commercially important fish stocks (size)**	**Tracks the percentage of commercially important fish species, or "stocks," that are increasing or decreasing in size. Only stocks whose population increased or decreased by at least 25% are reported. Trends are based on the estimated weight, or "biomass," of the entire stock.**	**Heinz Center, 2002; Heinz Center, 2008**	
56	Condition of bottom-dwelling animals (percent area inhabited)	Describes the condition of worms, clams, snails, and shrimplike animals in bottom sediments ("benthic communities") by reporting the percentage of area in which these communities are in "undegraded," "moderate," and "degraded" condition. The index reflects changes in benthic community diversity and the abundance of pollution-tolerant and pollution-sensitive species. A low benthic index rating indicates that the benthic communities are less diverse than expected, are populated by more than expected pollution-tolerant species, and contain fewer than expected pollution-sensitive species. The data in this report reflect an assessment of benthic communities as "good" (high index score), "fair" (moderate index score), or "poor" (low index score).	Heinz Center, 2002; Heinz Center, 2008	
57	Constructed Materials - 30% or Greater Area Covered by Constructed Materials (area)	This indicator would report on the percentage of land area covered by 30% or more constructed materials.	Heinz Center, 2002; Heinz Center, 2008	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
58	Contaminants in fish and shellfish (chemical concentration)	Measures the concentration of PCBs, mercury, and DDT in the edible tissue of seafood from U.S. coastal waters.	Heinz Center, 2002; Heinz Center, 2008	48, 99, 579
59	Contamination in bottom sediments (concentration)	Information on the concentration, in coastal bottom sediments, of four major classes of contaminants that can harm fish and other aquatic organisms and can adversely affect human health if ingested while consuming fish or shellfish.	Heinz Center, 2002; Heinz Center, 2008	
60	Cropland (total area of land used for crops)	This indicator reports the amount of land used for crops, including pasture and hay. Acreage that is enrolled in long-term set-aside programs, such as the Conservation Reserve Program (CRP) is not considered to be part of this indicator.	Heinz Center, 2002; Heinz Center, 2008	
61	Croplands (extent/acreage)	This indicator presents the area of croplands as a percentage of the total U.S. land area, for the most recent 50-year period and compared to presettlement estimates.	Heinz Center, 2002; Heinz Center, 2008	
62	Cropped Land (area, ecosystem condition)	This indicator would report on the percentage of land area that is cropped land (not including interspersed natural areas).	Heinz Center, 2002; Heinz Center, 2008	
63	Delta accretion rate	The rate of sediment accretion in a river delta.	Day et al., 2008.	
64	Depth to Shallow Groundwater (Percent of shallow groundwater with a certain depth)	This indicator will describe the depth to shallow groundwater in grassland and shrubland areas. Specifically, it will report the percentage of grassland and shrubland areas where the depth to groundwater falls within several ranges (less than 5 feet, 5 to 10 feet, 10 to 20 feet and more than 20 feet).	Heinz Center, 2002; Heinz Center, 2008	
65	Disruptive Species - By Region (Number of disruptive species by region)	This indicator would report the number and type of “disruptive” species found in metropolitan areas. Disruptive species are those that have negative effects on natural areas and native species or cause damage to people and property. This indicator would report the number of disruptive native and non-native plant and animal species on a regional basis, for the most current year.	Heinz Center, 2002; Heinz Center, 2008	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
66	Disruptive Species in Metropolitan Areas (Number of disruptive species over time)	This indicator would report the number and type of "disruptive" species found in metropolitan areas. Disruptive species are those that have negative effects on natural areas and native species or cause damage to people and property. Specifically, the indicator will report the number of larger metropolitan areas with 5 or fewer, from 6 to 10, from 11 to 20, and more than 20 disruptive plant and animal species.	Heinz Center, 2002; Heinz Center, 2008	
67[X]	Dissolved inorganic nitrogen	N/A	Hayslip et al., 2006.	68
68	Dissolved Inorganic Nitrogen (DIN) (surface concentration)	Good: Surface concentrations are less than 0.1 mg/L (NE, SE, Gulf), 0.5 mg/L (West), or 0.05 mg/L (tropical). Fair: Surface concentrations are 0.1–0.5 mg/L (NE, SE, Gulf), 0.5–1.0 mg/L (West), or 0.05–0.1 mg/L (tropical). Poor: Surface concentrations are greater than 0.5 mg/L (NE, SE, Gulf), 1.0 mg/L (West), or 0.1 mg/L (tropical).	USEPA, 2006a.	67
69	Dissolved Inorganic Phosphorus (DIP) (surface concentration)	Good: Surface concentrations are less than 0.01 mg/L (NE, SE, Gulf), 0.01 mg/L (West), or 0.005 mg/L (tropical). Fair: Surface concentrations are 0.01–0.05 mg/L (NE, SE, Gulf), 0.01–0.1 mg/L (West), or 0.005–0.01 mg/L (tropical). Poor: Surface concentrations are greater than 0.05 mg/L (NE, SE, Gulf), 0.1 mg/L (West), or 0.01 mg/L (tropical).	USEPA, 2006a.	
70	Dissolved Organic Carbon	N/A	Lettenmaier et al., 2008.	
71[X]	Dissolved oxygen	Good: Concentrations are greater than 5 mg/L. Fair: Concentrations are between 2 mg/L and 5 mg/L. Poor: Concentrations are less than 2 mg/L.	USEPA, 2006a.	72, 73, 74, 75, 337, 131
72[X]	Dissolved oxygen	N/A	Chesapeake Bay Program, 2008.	71, 73, 74, 75, 337, 131
73[X]	Dissolved oxygen	N/A	Hayslip et al., 2006.	71, 72, 74, 75, 337, 131

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
74	Dissolved Oxygen	Percent of observations of ambient concentrations less than 5 mg/L.	Hurd et al., 1999.	71, 72, 73, 75, 337, 131
75[X]	Dissolved oxygen concentration	N/A	USEPA, 1995.	71, 72, 73, 74, 337, 131
76[X]	Dissolved solids (total)	N/A	USEPA, 2006b.	345
77	Drained or Impounded Wetlands (area, ecosystem condition)	This indicator would reports the percentage of land area drained or impounded wetlands (areas that remain wetlands but have been highly altered).	Heinz Center, 2002; Heinz Center, 2008	
78	Drought events (severity)	N/A	Lettenmaier et al., 2008.	
79	Dryness Ratio (ratio of precipitation/evapotranspiration)	Share of total average annual precipitation (P) that is lost through evapotranspiration (ET), where ET is defined as P-QS.	Hurd et al., 1999.	
80	Duration of Dry Periods in Grassland/Shrubland Streams and Rivers (Percent of streams with substantially shorter/longer dry-periods over time)	Duration of dry-period compared to a 50-year average). The indicator tracks the frequency and duration of zero-flow conditions for streams and rivers in grassland/shrubland regions. It reports the percentage of streams and rivers that have at least one no-flow day per year, and the percentage where the duration of zero-flow periods for a given period is substantially longer or shorter than the long-term (50-year) average.	Heinz Center, 2002; Heinz Center, 2008	
81	Ecosystem extent (classification of area)	Type of ecosystem.	U.S. Climate Change Science Program, 2008.	
82	Ecosystem heat sensitivity	The average annual number of days with maximum temperatures exceeding 90°F (32°C). *	Hurd et al., 1998.	
83	Ecosystem ice cover sensitivity	The average annual number of days with average temperatures below 32°F (0°C). *	Hurd et al., 1998.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
84	Electrical Conductivity	N/A	USEPA, 2006b.	603
85	Estuarine Waters Contamination (chemical occurrence)	This indicator reports on contaminants found in estuarine waters. Contaminants reported here include many pesticides, selected degradation products, polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), volatile organic compounds, other industrial contaminants, trace elements, nitrate, and ammonium. (Because nitrate, ammonium, and trace elements such as cadmium and chromium occur naturally, they are not included in the contaminant occurrence graphs).	Heinz Center, 2002; Heinz Center, 2008	
86	Evaporation and Transpiration	N/A	Lettenmaier et al., 2008.	87
87[x]	Evaporation and Transpiration	N/A	Gleick and Adams, 2000.	86
88	Expenditure on Dredging Activities in Waterways (economy)	Average annual expenditures on dredging activities in navigable waterways.	Hurd et al., 1999.	
89	Extreme temperatures (number)	Number of Threshold Exceedances per Year —Thresholds: Daily Maximum Temperature of 97°F/36°C.	Kling et al., 2003 using data from Wuebbles and Hayhoe, 2003.	
90	Extreme/heavy rainfall events (number)	Number of 24-hour and 7-day intense rainfall events.	Kling et al., 2003 using data from Wuebbles and Hayhoe, 2003.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
91	Farmland Landscape (Cropland as a percentage of total farmland)	This indicator reports the percentage of the farmland landscape that is actively used for crop production, pasture, or haylands. The "farmland landscape" includes croplands and the forests or woodlots, wetlands, grasslands and shrublands, and the like that surround or are intermingled with them. This indicator describes the degree to which croplands dominate the landscape, or, conversely, the degree to which these other lands are intermingled. This indicator also describes the composition of the noncropland portion of the farmland landscape by reporting the percentage of these lands that are forests, grasslands and shrublands, wetlands, developed areas, and other lands and waters. The noncropland elements of the farmland landscape (other than developed) provide wildlife habitat, serve as streamside buffers and windbreaks, and lend a distinctive visual character to the landscape. (Pasture and haylands are intermediate in character between "natural" grasslands and cultivated croplands; for this indicator, they are counted as croplands.)	Heinz Center, 2002; Heinz Center, 2008	
92	Finfish (abundance, biomass)	Indicators include abundance of popular sport fish (such as striped bass and bluefish), fish biomass, and abundance of fish that spawn in rivers in the Sound's watershed.	Long Island Sound Study, 2008.	
93	Fire Frequency (Percent of forest land burned over time)	This indicator describes the frequency with which forests are burned by wildfire. It would report the fraction of forest lands that experience wildfire much more or less frequently, moderately more or less frequently, or with about the same frequency as in presettlement times. Thus, a forest that, historically, burned every 50 years on average will be considered moderately altered if it burns every 100 years, and significantly altered if it burns only every 150 years, and about the same if it burns once every 50 years.	Heinz Center, 2002; Heinz Center, 2008	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
94	Fire Frequency (Percent of grasslands/shrublands by area that are burned over time)	This indicator will describe how often grassland and shrublands are burned by wildfire. Specifically, it will report the fraction of grassland and shrubland areas that burn much more or less often, moderately more or less often, or about as often as before European settlement. So, for example, an area that historically burned every 5 years on average might be considered moderately altered if it now burns every 10 years and significantly altered if it now burns only every 25 years. An area that historically burned every 80 years might be considered moderately altered if it now burns every 40 years and significantly altered if it now burns every 20 years. (Presettlement conditions are used here as a reference against which to compare current conditions, not as an implied management goal).	Heinz Center, 2002; Heinz Center, 2008	
95	**Fish and Bottom-Dwelling Animals (comparison to baseline)**	**This indicator reports on "biological integrity"—the degree to which the suite of fish and bottom-dwelling animals in a lake or stream resembles what one might find in a relatively undisturbed lake or stream in the same region. Tests assess the number of different species, the number and condition of individuals, and food chain interactions for fish and bottom-dwelling (or benthic) animals, which include insects, worms, mollusks, and crustaceans.**	**Heinz Center, 2002; Heinz Center, 2008**	
96	Fish and shellfish populations (5 species)	Blue Crab, Oyster, Striped Bass, Shad, and Juvenile Menhaden population characteristics.	Chesapeake Bay Program, 2008.	
97	Fish range distribution (species)	Northern/southern limit.	Kling et al., 2003.	
98	Fish Tissue Contaminants Index (exceedence of regulatory value)	Good: Concentrations of all chemical contaminants fall below the range of the EPA Advisory Guidance. Fair: Concentration of at least one chemical contaminant falls within the range of the EPA Advisory Guidance. Poor: Concentrations of at least one chemical contaminant exceeds the maximum value in the range of the EPA Advisory Guidance.	USEPA, 2006a.	
99[x]	Fish-tissue contaminants (chemical levels)	Inorganic arsenic, cadmium, lead, mercury, selenium, silver, zinc, DDT.	Hayslip et al., 2006.	58, 48, 579

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
100	**Flood events (frequency)**	**N/A**	**Lettenmaier et al., 2008.**	
101	Forest Age (Percent of forest lands by age group)	This indicator reports the percentage of forest lands with stands in several age classes.	Heinz Center, 2002; Heinz Center, 2008	
102	Forest Area and Ownership (Area of forest lands)	This indicator reports how much forest land there is in the United States and who owns it.	Heinz Center, 2002; Heinz Center, 2008	
103	Forest Community Types with Significantly Reduced Area (Area occupied by community type)	This indicator would report whether those forest community types that cover significantly fewer acres than they did in presettlement times are increasing or decreasing in area, and by how much. It would also report the total area occupied by these much-reduced forest community types—those that have been reduced by 70% or more in area.	Heinz Center, 2002; Heinz Center, 2008	
104	Forest Disturbance: Fire, Insects, Disease (Area affected by disturbance)	This indicator reports the acreage of forest affected each year by several important types of disturbance: forest fires, insects, and diseases of trees.	Heinz Center, 2002; Heinz Center, 2008	
105	Forest Management Categories (Change in percent of forested area with time)	This indicator reports the percentage of forest area in several different management categories. These range from “reserved lands” (forests in national parks, wilderness areas, and other similar areas) to forests under intensive management involving replanting after harvest. Other forest lands in intermediate categories are subject to a wide variety of both management practices and restrictions on use.	Heinz Center, 2002; Heinz Center, 2008	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
106	Forest Pattern and Fragmentation (Percent of a tree's surroundings that are forested)	This indicator describes a tree's forest neighborhood according to the degree of forest cover within various distances. Thus, the "immediate neighborhood" of a particular tree is everything within about 250 feet in all directions. This "immediate neighborhood" is "mostly forest" if the land is at least 90% forested. A tree's "local neighborhood" extends about 1/4 mile in all directions, and its "larger neighborhood" extends about 2 1/2 miles. This analysis relies upon computer analyses of satellite data on millions of individual forest points. While these points (called "pixels") are not individual trees—they are squares about 100 feet on a side—they serve much the same purpose.	Heinz Center, 2002; Heinz Center, 2008	
107	Forest products (economic production)	This indicator reports the production of food and fiber and the withdrawals of water (forest products), using an index with 1980 as the base year.	Heinz Center, 2002; Heinz Center, 2008	
108	Forest Types (Area covered by a certain forest type)	This indicator reports the acreage of a variety of forest "cover types." Cover types describe the dominant species of trees found in the forests (e.g., oak–hickory forests are dominated by oaks and hickories, but include other kinds of trees as well).	Heinz Center, 2002; Heinz Center, 2008	
109	Forests (extent/acreage)	This indicator presents the area of forests as a percentage of the total U.S. land area, for the most recent 50-year period and compared to presettlement estimates.	Heinz Center, 2002; Heinz Center, 2008	
110	Forests with Nursery Stock (area, ecosystem condition)	This indicator reports the percentage of land area that is comprised of forests planted with nursery stock.	Heinz Center, 2002; Heinz Center, 2008	
111	Fragmentation and Landscape Pattern	N/A	Heinz Center, 2002; Heinz Center, 2008	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
112	Fragmentation of Farmland Landscapes by Development (Ratio of cropland: developed land)	This indicator would report the degree to which suburban development and other built-up areas break up (fragment) the farmland landscape (defined as croplands plus intermingled "natural" areas such as forests, wetlands, and grasslands and shrublands). Areas with a mosaic of cropland and intermingled natural areas— but little or no development—would be rated as "low" on the "fragmentation index" used for this indicator, while those in which small patches of cropland are mixed into a backdrop of suburban development would be rated as "high."	Heinz Center, 2002; Heinz Center, 2008	
113	Fresh Water Resources Contamination (chemical occurrence)	This indicator reports on contaminants found in freshwater resources. Contaminants reported here include many pesticides, selected degradation products, polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), volatile organic compounds, other industrial contaminants, trace elements, nitrate, and ammonium. (Because nitrate, ammonium, and trace elements such as cadmium and chromium occur naturally, they are not included in the contaminant occurrence graphs).	Heinz Center, 2002; Heinz Center, 2008	
114	Fresh Waters (extent/acreage)	This indicator presents the area of fresh waters.	Heinz Center, 2002; Heinz Center, 2008	
115	Freshwater input to coastal ecosystems	Rate of freshwater input into coastal ecosystems.	Day et al., 2008.	
116	**Freshwater Rivers and Streams with Low Index of Biological Integrity (ecosystem condition)**	**This indicator would report on the percentage of freshwater rivers and streams with low IBI (Index of Biological Integrity, a species-based measure of disturbance).**	**Heinz Center, 2002; Heinz Center, 2008**	
117	Glaciers	N/A	Gleick and Adams, 2000.	
118	Grassland and Shrubland Areas (extent/acreage)	This indicator presents the area of grasslands and shrublands as a percentage of the total U.S. land area, for the most recent 50-year period and compared to presettlement estimates.	Heinz Center, 2002; Heinz Center, 2008	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
119	Grassland Patches (Percent of grassland patches that cover a certain area)	This indicator will describe the fraction of grassland area and shrubland area that is in patches of different sizes. The total area occupied by patches of a certain size will be reported as a percentage of the total area of either grasslands or shrublands.	Heinz Center, 2002; Heinz Center, 2008	
120	Grasslands and Shrublands (Area covered by grasslands/shrublands)	This indicator reports the acreage of U.S. grasslands and shrublands (although data are not available for Hawaii).	Heinz Center, 2002; Heinz Center, 2008	
121	**Groundwater Depletion - Ratio of Withdrawals/Baseflow**	**Ratio of average groundwater withdrawals (QGW) in 1990 to annual average baseflow (QBase), reflecting the extent that groundwater use rates may be exceeding recharge.**	**Hurd et al., 1999.**	
122	Groundwater Levels - Area of Aquifer subject to Change in Groundwater Levels	This indicator would report the percentage of the area of the nation's major regional aquifers in which water levels are increasing, decreasing, or stable. The indicator would report what fraction of the aquifer area declined, increased, or remained stable in comparison to a previous period, and it would be reported every 5 years.	Heinz Center, 2002; Heinz Center, 2008	
123	Groundwater recharge	Rate of groundwater recharge (mm/year) based on WaterGAP Global Hydrology Model and mapped on a 0.5 degree grid. It accounts for spatial variation in precipitation, infiltration capacity, hydrogeology, topography, and permafrost. *	Lettenmaier et al., 2008.	124
124[X]	Groundwater recharge	N/A	Gleick and Adams, 2000.	123
125**	**Groundwater reliance**	**Share of total annual withdrawals derived from groundwater in 1995. Method of calculation: QGW/QW. ***	**Hurd et al., 1998.**	
126	Growing season length	Number of days between last spring frost and first autumn frost.	Kling et al., 2003 using data from Wuebbles and Hayhoe, 2003.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
127	**Harmful algal blooms (occurrence)**	**Defined as (1) an increase in the abundance of species that are known to produce toxins harmful to marine animals or humans; (2) the occurrence of lesions or mass mortalities of marine animals caused by HAB species; and (3) the occurrence of human pathologies caused by HAB species. A single event counts only once toward the relative intensity scale, even if it produces multiple impacts (e.g., an increase in the abundance of a HAB species that causes mass mortalities and an increased human health risk will be counted as a single event).**	**Heinz Center, 2002; Heinz Center, 2008**	
128	Highest spring streamflow date	Peak streamflow in early spring, indicative of maximum baseflow and/or maximum snowmelt rate in a basin.	Frumhoff et al., 2006.	
129	Hydrologic isolation	Indicates whether a system is a closed basin, or "isolated water" (i.e., a single spring that flows for a short distance before re-infiltrating into ground).	MEA, 2005b.	
130	Hydropower capacity	Distribution of regional hydroelectric power capacity, in megawatts (MW).	Hurd et al., 1998.	
131[x]	Hypoxia (dissolved oxygen concentration)	Levels of dissolved oxygen below 2 milligrams per liter (mg/L).	USEPA, 2008b.	71, 72, 73, 74, 75, 337
132	Ice cover duration (freeze and ice-out dates)	Number of days waterbodies are covered by ice, or are ice-free.	Kling et al., 2003.	
133	Ice cover on rivers	N/A	Frumhoff et al., 2006.	
134[x]	Ice -out date	Date of spring ice-out on lakes in the Northeast.	Frumhoff et al., 2006.	275, 423
135	Industrial water use (average annual share consumed)	Share of total industrial water use that is consumed (i.e., not returned to the system). *	Hurd et al., 1999.	
136	Inland water extent	Total areal extent of inland waters (could be divided by area to calculate density).	MEA, 2005b.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
137	Institutional Barriers to Water Trading	Flexibility score (on a scale of integers from zero to five) is assigned to each state based on the relative degree of barriers to water trading.	Hurd et al., 1999.	
138	In-stream fish habitat	In-stream fish concealment features consisting of undercut banks, boulders, large pieces of wood, brush, and cover from overhanging vegetation within a stream and its banks.	USEPA, 2006b.	
139	Intactness of coastal buffer	The degree to which natural coastal landforms and vegetation are intact.	Day et al., 2007.	
140	Intensively Grazed Grassland (area, ecosystem condition)	This indicator would report on the percentage of land area that is intensively grazed grassland/shrubland.	Heinz Center, 2002; Heinz Center, 2008	
141	Invasive Plant Cover - Grasslands and Shrublands (Percent of non-native plant cover)	This indicator will report the percentage of plant cover in grasslands and shrublands that is made up of non-native species. The indicator will report on both invasive non-native species (those that spread aggressively) and all non-native species.	Heinz Center, 2002; Heinz Center, 2008	
142	Invasive plant coverage - Forests (Percent area of non-native cover)	This indicator describes the degree to which non-native plants are found in U.S. forests. It will report the percentage of the total area covered by overstory (large trees that form the canopy) and understory (shrubs, ground plants, and smaller trees) that is made up of non-native plants.	Heinz Center, 2002; Heinz Center, 2008	
143[x]	Invasive species	N/A	Twilley et al., 2001.	463, 144, 618
144	Invasive species	This indicator reports the percentage of watersheds with different numbers of nonnative species with established breeding populations. “Non-native” includes species not native to North America and those that are native to this continent but are now found outside their historic range.	Heinz Center, 2002; Heinz Center, 2008	618, 143, 463
145	**Invasive species - Coasts affected (area, ecosystem condition)**	**This indicator would report on the percentage of coastline length that is heavily affected by invasive species.**	**Heinz Center, 2002; Heinz Center, 2008**	
146	Invasive species - Forests	This indicator would report on the percentage of land area that is forests	Heinz Center, 2002; Heinz	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
	Affected (area, ecosystem condition)	heavily affected by invasive species.	Center, 2008	
147	Invasive species - Grasslands and Shrublands Affected (area, ecosystem condition)	This indicator would report on the percentage of land area that is grasslands and shrublands heavily affected by invasives.	Heinz Center, 2002; Heinz Center, 2008	
148	Invasive species (range expansion)	N/A	MEA, 2005b.	
149	**Invasive species in estuaries (percent influenced)**	**Percentage of major estuaries with high, medium, or low influence by non-native species. Ratings of the degree of influence should incorporate both the number of different species present and the degree to which they occupy available habitat.**	**Heinz Center, 2002; Heinz Center, 2008**	
150[X]	Irrigation withdrawal rate	N/A	MEA, 2005b.	444
151[X]	Lake and Stream Acidity	N/A	USEPA, 2008b.	604, 621

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
152	Lake Levels and Conditions	N/A	Gleick and Adams, 2000.	
153[x]	Lake stratification (thermal structure)	N/A	Kling et al., 2003.	343
154	Land use	N/A	U.S. Climate Change Science Program, 2008.	
155	Lands and Waters with Highly Altered Species Mix (area, ecosystem condition)	This indicator would report on the percentage of lands and waters with highly altered species mix, such as would be characteristic of altered fire or hydrologic regimes.	Heinz Center, 2002; Heinz Center, 2008	
156	Latitude/altitude	N/A	MEA, 2005b.	
157	Lined and Culverted Streams (area)	This indicator would report on the percentage of land area and stream length that is lined and culverted streams.	Heinz Center, 2002; Heinz Center, 2008	
158	Living Planet Index	N/A	MEA, 2005b.	
159	**Low flow sensitivity (mean baseflow)**	**Unregulated mean baseflow in cfslmi2, i.e. the amount of streamflow originating from groundwater outflow.**	**Hurd et al., 1999.**	
160	Low-flow events	N/A	Frumhoff et al., 2006.	
161	M&I water use share	Municipal and industrial sector share of total average annual withdrawals.	Hurd et al., 1998.	
162	Major Crop Yields (Tons or bushels per acre of land)	This indicator reports the yields of corn, soybeans, wheat, hay, and cotton (which account for 95% of crop production in the US), as an index with 1975 as the base year. Values above 1.0 indicate higher yields, typically measured as tons or bushels per acre, than in 1975; values below 1.0 indicate lower yields than in 1975.	Heinz Center, 2002; Heinz Center, 2008	
163	Mangrove cover	N/A	MEA, 2005b.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
164	Marine fish landings (economic production)	Specifically refers to marine fish landings. This indicator reports the production of food and fiber and the withdrawals of water, using an index with 1980 as the base year.	Heinz Center, 2002; Heinz Center, 2008	
165**	**Meteorological drought indices**	**Average Palmer Drought Severity Index value, 2003-2007. ***	**National Assessment Synthesis Team, 2000a.**	
166	Mid-channel clarity	N/A	Chesapeake Bay Program, 2008.	
167	Migratory bird use	N/A	MEA, 2005b.	
168	Miles of Hardened Coastline	This indicator would report on the percentage of coastline length that is hardened coastline.	Heinz Center, 2002; Heinz Center, 2008	
169	Miles of Streams Impounded to Lakes (area, ecosystem condition)	This indicator would report on the percentage of stream length (at some last baseline date) that has since been impounded into lakes.	Heinz Center, 2002; Heinz Center, 2008	
170	Modification of water regimes	A measure of the degree of anthropogenic influence, which may be worsened by climate change.	MEA, 2005b.	
171	Monetary Value of Agricultural Production - Time-related (Billions of 1999 $ per year)	This indicator reports the dollar value of the annual output of major crops and livestock, in billions of 1999 dollars per year. The value is determined by multiplying the amount of output by the prices received by farmers (in 1999 dollars).	Heinz Center, 2002; Heinz Center, 2008	
172	Monetary Value of Agricultural Production - Area-related (Thousands of 1999 $ per square mile)	This indicator reports the dollar value of the annual output of major crops and livestock, in thousands of 1999 dollars per square mile. The value is determined by multiplying the amount of output by the prices received by farmers (in 1999 dollars).	Heinz Center, 2002; Heinz Center, 2008	
173	Native Vegetation in Areas Dominated by Croplands (Percentage of vegetation native to a specific area)	This indicator would report, for areas where croplands account for a large percentage of the land cover, how much of the remaining vegetation (outside of croplands) is native to the area.	Heinz Center, 2002; Heinz Center, 2008	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
174	Natural coastal wetlands	N/A	MEA, 2005b.	
175	Natural Ecosystem Services	This indicator would report on the levels of key services provided by "natural" ecosystems—forests, grasslands and shrublands, fresh waters, and coasts and oceans. The goods, or products, these ecosystems provide—such as fish, wood products, and food—can be counted, and a monetary value often placed upon them.	Heinz Center, 2002; Heinz Center, 2008	176
176[x]	Natural Ecosystem Services - Urban/Suburban Lands	Urban and suburban areas are defined by what people have built, but the remaining "natural" components—trees, meadows, streams, wetlands, and the like—provide valuable services to the residents of these developed areas. Ecosystem services are the benefits, both tangible and intangible, that these natural elements provide. For example, forested areas reduce stormwater runoff, when compared to paved areas, and trees cool streets and buildings, reducing energy consumption; trees also reduce urban noise levels. Natural areas, including forests, grasslands and shrublands, beaches, lakes, streams, and wetlands, also provide recreational opportunities, increase property values and community amenities, and are aesthetically pleasing.	Heinz Center, 2002; Heinz Center, 2008	175
177	Nitrate and Pesticides in Shallow Ground Water in Agricultural Watersheds	N/A	USEPA, 2008b.	
178	Nitrate concentration - major aquifers on agricultural lands (Percent of samples with drinking water exceedances)	Percentage of samples exceeding drinking-water standard for nitrate (10 milligrams per liter).	USGS, 1999.	
179	Nitrate concentration - shallow groundwater	Median concentration of nitrate (in milligrams per liter).	USGS, 1999.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
180	Nitrate in Farmland Streams and Groundwater	This indicator reports on the concentration of nitrate in representative farmland streams and groundwater sites. Specifically, the indicator reports the percentage of streams and groundwater wells with average nitrate concentrations in one of four ranges, in areas that are primarily farmland.	Heinz Center, 2002; Heinz Center, 2008	
181	Nitrate in Grassland and Shrubland Groundwater (Percent of groundwater sites tested)	This indicator reports on the concentration of nitrate in groundwater in grassland and shrubland areas. Specifically, the indicator reports the percentage of groundwater sites with average nitrate concentrations in one of four ranges, in areas that are primarily grassland or shrubland.	Heinz Center, 2002; Heinz Center, 2008	
182	Nitrate in Streams (Average nitrate concentration)	This indicator reports on the concentration of nitrate in representative streams in forested areas. Specifically, the indicator reports the percentage of streams with average nitrate concentrations in one of four ranges, for streams draining watersheds that are primarily forested.	Heinz Center, 2002; Heinz Center, 2008	
183	Nitrate in Urban and Suburban Streams (Percent of streams with certain level of detects)	This indicator reports the concentration of nitrate in streams in representative urban areas. Specifically, the indicator reports the percentage of streams with average nitrate concentrations in one of four ranges, for streams draining watersheds that are primarily urban.	Heinz Center, 2002; Heinz Center, 2008	
184	Nitrogen (movement, yield/load)	This indicator reports the yield of nitrogen from major watersheds: pounds of nitrogen per square mile of watershed area that enters rivers and streams through discharges, runoff, and other sources. It also reports the load of nitrate, a common form of nitrogen, from major rivers: tons of nitrate carried to the ocean each year by the four largest U.S. rivers.	Heinz Center, 2002; Heinz Center, 2008	
185	Nitrogen (total)	This indicator reports the total nitrogen concentration in a system.	USEPA, 2006b.	
186[x]	Nitrogen and Phosphorus -large rivers	This indicator reports the nitrogen and phosphorus content of large rivers.	USEPA, 2008b.	459
187	Nitrogen and Phosphorus -streams in agricultural watersheds	This indicator reports the nitrogen and phosphorus content of streams and rivers in agricultural watersheds.	USEPA, 2008b.	
188	Nitrogen and Phosphorus -wadeable streams	This indicator reports the nitrogen and phosphorus content of wadeable streams.	USEPA, 2008b.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
189	Nitrogen concentration - streams (total)	Average annual concentration of total nitrogen (in milligrams per liter).	USGS, 1999.	
190	**Number of Dry Periods in Grassland/Shrubland Streams and Rivers (Percent of streams with dry periods over time)**	**The indicator tracks the frequency and duration of zero-flow conditions for streams and rivers in grassland/shrubland regions. It reports the percentage of streams and rivers that have at least one no-flow day per year, and the percentage where the duration of zero-flow periods for a given period is substantially longer or shorter than the long-term average.**	**Heinz Center, 2002; Heinz Center, 2008**	
191	Nutrient enrichment (coastal wetlands)	Nutrient enrichment of coastal wetland ecosystems.	Day et al., 2008.	
192	Open Mines, Quarries, and Gravel Pits (area)	This indicator would report on the percentage of land area that is open mines, quarries, and gravel pits, measured from satellite.	Heinz Center, 2002; Heinz Center, 2008	
193	Patches of Forest, Grassland and Shrubland, and Wetlands - By Region (Percent area of natural lands in urban/suburban areas by region)	This indicator reports how much of the "natural" area within urban and suburban lands is in patches of varying size, from less than 10 acres to greater than 10,000 acres. Natural areas include forests, grasslands and shrublands (including most pasturelands — especially in the west), and wetlands.	Heinz Center, 2002; Heinz Center, 2008	
194	Patches of Forest, Grassland and Shrubland, and Wetlands - National (Percent area of natural lands in urban/suburban areas)	This indicator reports how much of the "natural" area within urban and suburban lands is in patches of varying size, from less than 10 acres to greater than 10,000 acres. Natural areas include forests, grasslands and shrublands (including most pasturelands — especially in the west), and wetlands.	Heinz Center, 2002; Heinz Center, 2008	
195	Permafrost	N/A	Gleick and Adams, 2000.	
196	Permafrost temperatures	N/A	Lettenmaier et al., 2008.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
197	Pesticide Exceedances in Farmland Streams and Groundwater (Percent of waterbodies with regulatory exceedances)	This indicator reports on pesticides and pesticide degradates found in farmland streams and groundwater as the percentage of streams and shallow groundwater wells with contaminant concentrations that exceeded standards and guidelines (benchmarks) set for the protection of human health or aquatic life. Data report currently used agricultural pesticides and selected breakdown products of these pesticides, as well as selected organochlorine insecticides that were widely used in the past but whose use is no longer permitted in the United States.	Heinz Center, 2002; Heinz Center, 2008	
198	Pesticide Occurrence in Farmland Streams and Groundwater (Number of pesticides detected in waterbodies)	This indicator reports on pesticides and pesticide degradates found in farmland streams and groundwater as the average number of such contaminants detected throughout the year in streams and shallow groundwater wells. Data report currently used agricultural pesticides and selected breakdown products of these pesticides, as well as selected organochlorine insecticides that were widely used in the past but whose use is no longer permitted in the United States.	Heinz Center, 2002; Heinz Center, 2008	199
199[x]	Pesticides in Streams in Agricultural Watersheds	N/A	USEPA, 2008b.	198
200	Phosphorus (total)	Indicator reports total phosphorus concentration in water body	USEPA, 2006b.	
201	Phosphorus in Farmland Streams	This indicator reports on the concentration of phosphorus in representative farmland streams. Specifically, the indicator reports the percentage of streams with average annual concentrations in one of four ranges, for streams draining watersheds that are primarily farmland.	Heinz Center, 2002; Heinz Center, 2008	
202	Phosphorus in Urban and Suburban Streams (Percent of streams with certain level of detects)	This indicator reports the concentration of phosphorus in representative streams in urban areas. Specifically, the indicator reports the percentage of streams with average annual concentrations in one of four ranges, for streams draining watersheds that are primarily urban.	Heinz Center, 2002; Heinz Center, 2008	
203	Phosphorus -lakes, reservoirs (concentration)	This indicator reports the average concentration of phosphorus in lakes and rivers.	Heinz Center, 2002; Heinz Center, 2008	
204	Phosphorus -large rivers	This indicator reports the average concentration of phosphorus in large	Heinz Center, 2002; Heinz	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
	(concentration)	rivers.	Center, 2008	
205	Phytoplankton	N/A	Chesapeake Bay Program, 2008.	
206	Plant Growth Index	This indicator reports a plant growth index, based on satellite measurements of the amount of solar energy absorbed by vegetation and potentially used for photosynthesis. The index shows, for any given year, whether plant growth in a region or for an ecosystem type was above or below the 11-year average	Heinz Center, 2002; Heinz Center, 2008	
207	Population	N/A	Twilley et al., 2001.	208
208	Population (human)	This indicator reports the human population, using an index with 1980 as the base year.	Heinz Center, 2002; Heinz Center, 2008	207
209	**Population (human) susceptible to flood risk**	**Population within the 500-year flood plain.**	**Hurd et al., 1999.**	**360**
210	Population Trends in Invasive and Non-invasive Grassland/Shrubland Birds (Percent change in population size of species over time)	This indicator describes population trends for selected grassland/shrubland bird species by comparing trends for selected "invasive" species with those that are not invasive.	Heinz Center, 2002; Heinz Center, 2008	
211	Potential for wetland migration	Area of tidal wetlands compared to area of land within one-half tide range above spring high water. Ratio of tidal wetlands to dry land and all land.	U.S. Climate Change Science Program, 2008.	
212[X]	Precipitation	N/A	Twilley et al., 2001.	213, 214, 215
213[X]	Precipitation	N/A	Lettenmaier et al., 2008.	212, 214, 215

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
214[x]	Precipitation	N/A	Gleick and Adams, 2000.	212, 213, 215
215	Precipitation (average daily)	N/A	Kling et al., 2003 using data from Wuebbles and Hayhoe, 2003.	212, 213, 214
216	Production of Cattle on Grasslands and Shrublands (Number of cattle over time)	This indicator reports the number of cattle grazing on grasslands and shrublands (including pastures), rather than at feedlots, during July of each year.	Heinz Center, 2002; Heinz Center, 2008	
217	Publicly Accessible Open Space per Resident (Percent of metropolitan areas with a certain amount of open space per resident)	This indicator would report the amount of open space—land that is dominated by "natural" surfaces, like grass or woods, along with lakes, rivers, beaches, and wetlands—that is accessible to the general public in large metropolitan areas. Specifically, the indicator would report the percentage of metropolitan areas with different amounts of open space per resident.	Heinz Center, 2002; Heinz Center, 2008	
218**	**Ratio of Snow to Precipitation (S/P)**	**Average annual ratio of snowfall (in inches) to total precipitation (in inches). ***	**Lettenmaier et al., 2008.**	**259, 260**
219**	**Ratio of water withdrawals to annual stream flow**	**Ratio of total annual surface and groundwater withdrawal in 1990 (QW) to unregulated mean annual streamflow (Qs). Method of calculation: QW/Qs**	**Hurd et al., 1999.**	
220	Recreation - Outdoor (number of activities)	This indicator reports the number of times Americans over the age of 15 took part in a variety of outdoor recreational activities. (Each time someone took part in an activity is counted: if the activity took place over multiple days, each day counts as a separate event, and if a person took part in several activities on a single day, each activity is counted as a separate event.)	Heinz Center, 2002; Heinz Center, 2008	608
221	Recreation - Participation in freshwater activities (number of days)	This indicator shows the number of days that people took part in a variety of freshwater activities. A "recreation day" for this measure is any day during which a person was engaged in the activity, whether for only a few	Heinz Center, 2002; Heinz Center, 2008	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
		minutes or for many hours.		
222	Recreation in Forests (Number of days of recreational activity per year)	This indicator would report the number of days per year that people engage in a variety of recreational activities in forests. Activities such as walking, hiking and backpacking, fishing and hunting, wildlife viewing, cross-country and downhill skiing, and snowmobiling would be included.	Heinz Center, 2002; Heinz Center, 2008	
223	Recreation on Farmlands (Number of days of engagement in recreational activities)	This indicator would report the number of days spent fishing, hunting, viewing wildlife, or engaged in other recreational activities on farmland.	Heinz Center, 2002; Heinz Center, 2008	
224	Recreation on Grasslands and Shrublands (Number of days of recreational activity per year)	This indicator will report the number of days per year that people engage in a variety of recreational activities on the nation's grasslands and shrublands. Activities will include: hunting; off-road vehicle (ORV) driving, motorsports, mountain biking, and snowmobiling; bird watching and nature study; and hiking and camping.	Heinz Center, 2002; Heinz Center, 2008	
225	Recreational water quality (beach-mile-days affected by Enterococcus)	This indicator will report the percentage of "beach-mile-days" affected by various levels of Enterococcus, a bacterium that indicates contamination with human or animal waste. A "beach-mile-day" is one mile of beach affected for one day—100 miles of beach affected for one day would count the same as 1 mile affected for 100 days.	Heinz Center, 2002; Heinz Center, 2008	
226	Red List Index	Index of threatened/endangered status for birds, based on a 1988 baseline.	MEA, 2005b.	
227	Relative Bed Stability (RBS)	Ratio that compares measures of particle size of observed sediments to the size of sediments that each stream can move or scour during its flood stage (based on measures of the size, slope, and other physical characteristics of the stream channel).	USEPA, 2006b; USEPA, 2008b.	
228[x]	Relative sea level rise (RSLR)	Function of absolute sea level, changes in land level, and sediment delivery	MEA, 2005b.	229, 241, 405, 412

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
229	Relative sea level rise (RSLR)	The net change in the relative elevations of the sea surface and coastal lands	Day et al., 2008.	228, 241, 405, 412
230	Riparian Areas (extent, acreage)	For streams and rivers, the indicator reports on the type of land cover on their shorelines and adjacent areas ("riparian" areas): forest; grasslands, shrublands, or wetlands; and urban/suburban or agricultural land.	Heinz Center, 2002; Heinz Center, 2008	
231	**Riparian Condition (Riparian Condition Index)**	**This indicator will describe the condition of riparian (streamside) areas. The condition of these areas will be rated using an index that combines key factors such as water flows, streambed physical condition, riparian vegetation composition and structure, and use by various species. Such a measure should take into account multiple factors, including hydrology (e.g., relationship to natural flow patterns), geomorphology (e.g., stream sediment transport), and biology (e.g., canopy cover) to provide an overall index of condition.**	**Heinz Center, 2002; Heinz Center, 2008**	
232	River channel and geomorphology	N/A	Gleick and Adams, 2000.	
233	River flow and nitrogen loads	Indicator reports total nitrogen arriving in a water body (e.g., from the Mississippi River system to the Gulf of Mexico).	Chesapeake Bay Program, 2008.	
234	Road surface (area)	This indicator would report on the percentage of land area that is road surface (including unpaved roads).	Heinz Center, 2002; Heinz Center, 2008	
235[x]	Runoff	N/A	Twilley et al., 2001.	236
236	Runoff from precipitation and snowmelt (mean annual)	Water-balance model (monthly precipitation and potential evapotranspiration) and output from the two GCMs to estimate the effects of climate change	National Assessment Synthesis Team, 2000a.	235
237	Runoff -large areas	N/A	Gleick and Adams, 2000.	
238	Runoff patterns	N/A	Lettenmaier et al., 2008.	
239	Runoff -regions	N/A	Gleick and Adams, 2000.	
240[x]	Salinity	N/A	USEPA, 2006b.	603, 84

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
241[x]	Sea level rise	N/A	Gleick and Adams, 2000.	228, 229, 405, 412
242	Sea surface temperature (difference from average)	Indicator describes whether sea surface temperature (SST) is above or below average. Method used: (1) the seasonal average sea surface temperature (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. Thus, values greater than zero are positive "anomalies" (i.e., deviations from the long-term average), and those less than zero are negative anomalies.	Heinz Center, 2002; Heinz Center, 2008	243
243[x]	Sea surface temperature (trend)	N/A	Twilley et al., 2001.	242
244	Seagrass cover	N/A	MEA, 2005b.	
245	Seals (number)	Number of seals observed in winter months at two monitoring locations.	Long Island Sound Study, 2008.	
246	Sediment contaminants (chemical levels)	Total organic carbon, metals, polynuclear aromatic hydrocarbons (PAH), PCBs (Polychlorinated Biphenyls), pesticides.	Hayslip et al., 2006.	
247	Sediment Contamination (exceedance of regulatory value)	Using ERM and ERL guidelines. Good: No ERM values are exceeded, and fewer than five ERL values are exceeded. Fair: No ERM values are exceeded, and five or more ERL values are exceeded. Poor: One or more ERM values are exceeded.	USEPA, 2006a.	
248[x]	Sediment delivery	N/A	MEA, 2005b.	249
249	Sediment discharge (river to coast)	Sediment load discharged from riverine systems into estuarine and coastal systems	Day et al., 2008.	248

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
250	Sediment Quality Index (3 components)	Based on three sediment quality component indicators: sediment toxicity, sediment contaminants, and sediment TOC. Good: Less than 5% of the NEP estuarine area is in poor condition, and more than 50% of the NEP estuarine area is in good condition. Fair: 5% to 15% of the NEP estuarine area is in poor condition, or more than 50% of the NEP estuarine area is in combined poor and fair condition. Poor: More than 15% of the NEP estuarine area is in poor condition.	USEPA, 2006a.	50
251	Sediment Total Organic Carbon (TOC)	Good: The TOC concentration is less than 2%. Fair: The TOC concentration is between 2% and 5%. Poor: The TOC concentration is greater than 5%.	USEPA, 2006a.	
252	Sediment toxicity	Acute sediment toxicity test.	Hayslip et al., 2006.	
253	Sediment Toxicity (species test)	Using a 10-day static toxicity test with the amphipod Ampelisca abdita. Good: Mortality is less than or equal to 20%. Poor: Mortality is greater than 20%.	USEPA, 2006a.	
254	Shape of "Natural" Patches (Ratio of perimeter to area of patch)	This indicator describes the shape of patches of "natural" lands in the farmland landscape, by reporting on the percentage of patch area that is found in "compact" patches (e.g., like a circle), "elongated" patches (e.g., like a long narrow rectangle), and an intermediate class of patch shape. These classes are defined based on the ratio of the perimeter, or edge, of each patch to its area; these perimeter-to-area ratios will be divided by patch area for the sake of comparison. "Natural" areas include forest, grasslands and shrublands, wetlands, and lands enrolled in the Conservation Reserve Program (CRP).	Heinz Center, 2002; Heinz Center, 2008	
255	Shellfish (acreage, harvest)	Indicators include acreage of shellfish beds and harvests of important commercial mollusks and crustaceans (oyster and lobster).	Long Island Sound Study, 2008.	
256	Shoreline types (miles/category)	Reports the miles of coastline in several categories, including: beach; mud or sand flats; steep sand, rock, or clay cliffs; wetlands; and coastline "armored" with bulkhead or riprap. The coastline includes ocean-front areas and the shoreline of estuaries and bays.	Heinz Center, 2002; Heinz Center, 2008	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
257	Shrubland Patches (Percent of grassland patches that cover a certain area)	This indicator will describe the fraction of grassland area and shrubland area that is in patches of different sizes. The total area occupied by patches of a certain size will be reported as a percentage of the total area of either grasslands or shrublands.	Heinz Center, 2002; Heinz Center, 2008	
258	Silt-Clay content of sediment	The proportion of fine grained materials (silt and clay) in the estuarine sediments.	Hayslip et al., 2006.	
259[x]	Snow influence	Share of average annual precipitation (P) that falls as snow (Ps) (i.e., snow water equivalent).	Hurd et al., 1998.	218, 260
260[x]	Snow Water Equivalent (SWE)	N/A	Lettenmaier et al., 2008.	259, 218
261	Snowmelt event dates	N/A	Lettenmaier et al., 2008.	
262	Snowmelt runoff volume	N/A	Lettenmaier et al., 2008.	
263[x]	Snowpack	N/A	Frumhoff et al., 2006; Frumhoff et al., 2007.	264
264	Snowpack	N/A	Gleick and Adams, 2000.	263
265	Snowpack density	N/A	Lettenmaier et al., 2008.	
266[x]	Snowpack depth	N/A	Lettenmaier et al., 2008.	438, 440
267	Soil Biological Condition (Percentage of croplands with variety of worms)	This indicator reports the percentage of croplands in three different ranges on the Nematode Maturity Index (NMI), an index that measures the types of roundworms, or nematodes, in the soil. Calculation of the NMI is based on the proportion of nematodes with different levels of tolerance for disturbance. A map showing the percentage of cropland in each major cropland region with low index values (indicating disturbed soils) would accompany the nationwide map.	Heinz Center, 2002; Heinz Center, 2008	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
268	Soil Erosion (Percentage of U.S. farmlands prone to erosion)	This indicator reports the percentage of U.S. farmlands according to their potential for erosion by wind or water. These data are based on an index that combines information on soil characteristics, topography, and management activities such as tillage practices and whether crop residue is left on the field or not. This indicator covers croplands (excluding pastures) and Conservation Reserve Program (CRP) lands.	Heinz Center, 2002; Heinz Center, 2008	
269[x]	Soil moisture	N/A	Twilley et al., 2001.	270
270	Soil moisture	N/A	Gleick and Adams, 2000.	269
271	Soil Organic Matter (Percentage of organic matter by soil weight)	This indicator reports the amount of organic matter — partially decayed plant and animal matter —in the top 4-6 inches of cropland soil. Soil organic matter is usually measured as the percentage of organic matter (by dry weight) in the top 4-6 inches of the soil, where human activities have most influence on soil condition.	Heinz Center, 2002; Heinz Center, 2008	
272	Soil Salinity (Percentage of croplands with high salinity)	This indicator reports the percentage of cropland with different levels of salt content, measured in decisiemens per meter (dS/m). A map showing the percentage of land in each major cropland region with elevated salt levels (i.e., over 4 dS/m), would accompany the nationwide map.	Heinz Center, 2002; Heinz Center, 2008	
273	Species Status (Percent of metropolitan areas with species at risk)	This indicator reports the degree to which "original" plants and animals are either absent entirely or are at risk of being lost from metropolitan areas. Original species are those that, before European settlement, inhabited the lands now occupied by metropolitan areas. Specifically, the indicator will report on the fraction of metropolitan areas where 25% or more, 50% or more, and 75% or more of original species are at risk of being displaced or are absent.	Heinz Center, 2002; Heinz Center, 2008	
274	Spring high water	This indicator is the average high tide during a full or new moon. It approximates the boundary between tidal wetlands and dry land.	U.S. Climate Change Science Program, 2008.	
275[x]	Spring ice-out dates	This indicator reports the date at which lake ice cover ends.	Lettenmaier et al., 2008.	134, 423

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
276	**Status of Animal Communities in Urban and Suburban Streams (Percent of urban/suburban sites with undisturbed and disturbed species)**	**This indicator reports on "biological integrity" in urban and suburban streams. Biological integrity is a measure of the degree to which the suite of fish and bottom-dwelling (or benthic) animals (including insects, worms, mollusks, and crustaceans) resemble what one might find in a relatively undisturbed stream in the same region. Tests assess the number of different species, number and condition of individuals, and food chain interactions. High scores indicate close resemblance to "reference" or undisturbed conditions, and low scores indicate significant deviation from them.**	**Heinz Center, 2002; Heinz Center, 2008**	
277	Status of Animal Species in Farmland Areas	This indicator reports the status of wildlife in farmland areas.	Heinz Center, 2002; Heinz Center, 2008	
278	Stream Bank Vegetation	This indicator describes the percentage of miles of stream (stream-miles) in urban and suburban areas that are lined with trees, shrubs, and other plants.	Heinz Center, 2002; Heinz Center, 2008	
279	**Stream flow variability (annual)**	**The coefficient of variation (CV) of unregulated streamflow is an indicator of annual streamflow variability. It is computed as the ratio of the standard deviation of unregulated annual streamflow (oQs) to the unregulated mean annual streamflow (QS)'.**	**Hurd et al., 1999.**	**413, 415**
280[x]	Stream flow variability (daily and weekly)	Trends in stream flow volumes based on daily flow data (same as "Changing Stream Flows" from (2) Heinz Center, 2002) are indicators of daily and weekly stream flow variability.	USEPA, 2008b.	281, 282
281	Stream flow variability (daily and weekly)	This indicator describes changes in the amount and timing of river and stream flow by reporting the percentage of monitored streams or rivers with major, moderate, and minimal changes in low flow, high flow, and the timing of these two extreme events. The indicator also describes the nature of major flow changes. Four subindicators were included in the analysis:	Heinz Center, 2002; Heinz Center, 2008	280, 282
282[x]	Stream flow variability (daily)	N/A	Lettenmaier et al., 2008.	280, 281

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
283[x]	Stream Habitat Quality - Farmland Streams (Presence of certain attributes compared to undisturbed streams)	This indicator describes the habitat quality of farmland streams by comparing a number of key attributes to those of relatively undisturbed streams in the same general area. The index would incorporate the presence of riffles and pools, the size of streambed sediments and the degree to which larger gravel and cobbles are buried in silt, the presence of branches, tree trunks, and other large woody pieces, and the stability of the bank.	Heinz Center, 2002; Heinz Center, 2008	284
284**	**Stream habitat quality (comparison to baseline)**	**This indicator is represented by the Rapid Bioassessment Protocol score, an index that can be used to assess the condition of underwater and bank habitats. The Rapid Bioassessment Protocol score is used to assess habitat conditions based on field observations of ten variables: epifaunal substrate/ available cover, embeddedness (for riffles) or pool substrate characterization (for pools), velocity and depth regimes (for riffles) or pool variability (for pools), sediment deposition, channel flow status, channel alteration, frequency of riffles or bends (for riffles) or channel sinuosity (for pools), bank stability (condition of banks), bank vegetative protection, and riparian vegetated zone width.***	**Heinz Center, 2002; Heinz Center, 2008**	**283**
285	Streamflow (discharge)	Discharge data from a national network of stream gages	National Assessment Synthesis Team, 2000a.	549
286	Submerged Aquatic Vegetation (SAV)	Rooted aquatic plants that support the health of ecosystems by generating food and habitat for waterfowl, fish, shellfish, and invertebrates.	USEPA, 2008b.	
287	Suburban/Rural Land Use Change	This indicator describes the pattern and intensity, or density, of development, both at the outer edge of suburban development around cities, and in rural areas that, despite the lack of a large town center, are growing rapidly toward suburban densities.	Heinz Center, 2002; Heinz Center, 2008	
288	Suspended solids (total, 4 substances)	Suspended materials include soil particles (clay and silt), algae, plankton, and other substances. Total suspended solids (TSS) refer to the matter that is suspended in water.	Hayslip et al., 2006.	
289	Temperature (average annual)	Mean annual temperature.	Gleick and Adams, 2000.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
290	Temperature (average daily)	N/A	Kling et al., 2003 using data from Wuebbles and Hayhoe, 2003.	
291	Temperature -streams	N/A	Lettenmaier et al., 2008.	
292	Thermal sensitivity (changes in extremes)	This indicator is based on the sensitivity to changes in extreme temperatures. It combines the vulnerability of two sub-indicators: (1) heat (the average annual number of days with maximum temperatures exceeding 35 degrees C) and (2) cold (the average annual number of days with average temperatures below O degrees C).	Hurd et al., 1999.	
293	Tidal wetlands area	N/A	Chesapeake Bay Program, 2008.	
294	Timber Growth and Harvest - Private (Volume of timber harvested vs. grown over time)	This indicator reports the annual amount of new wood grown and the annual amount of wood harvested on public and private timberlands, by region.	Heinz Center, 2002; Heinz Center, 2008	
295	Timber Harvest - By Region (Volume of timber over time)	This indicator reports trends in timber harvest, by regions East and West, and by primary product category (sawlogs, pulpwood, etc.).	Heinz Center, 2002; Heinz Center, 2008	
296	Timber Harvest - By Use: Fuelwood (Volume of timber over time)	This indicator reports trends in timber harvest, by region and by primary product category (sawlogs, pulpwood, etc.).	Heinz Center, 2002; Heinz Center, 2008	
297	Timber Harvest - By Use: Logging Residues/Other (Volume of timber over time)	This indicator reports trends in timber harvest, by region and by primary product category (sawlogs, pulpwood, etc.).	Heinz Center, 2002; Heinz Center, 2008	
298	Timber Harvest - By Use: Other Products (Volume of timber over time)	This indicator reports trends in timber harvest, by region and by primary product category (sawlogs, pulpwood, etc.).	Heinz Center, 2002; Heinz Center, 2008	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
299	Timber Harvest - By Use: Pulpwood (Volume of timber over time)	This indicator reports trends, by region, in the harvest of pulpwood.	Heinz Center, 2002; Heinz Center, 2008	
300	Timber Harvest - By Use: Sawlogs (Volume of timber over time)	This indicator reports trends, by region, in the harvest of sawlogs.	Heinz Center, 2002; Heinz Center, 2008	
301	Timber Harvest - By Use: Veneer logs (Volume of timber over time)	This indicator reports trends, by region, in the harvest of veneer logs.	Heinz Center, 2002; Heinz Center, 2008	
302	Topography/Elevation (LIDAR)	This indicator includes: (1) Light Detection and Ranging (LIDAR) mapping, and (2) shallow water-penetrating LIDAR.	Coastal States Organization, 2007.	
303	Total Impervious Area (Percent of urban/suburban areas having a certain amount of impervious area)	This indicator classifies urban and suburban areas according to their percentage of impervious surface (e.g., roads, parking lots, driveways, sidewalks, rooftops, etc.). The indicator uses several thresholds: less than 10% impervious surface in the region, at least 10%, at least 20%, and at least 30%.	Heinz Center, 2002; Heinz Center, 2008	
304	Trophic state	This indicator integrates water clarity, phosphorus concentration, and chlorophyll a.	USEPA, 1995.	
305	Trophic state (coastal waters)	This indicator refers to aspects of aquatic systems associated with the growth of algae, decreasing water transparency, and lowering oxygen levels in the lower water column that can harm fish and other aquatic life.	USEPA, 2008b.	
306	Tropical storm frequency	Frequency and intensity of tropical storms (current and predicted with climate change)	Day et al., 2007.	
307	Unusual marine mortalities	Unusual mortality events (UME) are characterized by an abnormal number of dead animals or by the appearance of dead animals in locations or at times of the year that are not typical for that species.	Heinz Center, 2002; Heinz Center, 2008	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
308	Urban and Suburban Areas (extent/acreage)	This indicator presents the extent/acreage of urban and suburban areas as a percentage of the total U.S. land area, for the most recent 50-year period and compared to pre-settlement estimates. It also reports on a key component of freshwater ecosystems (freshwater wetlands) and will report on the area of brackish water, a key component of coastal and ocean ecosystems when data become available.	Heinz Center, 2002; Heinz Center, 2008	
309	Urban and Suburban Lands - By Region (Area covered by urban/suburban lands by region)	This indicator reports the extent of urban and suburban lands, in acres.	Heinz Center, 2002; Heinz Center, 2008	
310	Urban and Suburban Lands - By Region (Percent area covered by urban/suburban lands by region)	This indicator reports the extent of urban and suburban lands as a percentage of all land area in a region.	Heinz Center, 2002; Heinz Center, 2008	
311	Urban and Suburban Lands - Composition of Undeveloped Urban and Suburban Lands (Percent area of undeveloped lands by region)	This indicator reports on the extent and composition of undeveloped lands, such as wetlands, croplands, forest, or grassland and shrubland, contained within urban and suburban areas.	Heinz Center, 2002; Heinz Center, 2008	
312	Urban Heat Island (Percent of metropolitan areas with having certain differences in air temperature between rural and urban areas)	This indicator describes the difference between urban and rural air temperatures for major U.S. metropolitan areas. Temperatures within urban areas will be compared to those in less-developed surrounding areas.	Heinz Center, 2002; Heinz Center, 2008	
313	Vegetative cover -riparian (area of 3 classes)	This indicator reports the sum of the amount of woody cover provided by three layers of riparian vegetation: the ground layer, woody shrubs, and	USEPA, 2006b.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
		canopy trees.		
314	Water Availability: Streamflow per Capita (Vulnerability of Domestic Water Uses)	A measure estimating per capita water availability based on per capita average annual streamflow (QS). Method of calculation: 1. QS/pop.	Hurd et al., 1998.	
315	Water Clarity	This indicator reports the percentage of lake and reservoir area with low-, medium-, and high-clarity water. (Ponds are not included because of their shallow depth.)	Heinz Center, 2002; Heinz Center, 2008	316, 317
316[x]	Water Clarity (secci, remote sensing)	This indicator presents correlations between water clarity, as measured by the Secchi disk, and light in the blue and red bands of the spectrum reflected from lake water surfaces and measured as "brightness" by satellite sensors.	Brezonik et al., 2007.	315, 317
317[x]	Water clarity (secci, transmitivity)	Light transmitivity, secci depth.	Hayslip et al., 2006.	315, 316
318	**Water Clarity Index (real vs. reference)**	**Water clarity index (WCI) is calculated by dividing observed clarity at 1 meter by a regional reference clarity at 1 meter. This regional reference is 10% for most of the U.S., 5% for areas with naturally high turbidity, and 20% for areas with significant submersed aquatic vegetation (SAV) beds or active SAV restoration programs. Good: WCI ratio is >2. Fair: WCI ratio is between 1 and 2. Poor: WCI ratio < 1.**	**USEPA, 2006a.**	
319	**Water Quality Index (5 components)**	**This indicator is based on 5 water quality component indicators (DIN, DIP, chlorophyll a, water clarity, and dissolved oxygen).**	**USEPA, 2006a.**	
320	Water use to storage	This indicator is the ratio of total annual average surface and groundwater withdrawals in 1990 (Qw) to total active basin storage (S). Method of calculation: QW/S.	Hurd et al., 1998.	
321	Water withdrawals	This indicator reports the total amount of surface water and groundwater withdrawn for use in the municipal, rural, industrial, thermoelectric, and	Heinz Center, 2002; Heinz Center, 2008	447

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
		irrigation sectors.		
322	**Waterborne human disease outbreaks (events)**	**This indicator reports the number of disease outbreaks (i.e., at least two people getting sick) attributed to drinking water that is untreated or where treatment has failed to remove disease-causing organisms, or to swimming or other recreational contact at lakes, streams, and rivers.**	**Heinz Center, 2002; Heinz Center, 2008**	
323	Watershed forest cover (area)	N/A	Chesapeake Bay Program, 2008.	
324	Wetland Extent, Change, and Sources of Change	N/A	USEPA, 2008b.	
325	**Wetland loss**	**Rate or total extent of wetland loss relative to original extent of wetland.**	**MEA, 2005b.**	
326**	**Wetland species at risk (number of species)**	**Number of wetland and freshwater species at risk, either threatened or endangered. ***	**Hurd et al., 1999.**	
327	Wetlands, Lakes, Reservoirs, and Ponds (extent, acreage)	This indicator reports the area of wetlands and lakes, reservoirs, and ponds and the length of small, medium, and large streams and rivers.	Heinz Center, 2002; Heinz Center, 2008	
328	**Ratio of water use to safe yield**	**Safe yield provides an estimate of the maximum quantity of water that can be withdrawn during an extended dry period without depleting the source beyond its ability to be replenished in naturally 'wet years.' It is measured as the water balance of inflows, usable storage, and evapotranspiration determined between Jun-Oct in a median year, using an 80% likelihood of water level recovery by the following spring. This indicator reports the ratio of water use to safe yield.**	**Schmitt et al., 2008.**	
329	Percent urbanized	N/A	Schmitt et al., 2008.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
330	Summer retail sales	N/A	Schmitt et al., 2008.	
331	Seasonal housing	N/A	Schmitt et al., 2008.	
332	Peak drinking water use	Peak drinking water use at individual public water systems.	Schmitt et al., 2008.	
333	nitrate in drinking water	Percent of public water systems (PWSs) nationally with at least one compliance monitoring sample detection of nitrate at a concentration greater than one-half the nitrate drinking water standard.	USEPA, 2008d.	
334	select pesticides in drinking water	Percent of PWSs nationally with at least one detection of alachlor, atrazine, carbofuran, endothall, and/or simazine at a concentration greater than one-half the respective drinking water standard.	USEPA, 2008d.	
335	Total Trihalomethanes (TTHMs) in drinking water	Percent of PWSs nationally with at least one compliance monitoring sample detection of Total Trihalomethanes (TTHMs, disinfection byproducts) greater than one-half the TTHM drinking water standard. TTHMs include chloroform, bromodichloromethane, dibromochloromethane, and bromoform.	USEPA, 2008d.	
336	Cyanotoxins (the 3 on the Contaminant Candidate List 3 or CCL3) in drinking water	Percent of PWSs sites with at least one detection of one of the three cyanotoxins.	USEPA, 2008d.	
337[x]	Dissolved oxygen concentration	N/A	Murdoch et al., 2000.	71, 72, 73, 74, 75, 131
338	Lake stratification timing	The occurrence and timing of thermal stratification in lakes.	Murdoch et al., 2000.	
339	Lake volume	N/A	Murdoch et al., 2000.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
340	Ice cover duration	N/A	Murdoch et al., 2000.	
341	Metabolic rate	Rates of productivity, decomposition, and chemical reactions in surface waters	Murdoch et al., 2000.	
342	Epilimnion volume	Volume of the upper mixed layer in stratified lakes.	Murdoch et al., 2000.	
343	Hypolimnion temperature	Temperature of the bottom water in stratified lakes.	Murdoch et al., 2000.	153
344	Permafrost and glacial extent	N/A	Murdoch et al., 2000.	
345	Solute concentration	Concentrations of dissolved materials in water	Murdoch et al., 2000.	76
346	Surface water extent	Areal extent of surface waters	Murdoch et al., 2000.	
347	Dominant flowpath	Relative importance of various hydrological pathways (i.e., surface runoff, shallow subsurface flow, deep groundwater flow)	Murdoch et al., 2000.	
348**	**Erosion rate**	**Rate of soil erosion from watershed lands**	**Murdoch et al., 2000.**	
349	Water clarity	N/A	Murdoch et al., 2000.	
350	Water residence time	Rate of water inflow to and outflow from a water body	Murdoch et al., 2000.	
351**	**Instream use/total streamflow**	**Ratio of in-stream use to total streamflow. Method of calculation: (In-stream flow requirements to meet the needs of fish and wildlife)/(1975 streamflow + 1975 consumption - 1975 groundwater overdraft)**	**Meyer et al., 1999.**	
352**	**Total use/total streamflow**	**Method of calculation: (In-stream flow requirements to meet the needs of fish and wildlife + 1975 consumption)/(1975 streamflow + 1975 consumption - 1975 groundwater overdraft)**	**Meyer et al., 1999.**	
353	Flow regime	This indicator is a composite of several measurable streamflow variables, including magnitude, frequency, duration, seasonal timing, and rate of change of flows	Meyer et al., 1999.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
354	Broad geographic region	Regions are Arctic and subarctic North America, Laurentian Great Lakes and Precambrian Shield, Rocky Mountains, Mid Atlantic and New England, Southeastern US, Pacific Coast and Western Great Basin, Great Plains, Arid Southwest	Meyer et al., 1999.	
355	Cyanobacteria abundance	Relative abundance of cyanobacteria in phytoplankton as characterized by photopigments. High performance liquid chromatography (HPLC), coupled to photodiode array spectrophotometry (PDAS).	Paerl et al., 2003.	
356	Enterococci abundance	Number of colony forming units of enterococcal bacteria per volume of water.	Paerl et al., 2003.	
357	Peatland extent	Extent or density of peatland.	Burkett and Kusler, 2000.	
358	Isolated wetland extent	Extent or density of isolated wetlands (alpine wetlands, prairie potholes).	Burkett and Kusler, 2000.	
359	Water quality criteria	Water quality criteria are developed for specific chemicals to evaluate whether a water body is supporting aquatic life uses. Such criteria describe the minimum level of water quality necessary to allow a use to occur. EPA has developed water quality criteria for 157 pollutants to protect a variety of water body uses.	USEPA, 2002.	
360[X]	Vulnerability to floods	Percent of population that lives in floodplains.	Intergovernmental Panel on Climate Change, 2007.	209
361	**Snowmelt reliance**	**Dependence of water uses on seasonal melting of snow and/or glaciers.**	**Intergovernmental Panel on Climate Change, 2007.**	
362	Pesticide concentration	Pesticide concentration in surface water, groundwater, bed sediments, or fish tissue relative to a health benchmark (human or aquatic life). Acute and chronic benchmarks have been determined for most commonly used pesticides.	Gilliom et al., 2006.	
363	Predicted pesticide concentration	Predicted pesticide concentration for selected pesticides (atrazine, dieldrin). The indicator values are predicted by a regression model.	Gilliom et al., 2006.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
364**	**Pesticide toxicity index**	**The Pesticide Toxicity Index (PTI) accounts for multiple pesticides in a sample, including pesticides without established benchmarks for aquatic life. The PTI combines information on exposure of aquatic biota to pesticides (measured concentrations of pesticides in stream water) with toxicity estimates (results from laboratory toxicity studies) to produce a relative index value for a sample or stream. The PTI value is computed for each sample of stream water by summing the toxicity quotients for all pesticides detected in the sample. The toxicity quotient is the measured concentration of a pesticide divided by its toxicity concentration from bioassays (such as an LC50 or EC50).**	**Gilliom et al., 2006.**	
365	Groundwater contribution to baseflow	Proportion of baseflow in streams that is contributed by groundwater discharge	Hayashi and Rosenberry, 2002.	
366	Phosphorus concentration -streams (total)	Average annual concentration of total phosphorus (in milligrams per liter).	USGS, 1999.	
367**	**Herbicide concentrations in streams (Percent of streams with highest concentration)**	**Average concentrations of herbicides in US streams. ***	**USGS, 1999.**	
368	Herbicides Use (Weight per unit of agricultural land)	Herbicide use in pounds, per acre of agricultural land.	USGS, 1999.	
369**	**Insecticide concentrations in streams (Percent of streams with highest concentration)**	**Average concentrations of insecticides in US streams. ***	**USGS, 1999.**	
370	Insecticide Use (Weight per unit of agricultural land)	Insecticide use in pounds, per acre of agricultural land.	USGS, 1999.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
371**	**Organochlorines in Bed Sediment (Percent of streams with highest concentration)**	**Average concentrations of organochlorines in bed sediments. ***	**USGS, 1999.**	
372	Organochlorines Use (Weight per unit of agricultural land)	Organochlorines use in pounds, per acre of agricultural land.	USGS, 1999.	
373**	**Herbicides in Groundwater (Percent of aquifers with highest concentration)**	**Average concentrations of herbicides in shallow groundwater and aquifers. ***	**USGS, 1999.**	
374**	**Insecticides in Groundwater (Percent of aquifers with highest concentration)**	**Average concentrations of insecticides in shallow groundwater and aquifers. ***	**USGS, 1999.**	
375	Occurrence of One or More VOCs in Aquifers (Concentration detected by aquifer)	Detection of VOCs in aquifer samples demonstrates the vulnerability of many of the Nation's aquifers to VOC contamination.	Zogorski et al., 2006.	
376	Occurrence of One or More VOCs in Aquifers - by Aquifer Study (Percent of aquifer studies with detects)	Percentage of the 98 aquifer studies conducted as part of the Study-Unit investigations that had detections of one or more VOCs at an assessment level of 0.2 µg/L.	Zogorski et al., 2006.	
377	Occurrence of One or More VOCs in Aquifers - by Principal Aquifer (Percent of aquifers with detects)	Detection frequencies, expressed as a percentage, by principal or other aquifer, of one or more VOCs at an assessment level of 0.2 µg/L.	Zogorski et al., 2006.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
378	Occurrence of One or More VOCs in Aquifers - by Aquifer Lithology (Percent of detects per aquifer type)	Detection frequencies, expressed as a percentage, by aquifer lithology category, of one or more VOCs at an assessment level of 0.2 µg/L.	Zogorski et al., 2006.	
379	Occurrence of VOC Groups in Aquifers (Percent of aquifers with detects)	Detection frequencies, expressed as a percentage, for various VOC groups at assessment levels of 0.2 µg/L and 0.02 µg/L.	Zogorski et al., 2006.	
380	Occurrence of Individual VOCs in Aquifers	Detection frequencies, expressed as a percentage, for various VOCs at assessment levels of 0.2 µg/L and 0.02 µg/L. The 15 most frequently detected VOCs represent most of the use groups and include 7 solvents, 4 THMs, 2 refrigerants, 1 gasoline oxygenate, and 1 gasoline hydrocarbon.	Zogorski et al., 2006.	
381	Population Served by Domestic Wells (Percent of population relying on domestic wells for drinking water)	Domestic wells are privately owned, self-supplied sources for domestic water use.	Zogorski et al., 2006.	
382	Population Served by Public Wells (Percent of population relying on public wells for drinking water)	Public wells are privately or publicly owned and supply ground water for PWSs. As defined by the USEPA, PWSs supply drinking water to at least 15 service connections or regularly serve at least 25 individuals daily at least 60 days a year.	Zogorski et al., 2006.	
383	Pesticide detection frequency	Atrazine, DEA, metolachlor, prometon, and simazine were "were detected with sufficient frequency to perform statistical analysis of temporal changes in both detection frequency and concentration."	Bexfield, 2008.	
384	Playas (shallow ephemeral lakes)	The existence of lakes in these valleys depends on local (watershed) precipitation, playa surface evaporation and, except in endorheic basins (especially prevalent in the Great Basin and north-central Mexico), alluvial hydrological drainage.	Grimm et al., 1997.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
385	Ecosystem thermal regime (latitude, shift in miles)	N/A	Poff et al., 2002.	
386	Migration corridor restriction	Dams and reservoirs, deforestation, diversion of water for offstream uses such as irrigation and urban development.	Poff et al., 2002.	
387	Thermal - Habitat suitable for trout	N/A	Poff et al., 2002.	
388	Stream baseflow (summer)	Water in stream channel.	Poff et al., 2002.	
389	Wetland hydroperiod	Patterns of water depth, and the duration, frequency, and seasonality of flooding.	Poff et al., 2002.	
390	Fens (area, abundance)	Groundwater-dominated wetlands	Poff et al., 2002.	
391	**Salinity intrusion (coastal wetlands)**	**N/A**	**Poff et al., 2002.**	
392	**Heat-Related Illnesses Incidence**	**N/A**	**Ebi et al., 2007.**	
393	Populations at Increased Risk - Older and Younger Age Groups	Heat-related mortality in individuals over 65 years of age, and in babies and infants.	Ebi et al., 2007.	
394	Populations at Increased Risk - Using of Certain Drugs	Certain drugs (such as stimulants, beta-blockers, anticholinergics, digitalis, and barbiturates) interfere with the body's ability to cope with high temperatures.	Ebi et al., 2007.	
395	Populations at Increased Risk - Dehydrated Individuals	Populations of individuals that have a tendency to consume fewer non-alcoholic fluids.	Ebi et al., 2007.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
396	Populations at Increased Risk - Individuals with Low Fitness	N/A	Ebi et al., 2007.	
397	Populations at Increased Risk - Individuals Who Engage in Excessive Exertion	Outdoor workers and those who maintain a vigorous exercise regimen during a heat wave are particularly at risk.	Ebi et al., 2007.	
398	Populations at Increased Risk - Individuals Who Are Overweight	N/A	Ebi et al., 2007.	
399	Populations at Increased Risk - Reduced Adjustment to High Outdoor Temperatures	N/A	Ebi et al., 2007.	
400	Populations at Increased Risk - Urban Populations	N/A	Ebi et al., 2007.	
401	Populations at Increased Risk - Individuals with Lower Socio-economic Status	N/A	Ebi et al., 2007.	
402	Populations at Increased Risk - Individuals Living Alone	N/A	Ebi et al., 2007.	
403	Temperature Increases	Impact of increased temperature on hypoxia in wetlands.	Ebi et al., 2007.	
404	Precipitation Increases	Impact of increased precipitation on hypoxia in wetlands.	Ebi et al., 2007.	
405[x]	Sea level rise	Impact of increased sea level rise on hypoxia in wetlands.	Ebi et al., 2007.	228, 229, 241, 412

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
406	Strength of Summer Wind	Impact of stronger summer winds on hypoxia in wetlands.	Ebi et al., 2007.	
407	Hurricane Intensity	N/A	Ebi et al., 2007.	
408	Hurricane Frequency	N/A	Ebi et al., 2007.	
409	Frequency and Magnitude of El Niño/Southern Oscillation (ENSO)	N/A	Ebi et al., 2007.	
410	Peak Flows	N/A	Ebi et al., 2007.	
411	Intensity of Rainfall	N/A	Ebi et al., 2007.	
412[x]	Sea level rise	N/A	Ebi et al., 2007.	228, 229, 241, 405
413[x]	Streamflow Variability (annual)	Annual minimum, median, and maximum daily streamflow values for 1941-1999 at 400 sites in the coterminous U.S. considered to have natural streamflow.	McCabe and Wolock, 2002.	279, 415
414	Days of 99th Percentile Flow	Number of days per year that meet or exceed 99th percentile streamflow values for 1941-1999 at 400 sites in the coterminous U.S. considered to have natural streamflow. 99th percentile flow value calculated for each site from HCDN streamflow data. 99th percentile value = 0.99 (highest flow value for site during period of record).	McCabe and Wolock, 2002.	
415[x]	Streamflow Variability (annual min, med, max value)	Annual minimum, median, and maximum daily streamflow values from 1940-1999 at 435 sites in the coterminous U.S. and southeastern Alaska considered to have natural streamflow.	Lins and Slack, 2005.	279, 413
416	Seasonal Streamflow Timing (Month of annual min, med, max)	Month of the annual minimum, median, and maximum streamflows for 1940-1999 at 435 sites in the coterminous U.S. and southeastern Alaska considered to have natural streamflow.	Lins and Slack, 2005.	421

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
417	Center of Volume Date	Date by which half of the total water volume for a time period has gone by a river gauging station. Time periods were winter/spring (Jan 1 to May 31) and fall (Oct 1 to Dec 31). Analyzed for 27 rural, unregulated river gauging stations in New England with an average of 68 years of record. Winter/spring center of volume date = WSCV.	Hodgkins et al., 2003.	
418	Peak Flow Date	Date of the highest daily mean flow within a season: winter/spring (Jan 1 to May 31) and fall (Oct 1 to Dec 31). Analyzed at 27 rural, unregulated river gauging stations in New England with an average of 68 years of record.	Hodgkins et al., 2003.	
419	Ratio of Seasonal to Annual Flow	N/A	Hodgkins et al., 2003.	
420	Magnitude of Monthly Flows	N/A	Hodgkins et al., 2003.	
421[x]	Timing of Seasonal Peak Flows	N/A	Hodgkins et al., 2003.	416
422	Median Total Seasonal Snowfall	The median accumulation of snow (usually in units of height) over a particular snow season.	Hodgkins et al., 2003.	
423	Lake Ice-Out Date	Lake ice-out dates are the dates of ice break-up, i.e. the annual dates in spring when winter ice cover leaves a lake.	Hodgkins et al., 2003.	134, 275
424	Monthly Average Streamflow	Daily streamflow data averaged into monthly time series data for 37 sites in New England considered to have natural streamflow.	Bradbury et al., 2002.	
425	Winter Average Streamflow	Daily streamflow data averaged into winter seasonal streamflow data for 37 sites in New England considered to have natural streamflow.	Bradbury et al., 2002.	
426	Winter Average Temperature	Monthly divisional temperature averaged into "winter average temperature" values for the period 1895-1999.	Bradbury et al., 2002.	
427	Winter Average Precipitation	Monthly divisional precipitation averaged into "winter average precipitation" values for the period 1895-1999.	Bradbury et al., 2002.	
428	Surface Air Temperature	N/A	Bradbury et al., 2002.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
429	Storm-Track Patterns	Spatial variations in the paths followed by centers of low atmospheric pressure.	Bradbury et al., 2002.	
430	Snowfall Variability	N/A	Bradbury et al., 2002.	
431	Tree-Ring Chronology	N/A	Bradbury et al., 2002.	
432	Diurnal Range of Surface Air Temperature (DTR)	The difference between the daytime maximum temperature and the nighttime minimum temperature for a 15 km by 15 km site on the Konza Prairie near Manhattan, KS, in 1987-1989.	Dai et al., 1999.	
433	Daily Mean Cloud Cover	The daily average amount of the sky covered by clouds (reported in eighths or oktas of sky covered) for a 15 km by 15 km site on the Konza Prairie near Manhattan, KS, in 1987-1989.	Dai et al., 1999.	
434	Top 5-cm Soil Moisture Content	The moisture content of the top 5 cm of soil for a 15 km by 15 km site on the Konza Prairie near Manhattan, KS, in 1987-1989.	Dai et al., 1999.	
435	Surface Specific Humidity	The ratio of the mass of water vapor within a given mass of air near the Earth's surface (reported in g of water vapor per kg of air at specified temperature) for a 15 km by 15 km site on the Konza Prairie near Manhattan, KS, in 1987-1989.	Dai et al., 1999.	
436	Dew Point	The temperature to which a given unit of air must be cooled (at constant pressure) in order for vapor to condense into water.	Roderick and Farquhar, 2002.	
437**	**Precipitation Elasticity of Streamflow**	**The proportional change in streamflow (Q) divided by the proportional change in precipitation (P) for 1,291 gauged watersheds across the continental US.**	**Sankarasubramanian et al., 2001.**	
438	Snowpack Depth	The regional average snowpack depth, in inches.	Sankarasubramanian et al., 2001.	266, 440
439	Concentration of Particulate and Colored Dissolved Organic Material (CDOM)	Concentration of pigmented compounds, dissolved in a waterbody that derives from organic material.	Warwick and Pienitz, 2006.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
440[x]	Snowpack Depth (2)	Regional snowpack for the Western United States.	Barnett, et al., 2005.	266, 438
441	Aerosols	The amount of aerosol pollution (particulate matter) in a unit of air.	Barnett, et al., 2005.	
442	Water withdrawals: Public Supply (Volume of water used per day)	Volume of water consumed in the public supply per day. This is different from water withdrawals, as one of the largest uses of water is for cooling of thermoelectric power plants, and much of that water is returned to the streams from which it is withdrawn (use of water for hydroelectric power generation, virtually none of which is consumptively used, is not included in this category). On the other hand, a much higher fraction of the water withdrawn for irrigation is consumptively used.	Lettenmaier et al., 2008.	
443	Water withdrawals: Rural Domestic and Livestock (Volume of water used per day)	Volume of water consumed by rural domestic and livestock per day. This is different from water withdrawals, as one of the largest uses of water is for cooling of thermoelectric power plants, and much of that water is returned to the streams from which it is withdrawn (use of water for hydroelectric power generation, virtually none of which is consumptively used, is not included in this category). On the other hand, a much higher fraction of the water withdrawn for irrigation is consumptively used.	Lettenmaier et al., 2008.	
444	Water withdrawals: Irrigation (Volume of water used per day)	Volume of water consumed for irrigation purposes per day. This is different from water withdrawals, as one of the largest uses of water is for cooling of thermoelectric power plants, and much of that water is returned to the streams from which it is withdrawn (use of water for hydroelectric power generation, virtually none of which is consumptively used, is not included in this category). On the other hand, a much higher fraction of the water withdrawn for irrigation is consumptively used.	Lettenmaier et al., 2008.	150
445	Water withdrawals: Thermoelectric Power (Volume of water used per day)	Volume of water consumed for thermoelectric power generation per day. This is different from water withdrawals, as one of the largest uses of water is for cooling of thermoelectric power plants, and much of that water is returned to the streams from which it is withdrawn (use of water for hydroelectric power generation, virtually none of which is consumptively used, is not included in this category). On the other hand, a much higher fraction of the water withdrawn for irrigation is consumptively used.	Lettenmaier et al., 2008.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
446	Water withdrawals: Other Industrial Uses (Volume of water used per day)	Volume of water consumed for other industrial uses per day. This is different from water withdrawals, as one of the largest uses of water is for cooling of thermoelectric power plants, and much of that water is returned to the streams from which it is withdrawn (use of water for hydroelectric power generation, virtually none of which is consumptively used, is not included in this category). On the other hand, a much higher fraction of the water withdrawn for irrigation is consumptively used.	Lettenmaier et al., 2008.	
447[x]	Water withdrawals: Total (Volume of water used per day)	The data compiled by the USGS are somewhat limited in that they are for water withdrawals, rather than consumptive use. The distinction is important, as one of the largest uses of water is for cooling of thermoelectric power plants, and much of that water is returned to the streams from which it is withdrawn (use of water for hydroelectric power generation, virtually none of which is consumptively used, is not included in this category). On the other hand, a much higher fraction of the water withdrawn for irrigation is consumptively used.	Lettenmaier et al., 2008.	321
448	Extent of reservoir storage (Volume of water stored per area)	N/A	Lettenmaier et al., 2008.	
449**	**Ratio of reservoir storage to mean annual flow (Volume of water stored per unit flow)**	**A small storage-to-runoff ratio usually indicates that the reservoir is primarily used to shape within-year variations in runoff, and a large storage-to-runoff value usually indicates that the reservoir is primarily used to smooth interannual variations in runoff. ***	**Lettenmaier et al., 2008.**	
450	Precipitation (variability)	Variability of mean annual precipitation, expressed as the Coefficient of Variation, C sub v (the standard deviation divided by the mean), for the continental U.S.	Lettenmaier et al., 2008.	
451	Runoff Ratio	Annual mean runoff divided by annual mean precipitation, for the continental U.S. and Alaska.	Lettenmaier et al., 2008.	
452	Snow to runoff ratio	Ratio of maximum mean snow accumulation to mean annual runoff, for the continental U.S. and Alaska.	Lettenmaier et al., 2008.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
453**	**Runoff (variability)**	**Variability of annual runoff, expressed as the Coefficient of Variation, C sub v (the standard deviation divided by the mean), for the continental U.S. and Alaska.**	**Lettenmaier et al., 2008.**	
454	Runoff (variability - persistence)	Variability of annual runoff, expressed as the "lag one" correlation coefficient, for the continental U.S. This correlation coefficient reflects the correlation between two values of the same variable (i.e. runoff) at different points in time.	Lettenmaier et al., 2008.	
455	Variability of April-Sept. streamflow	Variability of April-Sept. streamflow at 141 unregulated sites across the Western U.S.	Lettenmaier et al., 2008.	
456	Incidence of "surplus" flow days	Number of days with flows above a station-dependent surplus threshold, for 42 HCDN sites in the central and southern U.S.	Lettenmaier et al., 2008.	
457	Length of snow season	Length of the snow season in the Ohio Valley over the second half of the 20th century.	Lettenmaier et al., 2008.	
458	Warm Season Surface Water Supply	Defined as precipitation minus potential evapotranspiration, for several sites on the Arctic coastal plain over the past 50 years.	Lettenmaier et al., 2008.	
459	Phosphorus and nitrogen concentration	Concentrations of total P and N from 1975 to 1994 at 250 river sites with drainages greater than 1000 square kilometers.	Lettenmaier et al., 2008.	186
460**	**Macroinvertebrate Index of Biotic Condition**	**Total index score is the sum of scores for a variety of individual measures, also called indicators or metrics. The metrics used to develop the Macro-invertebrate Index for the WSA covered six different characteristics of macroinvertebrate assemblages that are commonly used to evaluate biological condition: taxonomic richness, taxonomic composition, taxonomic diversity, feeding groups, habits, and pollution tolerance. Each metric was scored and then combined to create an overall Macroinvertebrate Index for each region, with values ranging from 0 to 100. ***	**USEPA, 2006b.**	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
461**	**Macroinvertebrate Observed/Expected (O/E) Ratio of Taxa Loss**	**The Macroinvertebrate O/E Ratio of Taxa Loss (henceforth referred to as O/E Taxa Loss) measures a specific aspect of biological health: taxa that have been lost at a site. The taxa expected (E) at individual sites are predicted from a model developed from data collected at least-disturbed reference sites; thus, the model allows a precise matching of sampled taxa with those that should occur under specific, natural environmental conditions. By comparing the list of taxa observed (O) at a site with those expected to occur, the proportion of expected taxa that have been lost can be quantified as the ratio of O/E.**	**USEPA, 2006b.**	**569, 32**
462	**Coastal Benthic Communities**	**This indicator is based on a multi-metric benthic communities index that reflects overall species diversity in estuarine areas throughout the contiguous United States (adjusted for salinity, if necessary) and, for some regions, the presence of pollution-tolerant and pollution-sensitive species. The benthic community condition at each sample site is given a high score if the index exceeds a particular threshold (e.g., has high diversity or populations of many pollution-sensitive species), a low score if it falls below the threshold conditions, and a moderate score if it falls within the threshold range.**	**USEPA, 2008b.**	
463[x]	Alien or Invasive Plant Species	N/A	USEPA, 2008a.	143
464	Native Plant Species & Genera	N/A	USEPA, 2008a.	
465	Plant Species Diversity	N/A	USEPA, 2008a.	
466	Percent Similarity of Plant Species Composition to Reference Standard	N/A	USEPA, 2008a.	
467	**Threatened & Endangered Plant Species**	**N/A**	**USEPA, 2008a.**	**22**
468	Graminoid Taxa	N/A	USEPA, 2008a.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
469	Dominant Plant Taxa	N/A	USEPA, 2008a.	
470	Dicot and Monocot Species	N/A	USEPA, 2008a.	
471	Woody Species	N/A	USEPA, 2008a.	
472	Seedless Vascular Plants (Ferns & Fern Allies)	N/A	USEPA, 2008a.	
473	Nonvascular Plants/Bryophytes	N/A	USEPA, 2008a.	
474	Overall Floristic Quality - Floristic Quality Assessment Indices (FQAI) and Coefficients of Conservatism (CC)	FQAI use species-specific CCs that reflect the tendency of a species to occur in pristine vs. disturbed habitats. Intact native plant communities in relatively undisturbed sites will have high FQAI scores.	USEPA, 2008a.	
475	**Vegetation Indices of Biotic Integrity (IBI)**	**IBI use relationships of plant species, plant communities, plant guilds, vegetation structure, etc. to anthropogenic disturbance and stress to describe wetland condition. Typically, the highest IBI values represent reference standards or least-disturbed ecological conditions.**	**USEPA, 2008a.**	
476	Other Indices of Vegetation Condition	N/A	USEPA, 2008a.	
477	PFG Composition - Nutrient Functional Groups	Composition of plant functional groups (PFG) based on nutrient properties.	USEPA, 2008a.	
478	PFG Composition - Sediment Functional Groups	Composition of PFG based on sediment properties.	USEPA, 2008a.	
479	PFG Composition - Growth Habit/Canopy Architecture	Composition of PFG based on growth habit (tap-rooted, stoloniferous, rhizomatous, matrix interstitial, etc.).	USEPA, 2008a.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
480	PFG Composition - Sensitive Species	Composition of PFG based on species with high coefficients of conservatism.	USEPA, 2008a.	
481	PFG Composition - Tolerant Species	Composition of PFG based on species with low coefficients of conservatism.	USEPA, 2008a.	
482	PFG Composition - Hydrophyte Status	Composition of PFG based on hydrophyte status.	USEPA, 2008a.	
483	PFG Composition - Life Span	Composition of PFG based on life span (annual, perennial, .etc.).	USEPA, 2008a.	
484	PFG Composition - Aquatic Plant Guilds	Composition of PFG based on aquatic plants.	USEPA, 2008a.	
485	PFG Composition - Pioneer Species or Opportunistic Native or Alien Species	Composition of PFG based on pioneer status or opportunism.	USEPA, 2008a.	
486	PFG Composition - Light Requirements/Shade Tolerance	Composition of PFG based on light requirements or shade tolerance.	USEPA, 2008a.	
487	Community Type	N/A	USEPA, 2008a.	
488	Patchiness (Interspersion) of Vegetation	N/A	USEPA, 2008a.	
489	Distribution of Plant Communities	N/A	USEPA, 2008a.	
490	Zonation or Vegetation Distribution Typical of Wetland Class	N/A	USEPA, 2008a.	
491	Total Absolute Cover	N/A	USEPA, 2008a.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
492	Distribution and Cover of Growth Forms	Floating/submerged plants, emergent/terrestrial herbs, shrubs, and trees.	USEPA, 2008a.	
493	Vertical Strata Height and Volume	Herbaceous ground layer, shrub layer(s), tree canopy layer(s).	USEPA, 2008a.	
494	Local Microtopography Generated By Structure of Non-woody Plants	N/A	USEPA, 2008a.	
495	Leaf Area Index	N/A	USEPA, 2008a.	
496	Shrub or Small Tree Stem Density	N/A	USEPA, 2008a.	
497	Evidence or Quantity of Regeneration of Key Plant Species	N/A	USEPA, 2008a.	
498	Litter Cover	N/A	USEPA, 2008a.	
499	Below Ground Biomass	N/A	USEPA, 2008a.	
500	Wrack Extent/Cover	N/A	USEPA, 2008a.	
501	Allochthonous Inputs	N/A	USEPA, 2008a.	
502	Depth of Submerged Plant Cover	N/A	USEPA, 2008a.	
503	Distribution of Woody Debris	N/A	USEPA, 2008a.	
504	Percent Leaf and Root Tissue Carbon/Nitrogen	N/A	USEPA, 2008a.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
505	Root and Leaf Tissue Carbon/Phosphorus	N/A	USEPA, 2008a.	
506	Photosynthesis/Respiration (P/R) Ratio	N/A	USEPA, 2008a.	
507	Plant Health/Stress/Herbivory	N/A	USEPA, 2008a.	
508	Stable Nitrogen Isotopes in Leaf Tissue	N/A	USEPA, 2008a.	
509	Genetic Diversity	N/A	USEPA, 2008a.	
510	Palynology	N/A	USEPA, 2008a.	
511	Paleoecology	N/A	USEPA, 2008a.	
512	USDA-NRCS Hydric Soil Field Indicators	Presence of hydric soil indicators.	USEPA, 2008a.	
513	Soil Profile Description	N/A	USEPA, 2008a.	
514	Soil Bulk Density	The mass of soil particles divided by the total volume they occupy.	USEPA, 2008a.	
515	Thickness of Organic Soil Layers	N/A	USEPA, 2008a.	
516	Soil Texture	Percent sand, silt, and clay particles.	USEPA, 2008a.	
517	Soil pH	N/A	USEPA, 2008a.	
518	Major Plant Nutrients in Soil	Presence of P, K, Ca, Mg.	USEPA, 2008a.	
519	Soil Organic Matter	Percent organic matter or carbon.	USEPA, 2008a.	
520	Soil Electrical Conductivity	A measure of how well soil units conduct an electric current.	USEPA, 2008a.	
521	Soil Nitrogen	Presence of all N in soil.	USEPA, 2008a.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
522	Soil Micronutrients	Presence of Cu, Mn, Zn, Fe.	USEPA, 2008a.	
523	Soil Enzyme Analysis	N/A	USEPA, 2008a.	
524	Soil Sulfur	Presence of S.	USEPA, 2008a.	
525	Geomorphic Soil Disturbance	Presence of, e.g., aggregation/degradation.	USEPA, 2008a.	
526	Soil Surface Disturbance	N/A	USEPA, 2008a.	
527	Soil Channels	Presence of incisions, channels, ditches, etc.	USEPA, 2008a.	
528	Sedimentation Rate	Rate of accretion or erosion.	USEPA, 2008a.	
529	Bare Soil	Presence of bare soil features.	USEPA, 2008a.	
530	Presence of Plow Layer	N/A	USEPA, 2008a.	
531	Soil Subsidence	N/A	USEPA, 2008a.	
532[x]	Paleoecology	N/A	USEPA, 2008a.	567
533	Depth Measurements	Surface and groundwater depth (depth of standing water, depth of water in soil excavation pit, etc.).	USEPA, 2008a.	
534	Water Sources	N/A	USEPA, 2008a.	
535	Hydrogeomorphic Unit	N/A	USEPA, 2008a.	
536	Vegetation Hydrologic Guild	N/A	USEPA, 2008a.	
537	Landscape Characteristics	N/A	USEPA, 2008a.	
538	Water Chemistry	N/A	USEPA, 2008a.	
539	Season of Flooding	N/A	USEPA, 2008a.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
540	Hydrologic Complexity/Microhabitats	N/A	USEPA, 2008a.	
541	Water Velocity	N/A	USEPA, 2008a.	
542	Stream Bedforms	N/A	USEPA, 2008a.	
543	Hydrologic Regimes	N/A	USEPA, 2008a.	
544	COE Primary Indicators of Inundation	N/A	USEPA, 2008a.	
545	COE Secondary Indicators of Inundation	N/A	USEPA, 2008a.	
546	Extent of Inundation	Percent of assessment area inundated, as well as spatial pattern and average depth of inundation.	USEPA, 2008a.	
547	Tidal Range	N/A	USEPA, 2008a.	
548	Spatial Pattern of Flooding	N/A	USEPA, 2008a.	
549[x]	Stream Discharge	N/A	USEPA, 2008a.	285
550	Direct Observation of Streams	Information from landowner interviews.	USEPA, 2008a.	
551	Stream Gauge Data	N/A	USEPA, 2008a.	
552	Ditch Spacing & Depth	N/A	USEPA, 2008a.	
553	Dams or Weirs	Presence of dams or weirs.	USEPA, 2008a.	
554	Levees	Presence of levees.	USEPA, 2008a.	
555	Drain Spacing and Depth	N/A	USEPA, 2008a.	
556	Irrigation	N/A	USEPA, 2008a.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
557	Sediment Load	N/A	USEPA, 2008a.	
558	Snag Density	Snag density is a sign of impoundment.	USEPA, 2008a.	
559	Fetch	Length of water surface over which wind blows in generating waves.	USEPA, 2008a.	
560	Bird Species Diversity	N/A	USEPA, 2008a.	
561	Sensitive/Tolerant Bird Species	N/A	USEPA, 2008a.	
562	Alien Bird Species	N/A	USEPA, 2008a.	
563	Dominant Bird Species	N/A	USEPA, 2008a.	
564	Bird Guild Composition - Foraging	Composition of bird guild based on foraging technique.	USEPA, 2008a.	
565	Bird Guild Composition - Dietary	Composition of bird guild based on dietary habits (omnivores, granivores, insectivores, etc.).	USEPA, 2008a.	
566	Bird Guild Composition - Nesting Strategy	Composition of bird guild based on nesting strategy (platform, ground, cavity, etc.).	USEPA, 2008a.	
567	Bird Abundance	Number, status, and types of nests.	USEPA, 2008a.	532
568	Bird Habitat Evaluation	N/A	USEPA, 2008a.	
569[x]	Macroinvertebrate Species Diversity	N/A	USEPA, 2008a.	461
570	Sensitive/Tolerant Macroinvertebrate Species	N/A	USEPA, 2008a.	
571	Alien Macroinvertebrate Species	N/A	USEPA, 2008a.	
572	Dominant	N/A	USEPA, 2008a.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
	Macroinvertebrate Species			
573	Macroinvertebrate Guild Compositions	N/A	USEPA, 2008a.	
574	Macroinvertebrate Habitat Evaluation	N/A	USEPA, 2008a.	
575	Fish Species Diversity	N/A	USEPA, 2008a.	
576	Sensitive/Tolerant Fish Species	N/A	USEPA, 2008a.	
577	Alien Fish Species	N/A	USEPA, 2008a.	
578	Dominant Fish Species	N/A	USEPA, 2008a.	
579[x]	Fish Tissue Contaminants	Presence of toxicants in fish tissue.	USEPA, 2008a.	48, 58, 99
580	Fish Guilds	N/A	USEPA, 2008a.	
581	Fish Habitat Evaluation	N/A	USEPA, 2008a.	
582	Fish Deformities	N/A	USEPA, 2008a.	
583	Algae Species Diversity	N/A	USEPA, 2008a.	
584	Sensitive/Tolerant Algae Species	N/A	USEPA, 2008a.	
585	Alien Algae Species	N/A	USEPA, 2008a.	
586	Dominant Algae Species	N/A	USEPA, 2008a.	
587	Algal Productivity	Measure of algal chlorophyll and biovolume.	USEPA, 2008a.	
588	Algae Habitat Evaluation	N/A	USEPA, 2008a.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
589	Hydrologic Modification	N/A	USEPA, 2008a.	
590	Vegetative Alteration	N/A	USEPA, 2008a.	
591	Buffer Alteration/Buffer Characteristics	N/A	USEPA, 2008a.	
592	Onsite Human Disturbance	N/A	USEPA, 2008a.	
593	Invasive Species	N/A	USEPA, 2008a.	
594	Sedimentation	N/A	USEPA, 2008a.	
595	Landscape Composition/Land use/Land cover	N/A	USEPA, 2008a.	
596	Substrate Alterations	N/A	USEPA, 2008a.	
597	Local Surface Disturbance	N/A	USEPA, 2008a.	
598	Point Source Stormwater Input	N/A	USEPA, 2008a.	
599	Eutrophication and Nutrient Enrichment	N/A	USEPA, 2008a.	
600	Water Quality	N/A	USEPA, 2008a.	
601	Trash, Dredge, and Fill	N/A	USEPA, 2008a.	
602	Shoreline Hardening/Barriers to Landward Migration	N/A	USEPA, 2008a.	
603[x]	Salinity and/or	N/A	USEPA, 2008a.	240, 84

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
	Conductivity			
604	Acidity	Change in pH.	USEPA, 2008a.	621, 151
605	Alteration of Natural Disturbance Regime	N/A	USEPA, 2008a.	
606	Toxic Contaminants (Pharmaceuticals)	N/A	USEPA, 2008a.	
607	Habitat Modification	N/A	USEPA, 2008a.	
608[x]	Recreational Use	N/A	USEPA, 2008a.	220
609	Turbidity	N/A	USEPA, 2008a.	
610	Pipelines, Wells, Oil Rigs, Sewer Lines	N/A	USEPA, 2008a.	
611	Contaminants	N/A	USEPA, 2008a.	
612	Thermal Stress	N/A	USEPA, 2008a.	
613	Alteration of Natural Turbidity	N/A	USEPA, 2008a.	
614	Pathogens	N/A	USEPA, 2008a.	
615	Mercury Body Burdens in Sentinel Species	N/A	USEPA, 2008a.	
616	Thermal Alterations	N/A	USEPA, 2008a.	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
617[x]	Carbon Storage	This indicator reports the overall amount of carbon gained or lost over time by major ecosystem types; the change in the amount of carbon stored per unit area of land or water (carbon density), by major ecosystem type; and the recent trends in the concentrations of major carbon-containing gases - carbon dioxide and methane - in the atmosphere compared to average preiundustrial concentrations.	Heinz Center, 2008.	35, 36
618[x]	Established Non-native Species	This indicator reports for plants, animals, and plant and animal pathogens across all ecosystem types: (a) the number of new non-native species that become established over time, by decade; (b) the area with different numbers of established non-native species; (c) the area with different proportions of established non-native species, as a percentage of total species.	Heinz Center, 2008.	144
619	Pattern in Coastal Area	This indicator describes the intermingling of "natural" and "non-natural" landscape (or seascape) features in coastal areas. The interplay between various types of coastal habitats (such as wetlands and open waters), as well as between these habitat types and human development in the coastal zone (such as built structures and dredged areas) provide a general description of the structural pattern of coastal areas. The structural pattern of these areas can be linked to how well they function ecologically and to the amount and type of ecosystem services humans receive from them.	Heinz Center, 2008.	
620	**In-stream Connectivity**	**This indicator reports on the proportion of watersheds with different levels of in-stream connectivity measured as the distance downstream from the "pour point" (where the streams leaves the watershed) to the nearest dam or diversion, such as a pumping station. This indicator also reports on the proportion of watersheds that contain streams with unobstructed flow to their natural endpoint, typically the ocean or a large lake. This indicator focueses on the loss of connectivity over and above any natural discontinuities in aquatic systems.**	**Heinz Center, 2008.**	

Indicator ID#	Indicator	Definition	Literature Source *[See Appendix A for full citation]*	Duplicate
621[x]	Freshwater Acidity	This indicator reports: (a) the amount of nitrogen and sulfate deposited from the atmosphere to watersheds each year; (b) the percentage of stream miles and area of lakes and ponds with different levels of acid-neutralizing capacity, a measure of sensitivity of acidification.	Heinz Center, 2008.	604, 151
622	Total withdrawal information by source & type of use	N/A	Miller, personal communication	
623**	**Water Availability: Net Streamflow per Capita (Vulnerability of Domestic Water Uses)**	**A measure estimating per capita water availability using net withdrawals (QW) from streamflow. Method of calculation: (QS-QW)/pop.**	**Hurd et al., 1998**	

Appendix C. Data Sources and Supporting Information

This appendix describes the data sources obtained for 32 of the 53 vulnerability indicators. These data sources were used, when possible, to create one or more maps for each indicator. Supporting information for each data source include: the names of the data sets used; how to obtain the data; website, when available; spatial and temporal resolution; coverage of data set (i.e. national, state, or local); type of data source; format of data relevant to mapping (e.g., ArcGIS, Excel, Access, etc.); and metadata (e.g., definitions of variables in data set, method of data collection, etc.). The Additional Data Characteristics sections for each indicator provide additional detail not captured in the preceding sections.

One indicator (marked with *) had an incomplete map. Five indicators (marked with **) were not mappable given project resources and technical difficulties encountered, as noted in the main report and in Appendix D. The remaining 25 indicators were mapped. The mapping methodology for the 25 mapped indicators is presented in Appendix E, and maps for these indicators are presented in Appendix F (by HUC-4 watershed) and Appendix H (by ecoregion).

#1 Acid Neutralizing Capacity (ANC)

Literature Source (see Appendix A for full citation):
USEPA, 2006b.

Data Sets Used:
USEPA - Wadeable Streams Assessment (WSA): Water Chemistry Data.

How To Obtain Data:
Download online

URL to Data (if any):
http://www.epa.gov/owow/streamsurvey/web_data.html

Spatial Resolution:
Small streams

Temporal Resolution (period and frequency of collection):
2004-2005; every 5 years (first year of round of data collection was 2004-2005)

Extent/Coverage of Data Set:
National

Type of Data Source:
Survey

Format of Data:
Comma separated

Metadata:

- *Definitions and data descriptions as .txt files.*
  USEPA. 2008. Wadeable Streams Assessment - Definitions of Variables. Available at: http://www.epa.gov/owow/streamsurvey/web_data.html. Accessed July 21, 2009.

Additional Data Characteristics:
The WSA Water Chemistry data set contains water chemistry data for small streams, including pH data. Data files are associated with companion text files (using EPA's WSA Definitions of Variables in metadata) that list data set labels and give individual descriptions for each variable. The original literature source, EPA's 2006 WSA report (USEPA, 2006b; see Appendix A for full citation), provides an explanation of how wadeable streams were selected for this study and how data were collected from various sites.

#22 At-Risk Freshwater Plant Communities

Literature Source (see Appendix A for full citation):
Heinz Center, 2008.

Data Sets Used:
NatureServe - Explorer (customized dataset)

How To Obtain Data:
Data were obtained from Jason McNees at NatureServe, 1101 Wilson Blvd., 15th Floor Arlington, VA 22201 via email on July 31, 2009.

URL to Data (if any):
N/A

Spatial Resolution:
State

Temporal Resolution (period and frequency of collection):
2006; not specified

Extent/Coverage of Data Set:
National

Type of Data Source:
Census

Format of Data:
Excel

Metadata:

- *Details of the National Vegetation Classification System (NVCS).*
  Federal Geographic Data Committee. International Classification of Ecological Communities - Terrestrial Vegetation of the United States. Volume I: The National Vegetation Classification System: Development, Status, and Applications. Available online at: http://www.NatureServe.org/library/vol1.pdf. Accessed July 21, 2009.
- *Explanation of Conservation Status Ranks.*
  NatureServe and Natural Heritage. 2009. Conservation Status Ranks. Available online at: http://www.NatureServe.org/explorer/ranking.htm. Accessed July 21, 2009.
- *Explanation of the Terrestrial Ecological Classification System.*
  NatureServe. 2008. Terrestrial Ecological Classification System. Available online at: http://www.NatureServe.org/publications/usEcologicalsystems.jsp.

Additional Data Characteristics:
NatureServe data, customized for EPA, were used to inform this indicator. Data include the percent of plant species at risk of extinction in each state. In each state, species considered to be at a risk of extinction were ones classified by NatureServe as critically imperiled, imperiled, or vulnerable (using NatureServe and Natural Heritage's Conservation Status Ranks in metadata). In addition, plant species were classified into plant community types based on their physiognomy (using FGDC's NVCS) or based on their landscape settings, biological dynamics, and environmental features (using NatureServe's Terrestrial Ecological Classification System).

#24 At-Risk Native Freshwater Species

Literature Source (see Appendix A for full citation):
Heinz Center, 2008.

Data Sets Used:
NatureServe - Explorer (customized dataset).

How To Obtain Data:
Data were obtained from Jason McNees at NatureServe, 1101 Wilson Blvd., 15th Floor Arlington, VA 22201 via email on July 31, 2009.

URL to Data (if any):
N/A

Spatial Resolution:
State

Temporal Resolution (period and frequency of collection):
2006; not specified

Extent/Coverage of Data Set:
National

Type of Data Source:
Census

Format of Data:
Excel

Metadata:
- *Explanation of Conservation Status Ranks.*
  NatureServe and Natural Heritage. 2009. Conservation Status Ranks. Available online at: http://www.NatureServe.org/explorer/ranking.htm. Accessed July 21, 2009.

Additional Data Characteristics:
NatureServe data, customized for EPA, were used to inform this indicator. Data include the percent of all species at risk of extinction in each state. In each state, species considered to be at a risk of extinction were ones classified by NatureServe as critically imperiled, imperiled, or vulnerable (using NatureServe and Natural Heritage's Conservation Status Ranks in metadata).

Note: The data set used to inform this indicator was the same as that used for the indicator #326 (Wetland and Freshwater Species at Risk (number of species)).

#51 Coastal Vulnerability Index (CVI)

Literature Source (see Appendix A for full citation):
Day et al., 2005.

Data Sets Used:
USGS - A Preliminary Database for the U.S. Atlantic, Pacific and Gulf of Mexico Coasts (U.S. Geological Survey Digital Data Series – 68)

How To Obtain Data:
Download online

URL to Data (if any):
http://pubs.usgs.gov/dds/dds68/htmldocs/data.htm

Spatial Resolution:
1:2,000,000 shoreline at 3-minute resolution

Temporal Resolution (period and frequency of collection):
Time periods vary for the 3 different regions of United States: Atlantic Coast (2000); Pacific Coast (2001); and Gulf Coast (2001). Variable frequency (as data on each of the six variables on which the CVI depends are collected for different time periods and at a different frequencies).

Extent/Coverage of Data Set:
All U.S. coastline.

Type of Data Source:
Database

Format of Data:
ARC/INFO or ASCII

Metadata:

- *Calculation of the CVI.*
  Thieler, R.R., Hammar-Klose, E.S., 2001. National Assessment of Coastal Vulnerability to Sea-Level Rise: Preliminary Results for the U.S. Gulf of Mexico Coast. *U.S. Geological Survey Open-File Report 00-179.* Available online at: http://pubs.usgs.gov/of/2000/of00-179/index.html. Accessed July 21, 2009.

Additional Data Characteristics:
The calculation of the value of this indicator is based on six independent variables (described in Thieler and Hammar-Klose, 2001 in metadata). The original data were housed in the Carbon Dioxide Information Analysis Center's (CDAIC) Coastal Hazards Database(CHD) for 3 geographic regions - East Coast, West Coast, and Gulf Coast. The attributes in this dataset are based on A Coastal Hazards Database for the U.S. Gulf Coast (Gornitz, V. and White, T. W. 1992. ORNL/CDIAC-60, NDP-043B. Oak Ridge National Laboratory, Oak Ridge, Tennessee) updated with data from more recent sources.

*#55 Commercially Important Fish Stocks***

Literature Source (see Appendix A for full citation):
Heinz Center, 2008.

Data Sets Used:
NOAA National Marine Fisheries Service (NMFS)

How To Obtain Data:
Request directly from NOAA NMFS Research Centers

URL to Data (if any):
N/A

Spatial Resolution:
Regional (e.g., Pacific Coast, Southeast, Northeast, etc.)

Temporal Resolution (period and frequency of collection):
1981-2005; at least 10 years of annual data per stock

Extent/Coverage of Data Set:
National (coastal)

Type of Data Source:
Census

Format of Data:
Unknown

Metadata:
N/A

Additional Data Characteristics:
The NOAA NMFS data set includes spawning stock biomass and total exploitable stock biomass data on 109 fish stocks over a 10-year period. These data do not include near-shore stocks (i.e., those in state waters within 3 miles of the shore), many of which are under state management jurisdiction, and anadromous salmon stocks from the Pacific Northwest. The Heinz Center calculated stock trends for 109 stocks based on the estimated weight or biomass of the entire stock using linear regression analysis to establish which stocks were increasing or decreasing by more than 25%.

*#95 Fish and Bottom-Dwelling Animals***

Literature Source (see Appendix A for full citation):
Heinz Center, 2008.

Data Sets Used:
(a) USEPA - Wadeable Streams Assessment (WSA)
(b) USEPA - Storage and Retrieval System (STORET)

How To Obtain Data:
(a) Download online
(b) Download online (if file size is large, can get via e-mail).

URL to Data (if any):
(a) http://www.epa.gov/owow/streamsurvey/web_data.html
(b) http://iaspub.epa.gov/storpubl/DW_home

Spatial Resolution:
(a) N/A
(b) HUC-8 watershed level

Temporal Resolution (period and frequency of collection):
(a) 2004-2005, every 5 years (first year of round of data collection was 2004-2005)
(b) 1900-2009; daily

Extent/Coverage of Data Set:
(a) National
(b) National

Type of Data Source:
(a) Survey
(b) Database

Format of Data:
(a) Comma separated
(b) Excel

Metadata:
- *Definitions and data descriptions as txt files.*
  USEPA. 2008a. Wadeable Streams Assessment - Definitions of Variables. Available at: http://www.epa.gov/owow/streamsurvey/web_data.html. Accessed July 21, 2009.

Additional Data Characteristics:
To assess the condition of fish and bottom-dwelling animals, the Macroinvertebrate Index of Biotic Condition was calculated (using methods in EPA's 2006 WSA report; USEPA 2006b). This index is based on multiple metrics, such as: taxa richness, evenness of species across taxa, the relative abundance of different taxa, the feeding strategy of taxa, the habitat preference of taxa, and the tolerance of taxa to stressors. Data on these are available in EPA's WSA data set and in EPA's STORET data set. Sites with index scores 75-95% lower than the reference streams were identified as 'moderate,' whereas 'degraded' sites were those with index scores lower than 95% of the reference streams.

#125 Groundwater Reliance

Literature Source (see Appendix A for full citation):
Hurd et al., 1998; Hurd et al.,1999.

Data Sets Used:
United States Geological Survey (USGS) - National Water-Use Dataset.

How To Obtain Data:
Download online

URL to Data (if any):
http://water.usgs.gov/watuse/

Spatial Resolution:
HUC-8 watershed

Temporal Resolution (period and frequency of collection):
1985-2000; every 5 years

Extent/Coverage of Data Set:
National

Type of Data Source:
Database

Format of Data:
ASCII

Metadata:

- *Description of water use parameters.*
  USGS. Estimated Use of Water in the United States. Available online at: http://water.usgs.gov/watuse/. Accessed December 15, 2010.

Additional Data Characteristics:
The USGS National Water-Use Dataset provides data on the total annual withdrawals from groundwater and surface water and total annual withdrawals from only groundwater for the year 1990.

#165 Meteorological Drought Indices

Literature Source (see Appendix A for full citation):
National Assessment Synthesis Team, 2000a.

Data Sets Used:
NOAA National Climatic Data Center (NCDC) - Divisional Data on the Palmer Drought Severity Index (PSDI).

How To Obtain Data:
Download online

URL to Data (if any):
http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp

Spatial Resolution:
344 "climate divisions," with varying number of divisions per state

Temporal Resolution (period and frequency of collection):
1895 to present; monthly

Extent/Coverage of Data Set:
National

Type of Data Source:
Database

Format of Data:
ASCII

Metadata:

- *Description of the PSDI.*
  Karl, T.R., R.W. Knight, D.R. Easterling, and R.G. Quayle. 1996. Indices of climatic change for the United States. *Bulletin of the American Meteorological Society.* 77 (2): 279-292.
- *Data dictionary for PSDI data.*
  National Oceanic and Atmospheric Administration (NOAA). 2007. Time-bias Corrected Divisional Temperature-Precipitation-Drought Index. Prepared by the National Climatic Data Center (NCDC). Available online at: http://www7.ncdc.noaa.gov/CDO/DIV_DESC.txt. Accessed July 21, 2009.
- *Definitions of climate divisions.*
  National Oceanic and Atmospheric Administration (NOAA). 2009. Definitions of Climate Divisions. Prepared by the National Climatic Data Center (NCDC). Available online at: http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?WWDI~getstate~US. Accessed July 21, 2009.

Additional Data Characteristics:
The NOAA NCDC Divisional Data on the PSDI includes the calculated value of the PSDI for each of 344 climate divisions in the U.S. The description of the index (from Karl et al., 1996 in metadata) and other supporting information (from NOAA's data dictionary for PSDI data and definitions of climate divisions in metadata) are also available.

*#190 Number of Dry Periods in Grassland/Shrubland Streams and Rivers (Percent of streams with dry periods over time)**

Literature Source (see Appendix A for full citation):
Heinz Center, 2008.

Data Sets Used:
(a) USGS - Hydro Climatic Data Network (HDCN)
(b) USGS - Stream Gauge Data

How To Obtain Data:
Data (integrated data set of (a) and (b) above) were obtained from Anne Marsh, Ph. D., Director of Observation and Understanding Programs, The H. John Heinz III Center for Science, Economics, and the Environment, 900 17th Street, NW, Suite 700, Washington, D. C. 20006 via email on April 28, 2009.

URL to Data (if any):
(a) N/A
(b) N/A

Spatial Resolution:
(a) HUC-8 watershed level
(b) HUC-8 watershed level

Temporal Resolution (period and frequency of collection):
(a) 1874-1988 (inclusive); daily, monthly, and annual
(b) 1899-2007; daily, monthly, annual

Extent/Coverage of Data Set:
(a) National
(b) National

Type of Data Source:
(a) Database
(b) Database

Format of Data:
(a) ASCII;
(b) .rrd or .img or .xml or .sgml

Metadata:

- *Ecoregion definitions.*
  Bailey, R. G. 1995. Description of the Ecoregions of the United States. Available online at: http://www.fs.fed.us/land/ecosysmgmt/. Accessed July 21, 2009.
- *National Land Cover Dataset (NLCD) - Landcover categories.*
  USEPA. Undated. National Land Cover Dataset (NLCD) - Landcover categories. Available online at: http://www.mrlc.gov/index.php. Accessed July 21, 2009.

Additional Data Characteristics:
Data were obtained from the two different datasets: daily streamflow data at study sites from USGS' Stream Gauge Data data set, and daily streamflow data for reference sites in relatively undisturbed locations from USGS' HDCN data set. Data were integrated into a single data set by the Heinz Center; this integrated data set was ultimately used for mapping. In addition, ecoregion definitions (from Bailey, 1995 in metadata) and land cover region definitions (from USEPA's NLCD Landcover Categories in metadata) were used to define watersheds in grasslands and shrublands.

*#209 Population (human) Susceptible to Flood Risk***

Literature Source (see Appendix A for full citation):
Hurd et al., 1998; Hurd et al.,1999.

Data Sets Used:
(a) FEMA Q3 Flood Data
(b) ESRI ArcUSA - US Census tract data.

How To Obtain Data:
(a) 26 CDs (for all USA) available for a fee, online or on phone.
(b) Available on ArcGIS.

URL to Data (if any):
(a) http://www.fema.gov/hazard/map/q3.shtm#0
(b) N/A

Spatial Resolution:
(a) Individual street addresses
(b) 2 scales - 1:2,000,000 and 1:25,000,000

Temporal Resolution (period and frequency of collection):
(a) N/A
(b) N/A

Extent/Coverage of Data Set:
(a) National
(b) National

Type of Data Source:
(a) Collection of flood maps
(b) Census

Format of Data:
(a) Digital Line Graph (DLG), ARC/INFO, MapInfo
(b) ARC/INFO (ArcView and ArcGIS compatible)

Metadata:
N/A

Additional Data Characteristics:
500-year floodplain data from FEMA's Q3 Digital Flood Data were overlaid with U.S. Census Tract Data from ArcGIS.

#218 Ratio of Snow to Total Precipitation

Literature Source (see Appendix A for full citation):
Lettenmaier et al., 2008.

Data Sets Used:
Monthly Climate Data and Observation Station Locations from National Climatic Data Center.

How To Obtain Data:
Download online (free for .gov and .edu domains).

URL to Data (if any):
http://gis.ncdc.noaa.gov/snowfallmo/

Spatial Resolution:
18,116 stations

Temporal Resolution (period and frequency of collection):
1867 to present; annual

Extent/Coverage of Data Set:
National

Type of Data Source:
Database

Format of Data:
Tabular, Delimited, Time Series, NWS Condensed B (suitable for SWMM), Worksheet, dBase, Binary, NCDC

Metadata:
N/A

Additional Data Characteristics:
NOAA's Monthyl Climate Data and Observation Locations data set contains climate data (rain, snow, evaporation, temperature, degree days). Based on available station-level time-series data, the unweighted numeric average for each HUC-4 can be calculated using stations within that HUC watershed.

#219 Ratio of Withdrawals to Stream Flow

Literature Source (see Appendix A for full citation):
Hurd et al.,1999.

Data Sets Used:
(a) Oregon State University - PRISM Climate Modeling System: Mean Annual Precipitation data
(b) Oregon State University - PRISM Climate Modeling System: Mean Daily Maximum Temperature data
(c) USGS - National Water-Use Dataset.

How To Obtain Data:
Download online

URL to Data (if any):
(a) http://www.prism.oregonstate.edu/products/matrix.phtml
(b) http://www.prism.oregonstate.edu/products/matrix.phtml
(c) http://water.usgs.gov/watuse/

Spatial Resolution:
(a) 30 arc-second (800 meters)
(b) 30 arc-second (800 meters)
(c) HUC-8 watershed

Temporal Resolution (period and frequency of collection):
(a) 1971 – 2000; monthly
(b) 1971 – 2000; monthly
(c) 1985 – 2000; every 5 years

Extent/Coverage of Data Set:
(a) National
(b) National

Type of Data Source:
(a) Interpolated grid
(b) Interpolated grid
(c) Database

Format of Data:
ASCII

Metadata:
- *Calculation of streamflow.*
  Vogel, R.M., I. Wilson, and C. Daly. 1999. Regional Regression Models of Annual Streamflow for the United States." *Journal of Irrigation and Drainage Engineering.* 125 (3): 148-157.
- *Metadata for PRISM U.S. average monthly or annual precipitation data.*
  http://www.prism.oregonstate.edu/docs/meta/ppt_30s_meta.htm
- *Metadata for PRISM U.S. average monthly temperature data.*
  http://www.climatesource.com/us/fact_sheets/meta_tmin_us_71b.html
- *Description of water use parameters.*
  USGS. Estimated Use of Water in the United States. Available online at: http://water.usgs.gov/watuse/. Accessed December 15, 2010.

Additional Data Characteristics:
As described in the metadata for (b), mean annual temperature was calculated as the average of the mean maximum and mean minum temperature for a given location.

#284 Stream Habitat Quality

Literature Source (see Appendix A for full citation):
Heinz Center, 2008.

Data Sets Used:
USEPA - Wadeable Streams Assessment (WSA).

How To Obtain Data:
Download online

URL to Data (if any):
http://www.epa.gov/owow/streamsurvey/web_data.html

Spatial Resolution:
Small streams

Temporal Resolution (period and frequency of collection):
2004-2005; every 5 years (first year of round of data collection was 2004-2005)

Extent/Coverage of Data Set:
National

Type of Data Source:
Survey

Format of Data:
Comma separated

Metadata:
- *Definitions and data descriptions as .txt files.*
  USEPA. 2008. Wadeable Streams Assessment - Definitions of Variables. Available at: http://www.epa.gov/owow/streamsurvey/web_data.html. Accessed July 21, 2009.

Additional Data Characteristics:
Data on the biological condition of small streams, water quality, and biological data on various stream types were used to inform this indicator.

*#322 Waterborne Human Disease Outbreaks (events)***

Literature Source (see Appendix A for full citation):
Heinz Center, 2008.

Data Sets Used:
Centers for Disease Control and Prevention (CDC) - Waterborne Disease and Outbreak Surveillance System (WBDOSS).

How To Obtain Data:
Download online

URL to Data (if any):
http://www.cdc.gov/healthywater/statistics/wbdoss/surveillance.html

Spatial Resolution:
State

Temporal Resolution (period and frequency of collection):
1985-2004, yearly or every 2 to 3 years

Extent/Coverage of Data Set:
National

Type of Data Source:
Data summaries

Format of Data:
PDF and web page

Metadata:
N/A

Additional Data Characteristics:
Data from the CDC's WBDOSS on the number of waterborne human disease outbreaks in both drinking and recreational water, listed by state, by etiologic agent and type of water system, by deficiency/type of exposure and type of water system, are used to inform this indicator.

*#325 Wetland Loss***

Literature Source (see Appendix A for full citation):
MEA, 2005b.

Data Sets Used:
(a) USFWS - National Wetlands Inventory (NWI)
(b) NatureServe Explorer

How To Obtain Data:
(a) Download online
(b) Download online

URL to Data (if any):
(a) http://www.fws.gov/wetlands/Data/DataDownload.html
(b) http://www.NatureServe.org/explorer/

Spatial Resolution:
(a) Lower 48 states (USGS 1:24,000 or 1:100,000 topographic quadrangle), Alaska (USGS 1:63,000 topographic quadrangle), Hawaii (County and USGS topographic quadrangle), Puerto Rico and USVI (County and USGS topographic quadrangle), Pacific Trust Territories (County/Island), Data are in decimal degrees on the North American Datum of 1983
(b) State or by NLCD 2001 map-zones

Temporal Resolution (period and frequency of collection):
(a) N/A
(b) N/A

Extent/Coverage of Data Set:
(a) National
(b) National

Type of Data Source:
(a) Database
(b) Census

Format of Data:
(a) NWI - digital wetlands polygon, .sgml and .xml
(b) .xls or .xml

Metadata:
- *National Vegetation Classification System (NVCS).*
  Federal Geographic Data Committee. 2009. National Vegetation Classification System. Available online at: http://biology.usgs.gov/npsveg/nvcs.html. Accessed on November 19, 2009.
- *Terrestrial Ecological Classification System.*
  NatureServe/Natural Heritage. 2009. Terrestrial Ecological Classification System. Available online at: http://www.natureserve.org/explorer/classeco.htm. Accessed on November 19, 2009.

Additional Data Characteristics:
Data from two datasets were used to inform this indicator: data on wetland vegetation and hydrologic properties of wetlands from NWI, and plant species vulnerability rankings and data on their abundance in U.S. states from NatureServe Explorer. Vulnerability rankings (from Natural Heritage) were used to estimate relative susceptibility to extinction. In addition, plant species were classified into plant community types based on their physiognomy (using NVCS) or based on their landscape settings, biological dynamics, and environmental features (using Terrestrial Ecological Classification System).

#326 Wetland and Freshwater Species at Risk (number of species)

Literature Source (see Appendix A for full citation):
Hurd et al., 1998.

Data Sets Used:
NatureServe - Explorer (customized dataset).

How To Obtain Data:
Data were obtained from Jason McNees at NatureServe, 1101 Wilson Blvd., 15th Floor Arlington, VA 22201 via email on July 31, 2009.

URL to Data (if any):
N/A

Spatial Resolution:
State

Temporal Resolution (period and frequency of collection):
2006; not specified

Extent/Coverage of Data Set:
National

Type of Data Source:
Census

Format of Data:
Excel

Metadata:
- *Explanation of Conservation Status Ranks.*
  NatureServe and Natural Heritage. 2009. Conservation Status Ranks. Available online at: http://www.NatureServe.org/explorer/ranking.htm. Accessed July 21, 2009.

Additional Data Characteristics:
Data on the number of at-risk water-dependent species were originally compiled by the Natural Heritage Data Centers and The Nature Conservancy for the EPA's Index of Watershed Indicators (IWI), a study published in 1997. The IWI project was discontinued due to lack of adequate funding. Therefore, NatureServe data, customized for EPA, were used to inform this indicator. Data include the percent of all species at risk of extinction in each state. In each state, species considered to be at a risk of extinction were ones classified by NatureServe as critically imperiled, imperiled, or vulnerable (using NatureServe and Natural Heritage's Conservation Status Ranks in metadata).

Note: The data set used to inform this indicator was identical to that used for the indicator #24 (At-Risk Native Freshwater Species).

#348 Erosion Rate

Literature Source (see Appendix A for full citation):
Murdoch et al., 2000.

Data Sets Used:
Soil erosion rates estimated with the Revised Universal Soil Loss Equation (RUSLE)

How To Obtain Data:
Request directly from:
Dawen Yang, PhD, Professor
Department of Hydraulic Engineering
Tsinghua University
Beijing 100084, China
Tel: +86-10-62796976
Fax: +86-10-62796971
E-mail: yangdw@tsinghua.edu.cn

URL to Data (if any):
N/A

Spatial Resolution:
0.5 degree grid

Temporal Resolution (period and frequency of collection):
1980; not applicable (modeled data)
Extent/Coverage of Data Set:
Global

Type of Data Source:
Model output

Format of Data:
ASCII grid

Metadata:
- *Description of dataset development.*
  Yang, D. W., S. Kanae, T. Oki, T. Koike, and K. Musiake. 2003. Global potential soil erosion with reference to land use and climate changes. *Hydrological Processes.* 17:2913-2928.

Additional Data Characteristics:
Erosion Rate was estimated with the Revised Universal Soil Loss Equation (RUSLE). RUSLE does not account for deposition of eroded soil, so this indicator is more precisely defined as soil movement. The literature source also describes variations of this dataset that incorporate simulations of future climatic conditions (see Yang et al. (2003) for details). The study also includes future soil erosion predictions based on changes in precipitation, temperature, and land cover.

#351 Instream Use/Total Streamflow

Literature Source (see Appendix A for full citation):
Meyer et al.,1999.

Data Sets Used:
(a) USGS - National Water-Use Dataset
(b) USGS - Mean annual runoff data
(c) WRC (U.S. Water Resources Council) - Groundwater Recharge. From: WRC. 1978. The Nation's Water Resources: 1975-2000 (Vol. 2). U.S. Government Printing Office, Washington D.C.

How To Obtain Data:
(a) Download online
(b) Download online
(c) Hardcopy book (obtained from library).

URL to Data (if any):
(a) http://water.usgs.gov/watuse/
(b) http://water.usgs.gov/GIS/metadata/usgswrd/XML/runoff.xml
(c) N/A

Spatial Resolution:
(a) HUC-8 watershed
(b) 1:5,000,000 (runoff of tributary streams)
(c) HUC-2 regions

Temporal Resolution (period and frequency of collection):
(a) 1985-2000; every 5 years
(b) 1951-1980; one-time effort
(c) 1975; one-time effort

Extent/Coverage of Data Set:
(a) National
(b) National
(c) National

Type of Data Source:
(a) Database
(b) Modeled dataset
(c) Published report

Format of Data:
(a) ASCII
(b) ArcGIS file (.e00)
(c) Tabular (hard copy)

Metadata:

- *Description of water use parameters.*
  USGS. Estimated Use of Water in the United States. Available online at: http://water.usgs.gov/watuse/. Accessed December 15, 2010.

Additional Data Characteristics:
Data for this indicator were derived from three sources: data on total groundwater withdrawals for the year 1995 from USGS' National Water-Use Dataset, modeled mean annual runoff estimates based on annual streamflow data from USGS' mean annual runoff dataset, and groundwater recharge estimates from WRC, 1978. The ratio of in-stream use to total streamflow was then calculated as described in the WRC report (1978).

#352 Total Use/Total Streamflow

Literature Source (see Appendix A for full citation):
Meyer et al.,1999.

Data Sets Used:
(a) USGS - National Water-Use Dataset
(b) USGS - Mean annual runoff data
(c) WRC (U.S. Water Resources Council) - Groundwater Recharge. From: WRC. 1978. The Nation's Water Resources: 1975-2000 (Vol. 2). U.S. Government Printing Office, Washington D.C.

How To Obtain Data:
(a) Download online
(b) Download online
(c) Hardcopy book (obtained from library).

URL to Data (if any):
(a) http://water.usgs.gov/watuse/
(b) http://water.usgs.gov/GIS/metadata/usgswrd/XML/runoff.xml
(c) N/A

Spatial Resolution:
(a) HUC-8 watershed
(b) 1:5,000,000 (runoff of tributary streams)
(c) HUC-2 regions

Temporal Resolution (period and frequency of collection):
(a) 1985-2000; every 5 years
(b) 1951-1980; 1 time effort
(c) 1975; one-time effort

Extent/Coverage of Data Set:
(a) National
(b) National
(c) National

Type of Data Source:
(a) Database
(b) Modeled dataset
(c) Published report

Format of Data:
(a) ASCII
(b) ArcGIS file (.e00)
(c) Tabular (hard copy)

Metadata:
- *Description of water use parameters.*
  USGS. Estimated Use of Water in the United States. Available online at: http://water.usgs.gov/watuse/. Accessed December 15, 2010.

Additional Data Characteristics:
Data for this indicator were derived from three sources: data on total groundwater withdrawals and consumptive use for the year 1995 from USGS' National Water-Use Dataset, modeled mean annual runoff estimates based on annual streamflow data from USGS' mean annual runoff dataset, and groundwater recharge estimates from WRC, 1978. The ratio of total use to total streamflow was then calculated as described in the WRC report (1978).

#364 Pesticide Toxicity Index (PTI)

Literature Source (see Appendix A for full citation):
Gilliom et al., 2006.

Data Sets Used:
USGS - NAWQA.

How To Obtain Data:
Download online

URL to Data (if any):
http://water.usgs.gov/nawqa/pnsp/pubs/circ1291/appendix6/

Spatial Resolution:
51 study units

Temporal Resolution (period and frequency of collection):
1991 (20 study units); 1994 (16 study units); 1997 (15 study units); Variable frequency (from one-time collection to daily depending on purpose and collection site)

Extent/Coverage of Data Set:
National

Type of Data Source:
Database

Format of Data:
Comma separated or Excel

Metadata:

- *NAWQA Study Description.*
  USGS. 2006. About NAWQA Study Units. Available online at: http://water.usgs.gov/nawqa/studies/study_units.html. Accessed July 21, 2009.
- *Daphnia EC50 Values.*
  USEPA. 2009. ECOTOX Database. Available online at: http://cfpub.epa.gov/ecotox/. Accessed September 11, 2009.

Additional Data Characteristics:
The USGS NAWQA data set, which contained data on the occurrence of 76 pesticides (including herbicides and insecticides) and 7 pesticide by-products in streams and shallow groundwater (100ft or less below ground level) at 20 USGS study sites in 1991, 1994, and 1997, was used to inform this indicator. Descriptions of study sites and their year of assessment were also available (from USGS's About NAWQA webpage in metadata). The Pesticide Toxicity Index (PTI) accounts for multiple pesticides in a sample, including pesticides without established benchmarks for aquatic life. The PTI combines information on measured concentrations of pesticides in stream water with toxicity estimates (i.e. toxicity quotients calculated based on laboratory toxicity studies, e.g. EC50 values for *Daphnia* from EPA's ECOTOX database) to produce a relative index value for a sample or stream. The PTI value is computed for each sample of stream water by summing the toxicity quotients for all pesticides detected in the sample.

#367 Herbicide Concentrations in Streams

Literature Source (see Appendix A for full citation):
USGS, 1999.

Data Sets Used:
USGS - NAWQA.

How To Obtain Data:
Download online

URL to Data (if any):
http://water.usgs.gov/nawqa/pnsp/pubs/circ1291/appendix6/

Spatial Resolution:
51 study units

Temporal Resolution (period and frequency of collection):
1991 (20 study units); 1994 (16 study units); 1997 (15 study units); Variable frequency (from one-time collection to daily depending on purpose and collection site)

Extent/Coverage of Data Set:
National

Type of Data Source:
Database

Format of Data:
Comma separated or Excel

Metadata:
- *NAWQA Study Description.*
  USGS. 2006. About NAWQA Study Units. Available online at: http://water.usgs.gov/nawqa/studies/study_units.html. Accessed July 21, 2009.

Additional Data Characteristics:
The USGS NAWQA data set, which contained data on the occurrence of 76 pesticides (including herbicides and insecticides) and 7 pesticide by-products in streams and shallow groundwater (100ft or less below ground level) at 20 USGS study sites in 1991, 1994, and 1997, was used to inform this indicator. Descriptions of study sites and their year of assessment were also available (from USGS's About NAWQA webpage in metadata).

#369 Insecticide Concentrations in Streams

Literature Source (see Appendix A for full citation):
USGS, 1999.

Data Sets Used:
USGS - NAWQA.

How To Obtain Data:
Download online

URL to Data (if any):
http://water.usgs.gov/nawqa/pnsp/pubs/circ1291/appendix6/

Spatial Resolution:
51 study units

Temporal Resolution (period and frequency of collection):
1991 (20 study units); 1994 (16 study units); 1997 (15 study units); Variable frequency (from one-time collection to daily depending on purpose and collection site)

Extent/Coverage of Data Set:
National

Type of Data Source:
Database

Format of Data:
Comma separated or Excel

Metadata:
- *NAWQA Study Description.*
  USGS. 2006. About NAWQA Study Units. Available online at: http://water.usgs.gov/nawqa/studies/study_units.html. Accessed July 21, 2009.

Additional Data Characteristics:
The USGS NAWQA data set, which contained data on the occurrence of 76 pesticides (including herbicides and insecticides) and 7 pesticide by-products in streams and shallow groundwater (100ft or less below ground level) at 20 USGS study sites in 1991, 1994, and 1997, was used to inform this indicator. Descriptions of study sites and their year of assessment were also available (from USGS's About NAWQA webpage in metadata).

#371 Organochlorines in Bed Sediment

Literature Source (see Appendix A for full citation):
USGS, 1999.

Data Sets Used:
USGS - National Water-Quality Assessment (NAWQA).

How To Obtain Data:
Download online

URL to Data (if any):
http://water.usgs.gov/nawqa/pnsp/pubs/circ1291/appendix6/

Spatial Resolution:
51 study units

Temporal Resolution (period and frequency of collection):
1991 (20 study units); 1994 (16 study units); 1997 (15 study units); Variable frequency (from one-time collection to daily depending on purpose and collection site)

Extent/Coverage of Data Set:
National

Type of Data Source:
Database

Format of Data:
Comma separated or Excel

Metadata:
- *NAWQA Study Description.*
  USGS. 2006. About NAWQA Study Units. Available online at: http://water.usgs.gov/nawqa/studies/study_units.html. Accessed July 21, 2009.

Additional Data Characteristics:
The USGS NAWQA data set, which contained data on the occurrence of 32 compounds (8 individual parent compounds, 1 individual breakdown product, and 7 groups of parent compounds, plus related breakdown products or chemical impurities in the manufactured product) in bed sediment at 20 USGS study sites in 1991, 1994, and 1997, was used to inform this indicator. Descriptions of study sites and their year of assessment were also available (from USGS's About NAWQA webpage in metadata).

#373 Herbicides in Groundwater

Literature Source (see Appendix A for full citation):
USGS, 1999.

Data Sets Used:
USGS - NAWQA.

How To Obtain Data:
Download online

URL to Data (if any):
http://water.usgs.gov/nawqa/pnsp/pubs/circ1291/appendix6/

Spatial Resolution:
51 study units

Temporal Resolution (period and frequency of collection):
1991 (20 study units); 1994 (16 study units); 1997 (15 study units); Variable frequency (from one-time collection to daily depending on purpose and collection site)

Extent/Coverage of Data Set:
National

Type of Data Source:
Database

Format of Data:
Comma separated or Excel

Metadata:
- *NAWQA Study Description.*
  USGS. 2006. About NAWQA Study Units. Available online at: http://water.usgs.gov/nawqa/studies/study_units.html. Accessed July 21, 2009.

Additional Data Characteristics:
The USGS NAWQA data set, which contained data on the occurrence of 76 pesticides (including herbicides and insecticides) and 7 pesticide by-products in streams and shallow groundwater (100ft or less below ground level) at 20 USGS study sites in 1991, 1994, and 1997, was used to inform this indicator. Descriptions of study sites and their year of assessment were also available (from USGS's About NAWQA webpage in metadata).

#374 Insecticides in Groundwater

Literature Source (see Appendix A for full citation):
USGS, 1999.

Data Sets Used:
USGS - NAWQA.

How To Obtain Data:
Download online

URL to Data (if any):
http://water.usgs.gov/nawqa/pnsp/pubs/circ1291/appendix6/

Spatial Resolution:
51 study units

Temporal Resolution (period and frequency of collection):
1991 (20 study units); 1994 (16 study units); 1997 (15 study units); Variable frequency (from one-time collection to daily depending on purpose and collection site)

Extent/Coverage of Data Set:
National

Type of Data Source:
Database

Format of Data:
Comma separated or Excel

Metadata:

- *NAWQA Study Description.*
  USGS. 2006. About NAWQA Study Units. Available online at: http://water.usgs.gov/nawqa/studies/study_units.html. Accessed July 21, 2009.

Additional Data Characteristics:
The USGS NAWQA data set, which contained data on the occurrence of 76 pesticides (including herbicides and insecticides) and 7 pesticide by-products in streams and shallow groundwater (100ft or less below ground level) at 20 USGS study sites in 1991, 1994, and 1997, was used to inform this indicator. Descriptions of study sites and their year of assessment were also available (from USGS's About NAWQA webpage in metadata).

#437 Precipitation Elasticity of Streamflow

Literature Source (see Appendix A for full citation):
Sankarasubramanian et al., 2001.

Data Sets Used:
(a) USGS - Hydroclimatic Data Network (HDCN): Streamflow data
(b) Oregon State University - PRISM Climate Modeling System: Mean Annual Precipitation data

How To Obtain Data:
(a) Download online
(b) Download online

URL to Data (if any):
(a) http://pubs.usgs.gov/of/1992/ofr92-129/hcdn92/hcdn/ascii/
(b) http://www.prism.oregonstate.edu/

Spatial Resolution:
(a) HUC-8
(b) 2.5 arc-min

Temporal Resolution (period and frequency of collection):
(a) 1874 - 1988; annual
(b) 1990 - present; monthly

Extent/Coverage of Data Set:
(a) National
(b) National

Type of Data Source:
(a) Database
(b) Database

Format of Data:
(a) ASCII
(b) ASCII

Metadata:
- *Description of HDCN data.*
  Landwehr, J. M., and J. R. Slack, 1992. Hydro-Climatic Data Network: A U.S. Geological Survey Streamflow Data Set for the United States for the Study of Climate Variations, 1874-1988. U.S. Geological Survey Open-File Report 92-129. Available online at: http://pubs.er.usgs.gov/usgspubs/ofr/ofr92129. Accessed July 21, 2009.
- *Description of PRISM modeling.*
  Daly, C., R. P. Neilson, and D. L. Phillips. 1994. "A Statistical-Topographic Model for Mapping Climatological Precipitation over Mountainous Terrain." *Journal of Applied Meterology.* 33: 140-158.
- *Calculation of precipitation elasticity of streamflow.*
  Sankarasubramanian, A., R. M. Vogel, and J. F. Limbrunner. 2001. Climate Elasticity of Streamflow in the United States. Water Resources Research. 37 (6): 1771-1781.

Additional Data Characteristics:
Data on streamflow were obtained from USGS's HDCN data set. Data on precipitation were obtained from Oregon State University's PRISM data set. Explanations for how data in HDCN and PRISM were collected and/or modeled are also available (from Landwehr and Slack, 1992 and Daly et al., 1994 in metadata). For the purposes of mapping this indicator with relative ease, Figure 4 in the original literature source, Sankarasubramanian et al., 2001 (see Appendix A for full reference) was used. However, the complete original data set could also be recalculated for mapping purposes using the data sources listed here.

#449 Ratio of Reservoir Storage to Mean Annual Runoff

Literature Source (see Appendix A for full citation):
Lettenmaier et al., 2008.

Data Sets Used:
(a) US Army Corps of Engineers (USACE) - National Inventory of Dams (NID)
(b) USGS - Mean annual runoff data

How To Obtain Data:
(a) Download online (need to register for free)
(b) Download online

URL to Data (if any):
(a) https://nid.usace.army.mil (Note: You must accept the security certificate in order to view database) OR http://www.nationalatlas.gov/mld/dams00x.html
(b) http://water.usgs.gov/GIS/metadata/usgswrd/XML/runoff.xml

Spatial Resolution:
(a) 80,000 dams (latitude and longitude specifications included only major dams available at National Atlas site)
(b) 1:5,000,000 (runoff of tributary streams)

Temporal Resolution (period and frequency of collection):
(a) 1972-2006; unclear how often it is updated
(b) 1951-1980; 1 time effort

Extent/Coverage of Data Set:
(a) National
(b) National

Type of Data Source:
(a) Database
(b) Modeled dataset

Format of Data:
(a) Tabular (need to copy-paste into Excel)
(b) ArcGIS file (.e00)

Metadata:
- *Calculation of ratio of reservoir storage to mean annual runoff.*
  Graf, W.L., 1999: Dam nation: A geographic census of American dams and their large-scale hydrologic impacts, Water Resources Research, 35 (4): 1305-1311.

Additional Data Characteristics:
Data for this indicator were derived from two sources: dam reservoir storage data from the USACE's NID data set and modeled mean annual runoff estimates based on annual streamflow data from USGS' mean annual runoff dataset. The storage to runoff ratio can then be calculated (as specified in Graf, 1999 in metadata).

#453 Runoff Variability

Literature Source (see Appendix A for full citation):
Lettenmaier et al., 2008.

Data Sets Used:
University of Washington (Land Surface Hydrology Research Group) - Variable Infiltration Capacity (VIC) Land Surface Data Set.

How To Obtain Data:
Download online (need to register for free).

URL to Data (if any):
http://www.hydro.washington.edu/SurfaceWaterGroup/Data/VIC_retrospective/index.html (file is:
ftp://ftp.hydro.washington.edu/pub/CE/HYDRO/nijssen/vic_global/calibrated/runoff.calibrated.monthly.1980_1993.nc.gz)

Spatial Resolution:
2 degrees

Temporal Resolution (period and frequency of collection):
1950-2000; 3-hourly

Extent/Coverage of Data Set:
National

Type of Data Source:
Modeled dataset

Format of Data:
NetCDF

Metadata:

- *Explanation of VIC model.*
  Maurer, E.P., A.W. Wood, J.C. Adam, D.P. Lettenmaier, and B. Nijssen, 2002. A long-term hydrologically-based data set of land surface fluxes and states for the conterminous United States, Journal of Climate, 15: 3237-3251.
- *VIC Global Hydrologic Simulations – Variable descriptions.*
  University of Washington (Land Surface Hydrology Research Group). Undated. VIC Global Hydrologic Simulations. Available online at: http://www.hydro.washington.edu/SurfaceWaterGroup/Data/vic_global.html. Accessed July 21, 2009.

Additional Data Characteristics:
Data on runoff are available from the output of the University of Washington's VIC model which simulates the global land surface hydrological cycle. The model outputs include five model-derived variables: evapotranspiration, snow-water equivalent, soil moisture storage, total storage, and runoff (which is the variable of interest). Detailed descriptions of input variables and output parameters of this model are also availabled (from Maurer et al., 2002 in metadata).

#460 Macroinvertebrate Index of Biotic Condition

Literature Source (see Appendix A for full citation):
USEPA, 2006b.

Data Sets Used:
USEPA - Wadeable Streams Assesment (WSA) (Stream Water Benthic Macroinvertebrate Metrics).

How To Obtain Data:
Download online

URL to Data (if any):
http://www.epa.gov/owow/streamsurvey/web_data.html (file is: wsa_benmet300_ts_final.csv)

Spatial Resolution:
Small streams

Temporal Resolution (period and frequency of collection):
2004-2005; every 5 years (first year of round of data collection was 2004-2005)

Extent/Coverage of Data Set:
National

Type of Data Source:
Survey

Format of Data:
Comma separated

Metadata:

- *Definitions and data descriptions as .txt files.*
  USEPA. 2008. Wadeable Streams Assessment - Definitions of Variables. Available at: http://www.epa.gov/owow/streamsurvey/web_data.html. Accessed July 21, 2009.
- *Site information for WSA sites.*
  USEPA 2008. Wadeable Streams Assessment - Post-Sampling Site Info and Survey Design. Available at: http://www.epa.gov/owow/streamsurvey/web_data.html. Accessed July 21, 2009. (file is: wsa_siteinfo_ts_final.csv).

Additional Data Characteristics:
Data on counts of individual benthic macroinvertebrates at various stages of their life cycle were obtained from EPA's WSA Benthic Macroinvertebrate Metrics data set. Data files are associated with companion text files (using EPA's WSA Definitions of Variables in metadata) that list data set labels and give individual descriptions for each variable. The original literature source, EPA's 2006 WSA report (USEPA, 2006b; see Appendix A for full citation), provides an explanation of how wadeable streams were selected for this study and how data were collected from various sites.

#461 Macroinvertebrate Observed/Expected (O/E) Ratio of Taxa Loss

Literature Source (see Appendix A for full citation):
USEPA, 2006b.

Data Sets Used:
USEPA - Wadeable Streams Assessment (Stream Water Benthic Macroinvertebrate Metrics).

How To Obtain Data:
Download online

URL to Data (if any):
http://www.epa.gov/owow/streamsurvey/web_data.html (file is: wsa_benmet300_ts_final.csv)

Spatial Resolution:
Small streams

Temporal Resolution (period and frequency of collection):
2004-2005; every 5 years (first year of round of data collection was 2004-2005)

Extent/Coverage of Data Set:
National

Type of Data Source:
Survey

Format of Data:
Comma separated

Metadata:
- *Definitions and data descriptions as .txt files.*
  USEPA. 2008. Wadeable Streams Assessment - Definitions of Variables. Available at: http://www.epa.gov/owow/streamsurvey/web_data.html. Accessed July 21, 2009.

Additional Data Characteristics:
Data on percent diversity of benthic macroinvertebrates were obtained from EPA's WSA Benthic Macroinvertebrate Metrics data set. Data files are associated with companion text files (using EPA's WSA Definitions of Variables in metadata) that list data set labels and give individual descriptions for each variable. The original literature source, EPA's 2006 WSA report (USEPA, 2006b; see Appendix A for full citation), provides an explanation of how wadeable streams were selected for this study and how data were collected from various sites.

*#462 Coastal Benthic Communities***

Literature Source (see Appendix A for full citation):
USEPA, 2008b.

Data Sets Used:
Underlying sampling data in USEPA's National Coastal Assessment (NCA) database.

How To Obtain Data:
Download online

URL to Data (if any):
http://www.epa.gov/emap/nca/html/data/index.html

Spatial Resolution:
Not clear (EPA's website states that there are "thousands" of sampling sites, but no specific number; data contains latitude/longitude specs.)

Temporal Resolution (period and frequency of collection):
1990-2002; no defined frequency (1 datum/site for only year listed)

Extent/Coverage of Data Set:
National

Type of Data Source:
Database

Format of Data:
Excel

Metadata:
- *Definition and calculation of benthic index.*
  USEPA. 2005. National Coastal Condition Report (NCCR). EPA-620/R-03/002. Available online at: http://www.epa.gov/owow/oceans/nccr/2005/index.html. Accessed July 21, 2009.

Additional Data Characteristics:
The coastal benthic communities index used in this indicator is based on multiple independent variables (described in EPA's NCCR in metadata). Data for these independent variables, (including total count of taxa, total abundance, mean abundance, mean biomass, total biomass, and diversity index) can be obtained from the underlying sampling data in EPA's NCA dataset.

#623 Water Availability: Net Stream Flow per Capita

Literature Source (see Appendix A for full citation):
Hurd et al.,1999.

Data Sets Used:
(a) Oregon State University - PRISM Climate Modeling System: Mean Annual Precipitation data
(b) Oregon State University - PRISM Climate Modeling System: Mean Daily Maximum Temperature data
(c) USGS - National Water-Use Dataset.

How To Obtain Data:
Download online

URL to Data (if any):
(a) http://www.prism.oregonstate.edu/products/matrix.phtml
(b) http://www.prism.oregonstate.edu/products/matrix.phtml
(c) http://water.usgs.gov/watuse/

Spatial Resolution:
(a) 30 arc-second (800 meters)
(b) 30 arc-second (800 meters)
(c) HUC-8 watershed

Temporal Resolution (period and frequency of collection):
(a) 1971 – 2000; monthly
(b) 1971 – 2000; monthly
(c) 1985 – 2000; every 5 years

Extent/Coverage of Data Set:
(a) National
(b) National
(c) National

Type of Data Source:
(a) Interpolated grid
(b) Interpolated grid
(c) Database

Format of Data:
ASCII

Metadata:
- *Calculation of streamflow.*
  Vogel, R.M., I. Wilson, and C. Daly. 1999. "Regional Regression Models of Annual Streamflow for the United States." *Journal of Irrigation and Drainage Engineering.* 125(3): 148-157.
- *Metadata for PRISM U.S. average monthly or annual precipitation data.*
  http://www.prism.oregonstate.edu/docs/meta/ppt_30s_meta.htm
- *Metadata for PRISM U.S. average monthly temperature data.*
  http://www.climatesource.com/us/fact_sheets/meta_tmin_us_71b.html

- *Description of water use parameters.*
  USGS. Estimated Use of Water in the United States. Available online at: http://water.usgs.gov/watuse/. Accessed December 15, 2010.

Additional Data Characteristics:
As described in the metadata for (b), mean annual temperature was calculated as the average of the mean maximum and mean minum temperature for a given location.

Appendix D. Technical Notes

The following appendix is a compilation of technical notes for the 32 vulnerability indicators for which data sources were readily available. The issues presented below may affect the interpretation of an indicator map (if the indicator was mappable) or may provide guidance for future mapping efforts (if the indicator was non-mappable or had an incomplete map). Data sources for these 32 indicators are presented in Appendix C.

One indicators (marked with *) had an incomplete map. Five indicators (marked with ** were non-mappable). The remaining 25 indicators were mapped. The mapping methodology for these 25 mappable indicators is presented in Appendix E, and maps for these indicators are presented in Appendix F (by HUC-4 watershed) and Appendix H (by ecoregion).

*#1 Acid Neutralizing Capacity (ANC)***

- *Non-uniform Spatial Distribution of Data:* The ANC sample point data are not distributed homogeneously, which results in dissimilar amounts of ANC data within a HUC-4 boundary. In cases where there are few sample points within a HUC-4 boundary, individual sites may have a large influence on the metric (percentage of "at risk" sites) that is calculated for the reporting unit.

#22 At-Risk Freshwater Plant Communities

- *State-level Data:* The map for this indicator is based on data calculated on a state-by-state basis. Transforming the data from a state-based representation to a HUC-4 representation requires an assumption that the distribution of at-risk plants is uniform within each state. This assumption allows for area-weighted percentages to be calculated for HUC-4 units that intersect more than one state. Although this is an accepted transformation method because the spatial extent of the HUC-4 units and the state boundaries are identical, the assumption of uniform distribution may result in errors in the metric calculated for each HUC-4 unit.

#24 At-Risk Native Freshwater Species

- *State-level Data.* The map for this indicator is based on data calculated on a state-by-state basis. Transforming the data from a state-based representation to a HUC-4 representation requires an assumption that the percentage of at-risk species is uniform within each state. This assumption allows for area-weighted percentages to be calculated for HUC-4 units that intersect more than one state. Although this is an accepted transformation method because the spatial extent of the HUC-4 units and the state boundaries are identical, the assumption of uniform distribution may result in errors in the metric calculated for each HUC-4 unit.

#51 Coastal Vulnerability Index (CVI)

- *Spatial Distribution of Data (special case: coastal indicator):* The spatial extent of the data for this indicator is for coastal and nearshore areas only. This is inherently disconnected from the HUC-4 boundaries, which extend inland and do not consistently include coastal and nearshore regions. This makes aggregation for the purposes of reporting at the HUC-4 scale problematic. To address this issue, a special reporting unit was developed for this indicator.

Each unit extends approximately 20 miles inland and includes approximately 150 miles of coastline.

- *Local Variation:* CVI values vary considerably at local scales. By averaging the CVI values within the special coastal reporting units, localized vulnerability is masked.

*#55 Commercially Important Fish Stocks***

- *Spatial Distribution of Data (special case: marine indicator):* This indicator does not provide vulnerability information for any land or nearshore areas. This is a marine indicator that only evaluates fish stocks located at least 3 miles from the coast and is inherently disconnected from the HUC-4 boundaries which extend inland. No other data source for commercially important fish stocks in inland waters or nearshore areas was identified.

- *Low-Resolution Data:* The data set for this indicator only provides three data values at a very coarse spatial scale: NE Atlantic, SE Atlantic, and Pacific. These three data points do not provide the variation necessary to assess vulnerability.

*#95 Fish and Bottom-Dwelling Animals***

- *Duplicate indicator.* Upon further analysis, this indicator was determined to be a duplicate of the indicator Macroinvertebrate Index of Biotic Condition (#460). Although these indicators were cited by two distinct literature sources (Heinz Center, 2008 and USEPA, 2006b respectively), their underlying data source i.e. EPA's Wadeable Streams Assessment is the same and the same calculation is involved in obtaining the value of the indicator.

#125 Groundwater Reliance

There are no technical notes for this indicator.

#165 Meteorological Drought Indices

There are no technical notes for this indicator.

*#190 Number of Dry Periods in Grassland/Shrubland Streams and Rivers**

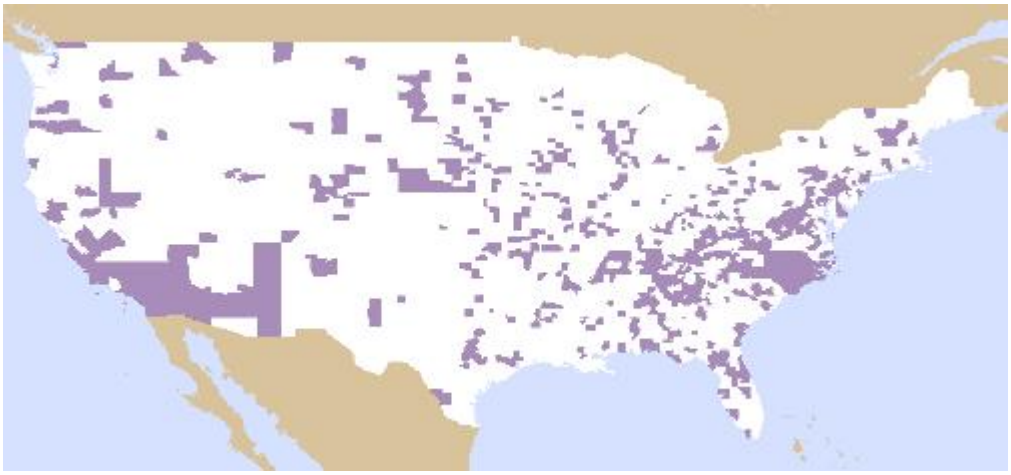
- *Data Gaps in National Coverage:* This indicator is based on a 2009 study by the H. John Heinz III Center for Science, Economics, and the Environment (Heinz Center) that evaluated the number of "zero-flow" periods in streams that flow through watersheds dominated by grassland and/or shrubland land cover types. The authors of the study delineated watersheds for USGS stream gages, calculated the land use within those watersheds, and then analyzed stream flow records for watersheds dominated by grassland and shrubland cover. They determined the average annual percent of streams in Western ecoregions that experienced dry periods during a rolling 5-year period. The Heinz Center did not conduct this analysis for Eastern ecoregions. Although the reasons for this are unclear, it is likely that this is because

few, if any, stream sites in Eastern ecoregions satisfied their definition of a "grassland" or "shrubland" stream.

- *Non-uniform Spatial Distribution of Data:* In the Western ecoregions, the number of grassland sites within each HUC-4 unit varies widely. In cases where there are few grassland sites within a HUC-4 boundary, individual sites may have a large influence on the average number of dry periods that is calculated for that areas. The resulting spatial heterogeneity may be a reflection of this sensitivity to data availability.

#209 Population Susceptible to Flood Risk**

- *Data Gaps in National Coverage:* This indicator evaluates the human population currently residing within the 500-year floodplain. This would be calculated by overlaying estimates of the 500-year floodplain from the Federal Emergency Management Agency (FEMA) with population data from the U.S. Census Bureau. According to FEMA's Map Service Center, GIS-compatible digital flood plain data are only available for certain parts of the country, as shown in the map below. Without the digital flood plain data, significant effort is required to create a national map for this indicator.



Availability of Digital Flood Insurance Rate Maps (DFIRMs). The Federal Emergency Management Agency provides GIS-compatible flood plain maps for all areas in purple. *Source: Federal Emergency Management Agency*

#218 Ratio of Snow to Total Precipitation

There are no technical notes for this indicator.

#219 Ratio of Withdrawals to Stream Flow

There are no technical notes for this indicator.

#284 Stream Habitat Quality

- *Non-uniform Spatial Distribution of Data:* The sampling effort for EPA's Wadeable Streams Assessment (WSA) varies across HUC-4 units. In cases where there are few sample points

within a HUC-4 boundary, individual sites may have a large influence on the average rapid assessment score that is calculated for that area. The map for this indicator shows a heterogeneous distribution of vulnerability, which may be a reflection of this sensitivity to sampling effort.

- *Local Variation:* Habitat quality varies at local scales and is affected by local factors. By calculating an average assessment score for each HUC-4 unit, localized vulnerability within the HUC-4 unit is masked.

*#322 Waterborne Human Disease Outbreaks***

- *Data Collection and Reporting Discontinued:* The most recent data from the Waterborne Disease and Outbreak Surveillance System (WBDOSS) appear to be from 2006. According to the Heinz Center (2008), data are no longer reported.

- *Quality of Source Data:* The WBDOSS relies on voluntary reporting from public health departments within the Unites States. The data collection methods used for the WBDOSS raise data quality concerns due to:

    - *Variable Resources for Reporting:* Some states, territories, or local public health departments may have more available resources for reporting WBDOs and may be more able or inclined to report such cases than other states. Therefore, a map of nationwide WBDOs reported may represent the distribution of actual outbreaks.

    - *Voluntary Data Reporting:* The Heinz Center (2008) study, which defined this indicator, states that inconsistencies in reporting or an altogether lack of reporting may occur as it is not mandatory for states, territories, and local public health departments to report WBDOs.

    - *Skewed Representation of Large vs. Small Public Water Supplies:* There may be under-reporting of WBDOs from public water supplies serving small communities and over-reporting due to larger outbreaks from larger PWSs as the latter is more likely to receive widespread attention from authorities and the media.

*#325 Wetland Loss***

- *Significant Data Processing Required:* National Wetlands Inventory (NWI) data can only be downloaded at the 7.5 minute (1:24K) or 15 minute (1:100K) scales. In the lower 48 states, the USGS has designated approximately 56,500 1:24K-scale quadrangles. It would require substantial effort to download data for each of these quadrangles and assemble them into a national dataset. It may be possible to acquire a national wetlands dataset from the U. S. Fish & Wildlife Service, although the FWS web site currently states that "Due to limited resources, custom wetland data extractions by the Wetlands Team are no longer available."

- *Data Gaps in National Coverage:* There are data gaps in the national coverage that would diminish the usefulness of this national map. According to the FWS, the wetlands in 13 states are either unmapped or are recorded on hardcopy maps only.

- *Inadequate Historical Data:* The indicator describes wetland loss, which suggests that a second data source must be used to calculate a change in the area of wetlands over time. A data source that delineates historical wetland extent at the national scale has not been identified.

#326 Number of Wetland Species at Risk

- *State-level Data:* The map for this indicator is based on data calculated on a state-by-state basis. Transforming the data from a state-based representation to a HUC-4 representation requires an assumption that the distribution of at-risk species is uniform within each state. This assumption allows for area-weighted totals to be calculated for HUC-4 units that intersect more than one state. Although this is an accepted transformation method because the spatial extent of the HUC-4 units and the state boundaries are identical, the assumption of uniform distribution may result in errors in the metric calculated for each HUC-4 unit.

#348 Erosion Rate

- *Limited Temporal Resolution of Source Data:* The source data for this map are based on land cover patterns in 1980. Changes in land cover since then may affect the spatial distribution of soil erosion.

#351 In-stream Use / Total Streamflow

- *Missing Data for Input Variables:* Estimates of runoff (streamflow) and groundwater overdraft (the amount of groundwater withdrawals that exceeds the long-term average annual recharge rate) are used to calculate this indicator. For some regions, groundwater recharge estimates were not available from the original source based on 1975 data. In these areas, withdrawal (as measured in 1975) was assumed to equal recharge. These recharge estimates were then compared to 1995 groundwater withdrawals to calculate updated estimates of groundwater overdraft.

- *Low-Resolution Data:* Estimates of groundwater recharge were developed at the 2-digit HUC scale and applied evenly to all sub-regions (4-digit HUCs) within the region.

#352 Total Use / Total Streamflow

- *Missing Data for Input Variables:* Estimates of runoff (streamflow) and groundwater overdraft (the amount of groundwater withdrawals that exceeds the long-term average annual recharge rate) are used to calculate this indicator. For some regions, groundwater recharge estimates were not available from the original source based on 1975 data. In these areas, withdrawal (as measured in 1975) was assumed to equal recharge. These recharge estimates

were then compared to 1995 groundwater withdrawals to calculate updated estimates of groundwater overdraft. In addition, this indicator assesses water consumption as a component of total use. The consumptive use data from USGS does not distinguish between water consumed from groundwater and surface water sources, and it is unclear in the original data source whether this distinction is relevant. Additional investigation into the role of consumptive use in this indicator and the original source of water consumed is recommended.

- *Low-Resolution Data:* Estimates of groundwater recharge were developed at the 2-digit HUC scale and applied evenly to all sub-regions (4-digit HUCs) within the region.

#364 Pesticide Toxicity Index (PTI)

- *Non-uniform Spatial Distribution of Data:* The sampling effort for the USGS National Water Quality Assessment (NAWQA) Program varies across HUC-4 units. In cases where there are few sample points within a HUC-4 boundary, individual sites may have a large influence on the average pesticide concentration that is calculated for that area. The map for this indicator shows a heterogeneous distribution of vulnerability, which may be a reflection of this sensitivity to sampling effort. In addition, there are numerous HUC-4 units where no data are available.

- *Local Variation:* Pesticide concentrations in streams vary at local scales and are affected by local factors. By calculating an average concentration for each HUC-4 unit, localized vulnerability within the HUC-4 unit is masked.

- *Relative Rather than Absolute Toxicity:* The Pesticide Toxicity Index (PTI) accounts for multiple pesticides in a sample, including pesticides without established benchmarks for aquatic life. The PTI combines information on exposure of aquatic biota to pesticides (measured concentrations of pesticides in stream water) with toxicity estimates (results from laboratory toxicity studies) to produce a relative index value for a sample or stream. The PTI value is computed for each sample of stream water by summing the toxicity quotients for all pesticides detected in the sample. The toxicity quotient is the measured concentration of a pesticide divided by its toxicity concentration from bioassays (such as an LC50 or EC50). This approach follows the Concentration Addition Model of toxicity. Although simple addition is unlikely to strictly apply for complex mixtures of pesticides from different classes and with different effects and modes of action, the PTI is still useful as a relative index. While the PTI does not indicate whether water in a sample is toxic, its value can be used to rank or compare the relative potential toxicity of different samples or different streams.

#367 Herbicide concentrations in streams

- *Non-uniform Spatial Distribution of Data:* The sampling effort for the USGS National Water Quality Assessment (NAWQA) Program varies across HUC-4 units. In cases where there are few sample points within a HUC-4 boundary, individual sites may have a large influence on the average herbicide concentration that is calculated for that area. The map for this indicator shows a heterogeneous distribution of vulnerability, which may be a reflection of

this sensitivity to sampling effort. In addition, there are numerous HUC-4 units where no data are available.

- *Local Variation:* Herbicide concentrations in streams vary at local scales and are affected by local factors. By calculating an average concentration for each HUC-4 unit, localized vulnerability within the HUC-4 unit is masked.

#369 Insecticide concentrations in streams

- *Non-uniform Spatial Distribution of Data:* The sampling effort for the USGS National Water Quality Assessment (NAWQA) Program varies across HUC-4 units. In cases where there are few sample points within a HUC-4 boundary, individual sites may have a large influence on the average insecticide concentration that is calculated for that area. The map for this indicator shows a heterogeneous distribution of vulnerability, which may be a reflection of this sensitivity to sampling effort. In addition, there are numerous HUC-4 units where no data are available.

- *Local Variation:* Insecticide concentrations vary at local scales and are affected by local factors. By calculating an average concentration for each HUC-4 unit, localized vulnerability within the HUC-4 unit is masked.

#371 Organochlorines in Bed Sediment

- *Non-uniform Spatial Distribution of Data:* The sampling effort for the USGS National Water Quality Assessment (NAWQA) Program varies across HUC-4 units. In cases where there are few sample points within a HUC-4 boundary, individual sites may have a large influence on the average concentration that is calculated for that area. The map for this indicator shows a heterogeneous distribution of vulnerability, which may be a reflection of this sensitivity to sampling effort. In addition, there are numerous HUC-4 units where no data are available.

- *Local Variation:* Organochlorine concentrations vary at local scales and are affected by local factors. By calculating an average concentration for each HUC-4 unit, localized vulnerability within the HUC-4 unit is masked.

#373 Herbicides in Groundwater

- *Non-uniform Spatial Distribution of Data:* The sampling effort for the USGS National Water Quality Assessment (NAWQA) Program varies across HUC-4 units. In cases where there are few sample points within a HUC-4 boundary, individual sites may have a large influence on the average concentration that is calculated for that area. The map for this indicator shows a heterogeneous distribution of vulnerability, which may be a reflection of this sensitivity to sampling effort. In addition, there are numerous HUC-4 units where no data are available.

- *Local Variation:* Herbicide concentrations vary at local scales and are affected by local factors. By calculating an average concentration for each HUC-4 unit, localized vulnerability within the HUC-4 unit is masked.

#374 Insecticides in Groundwater

- *Non-uniform Spatial Distribution of Data:* The sampling effort for EPA's Wadeable Streams Assessment (WSA) varies across HUC-4 units. In cases where there are few sample points within a HUC-4 boundary, individual sites may have a large influence on the average concentration that is calculated for that area. The map for this indicator shows a heterogeneous distribution of vulnerability, which may be a reflection of this sensitivity to sampling effort. In addition, there are numerous HUC-4 units where no data are available.
- *Local Variation:* Insecticide concentrations vary at local scales and are affected by local factors. By calculating an average concentration for each HUC-4 unit, localized vulnerability within the HUC-4 unit is masked.

#437 Precipitation Elasticity of Streamflow

- *Map Derived from Figure in Source Literature:* The original data used to calculate this indicator were not available and suitable alternatives would require significant effort to assemble. Therefore, the map for this indicator was derived from isopleths that are presented in the source literature (Figure 4 in Sankarasubramanian et al. 2001). The original map was based on data collected from 1951-1988. Streamflow and precipitation data available from the U.S. Geological Survey and Oregon State University's PRISM Group, respectively, could be used to reproduce an updated version of this map.

#449 Ratio of Storage to Runoff

- *Quality of Source Data:* This indicator uses the National Inventory of Dams to evaluate reservoir storage. This database contains a wide variety of water control structures, some of which may not be relevant for this indicator. An effort to remove irrelevant water control structures (e.g. coastal flood gates, navigational locks) was made, although the accuracy of the dam record attributes used to apply these filters is unclear.

#453 Runoff Variability

- *Low-Resolution Data:* This indicator uses simulations of the global land surface hydrological cycle from the Variable Infiltration Capacity (VIC) Model to predict runoff. The native spatial resolution of the model output is a 2° x 2° grid and the model output is stored in NetCDF format. A more recent series of VIC model predictions at a finer spatial resolution may be available from the same source, but the NetCDF file available online appears to be corrupt.

#460 Macroinvertebrate Index of Biotic Condition

- *Non-uniform Spatial Distribution of Data:* The sampling effort for EPA's Wadeable Streams Assessment (WSA) varies across HUC-4 units. In cases where there are few sample points within a HUC-4 boundary, individual sites may have a large influence on the average Macroinvertebrate Index of Biotic Condition value that is calculated for that area. The map for this indicator shows a heterogeneous distribution of vulnerability, which may be a reflection of this sensitivity to sampling effort.

- *Local Variation:* Macroinvertebrate community condition varies at local scales and is affected by local factors. By calculating an average value for the Macroinvertebrate Index of Biotic Condition for each HUC-4 unit, localized vulnerability within the HUC-4 unit is masked.

#461 Macroinvertebrate Observed / Expected (O/E) Ratio of Taxa Loss

- *Non-uniform Spatial Distribution of Data:* The sampling effort for EPA's Wadeable Streams Assessment (WSA) varies across HUC-4 units. In cases where there are few sample points within a HUC-4 boundary, individual sites may have a large influence on the average Macroinvertebrate O/E value that is calculated for that area. The map for this indicator shows a heterogeneous distribution of vulnerability, which may be a reflection of this sensitivity to sampling effort.

- *Local Variation:* Macroinvertebrate community condition varies at local scales and is affected by local factors. By calculating an average value for the Macroinvertebrate O/E Ratio, localized vulnerability is masked.

*#462 Coastal Benthic Communities***

- *Inconsistencies in Reporting Data:* Data provided on the National Coastal Assessment (NCA) web site were collected by multiple agencies. The methods used to calculate an index to describe the status of benthic communities vary between agencies. These differences make comparisons between states and regions problematic.

- *Data Gaps in National Coverage:* Data are not currently available for many of the nation's coastal areas.

#623 Water Availability: Net Streamflow per Capita

There are no technical notes for this indicator.

Appendix E. Mapping Methodology

This appendix provides details of the procedures used for mapping each of 26 indicators (including the indicator marked with a * that had an incomplete map.) Maps were created using ArcMap 9.2. Prior to mapping, data were prepared (including aggregation to the appropriate scale, when necessary) using Microsoft Excel or Microsoft Access.

Data sources listed in this appendix are described in greater detail in Appendix C. Technical issues related to creating or interpreting maps for these indicators are described in Appendix D. Maps of the 25 indicators are presented in Appendix F (by HUC-4 watershed).

#1 Acid Neutralizing Capacity (ANC)

Data Sources (see Appendix C for more details):

- Stream Water Chemistry (Filename: waterchemistry.csv): EPA Wadeable Streams Assessment. Available online at: http://www.epa.gov/owow/streamsurvey/web_data.html
- Stream Site Info: EPA Wadeable Streams Assessment (Filename: wsa_siteinfo_ts_final.csv). Available online at: http://www.epa.gov/owow/streamsurvey/web_data.html
- Hydrologic Units - http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) Water chemistry data were downloaded and opened as a comma-delimited text file in Microsoft Excel. The columns containing "SiteID" and "ANC" were saved as a new .dbf file.
(2) The .dbf file with water chemistry data, the hydrologic units, and Site Info were opened in ArcMap 9.2. The water chemistry table was joined to the Site Info table using the SiteID field.
(3) An event theme was mapped for all sites with corresponding water chemistry data, using the LON_DD and LAT_DD fields (North American Datum of 1983).This event theme was exported as a shapefile.
(4) The "AtRisk" field was added to the exported shapefile. If the value in the "ANC" field was < 100, then the AtRisk field value was calculated as 1. All other records were assigned a value of 0.
(5) The sites were aggregated with the 4-digit HUCs using a spatial join. If a HUC contained more than one site, the total (sum) for the numeric fields was calculated. As a result of the spatial join, a new shapefile was created. The "Pct_AtRisk" field was added to the new shapefile, and field values were calculated by using:

$$\text{Percent at Risk} = \frac{\text{At Risk Sites within HUC}}{\text{Total Sites within HUC}}$$

(6) Data were mapped using the Pct_AtRisk field to indicate low, medium, and high vulnerability categories.

#22 Percent of At-Risk Freshwater Plant Communities

Data Sources (see Appendix C for more details):

- Freshwater Plants Status: The H. John Heinz III Center for Science, Economics, and the Environment (Heinz Center). 2009. Email message to Cadmus. April 17, 2009. (Filename: G1-G5 wetlands by state.xls).
- State Boundaries: Environmental Systems Research Institute (ESRI) Data & Maps. – Projected to Albers map projection)
- Hydrologic Units - http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) The Microsoft Excel spreadsheet containing the percentages of at-risk plants was opened in ArcMap. These percentages were reported by state.
(2) State boundaries and hydrologic units were also opened in ArcMap.
(3) The percentages were joined to the state boundaries shapefile using a table join and the State Name attribute. The resulting shapefile was intersected with the 4-digit hydrologic units.
(4) Using the area of each hydrologic unit, the area of the intersected shapes, and the percentage of at-risk plant species, an area-weighted percentage value was calculated for each intersected area.
(5) The shapefile was dissolved by the 4-digit HUC code to re-aggregate the 4-digit HUCs. The area-weighted percentages were summed.
(6) The final map was created using the summed area-weighted percentages in the HUC4_AtRiskFWPlants.shp shapefile to indicate low, medium, and high vulnerability categories.

#24 Percent of At-Risk Freshwater Species

Data Sources (see Appendix C for more details):

- Freshwater Species Status: The H. John Heinz III Center for Science, Economics, and the Environment (Heinz Center). 2009. Email message to Cadmus. April 17, 2009. (Filename: AtRiskFWanimalSPby state.xls)
- State Boundaries: Environmental Systems Research Institute (ESRI) Data & Maps. – Projected to Albers map projection)
- Hydrologic Units - http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) The Microsoft Excel spreadsheet containing the percentages of at-risk species was opened in ArcMap. These percentages were reported by state.
(2) State boundaries and hydrologic units were also opened in ArcMap.
(3) The percentages were joined to the state boundaries shapefile using a table join and the State Name attribute. The resulting shapefile was intersected with the 4-digit hydrologic units.
(4) Using the area of each hydrologic unit, the area of the intersected shapes, and the percentage of at-risk species, an area-weighted percentage value was calculated for each intersected area.

(5) The shapefile was dissolved by the 4-digit HUC code to reaggregate the 4-digit HUCs. The area-weighted percentages were summed.
(6) The final map was created using the summed area-weighted percentages in the HUC4_AtRiskFWSpecies.shp shapefile to indicate low, medium, and high vulnerability categories.

#51 Coastal Vulnerability Index

Data Sources (see Appendix C for more details):

- USGS - A Preliminary Database for the U.S. Atlantic, Pacific and Gulf of Mexico Coasts (U.S. Geological Survey Digital Data Series – 68; Three data sets: Gulf Coast, East Coast, and West Coast).) Available online at: http://pubs.usgs.gov/dds/dds68/htmldocs/data.htm

Processing Steps:

(1) ArcGIS shapefiles, containing attributes for the raw CVI variables, CVI, and risk categories associated with CVI values, were opened in ArcMap 9.2.
(2) The Coastal Vulnerability Index (CVI) uses 6 variables, which appear as attributes in the shapefiles:
   - Mean Wave Height - - mean elevation of all nonnegative 5' by 5' grid cells within a given 0.25˚ grid cell; values in meters. WIS hindcast nearshore mean wave height 1976-1995.
   - Mean Tide Range - average of the mean tide range for all the gauge stations that occur within a given 0.25˚ grid cell (mean tide range is the difference in height between mean high water and mean low water in 1988); values in meters.
   - Regional Coastal Slope (%) – Acquired from ETOPO5 and NGDC elevation data.
   - Erosion and Accretion rates (m/yr) - the local subsidence trend.
   - Relative Sea-Level Rise (mm/yr) – Acquired from NOS tide stations.
   - Geomorphology Risk - ordinal value indicative of the type and susceptibility of the landforms within a given 0.25˚ grid cell to inundation and erosion.
(3) The values for each variables are grouped into risk categories, and these risk categories are used to calculate the CVI value using the following formula:

$$CVI = (a*b*c*d*e*f*g)/6] \wedge ½$$

The calculated CVI values are then grouped into risk categories (4 = very high risk, 3 = high risk, 2 = medium risk, 1 = low risk).
(4) Hydrologic units are not a suitable reporting unit for this indicator, so a new coastal unit was produced by creating a 20 mile inland buffer of the shoreline. The buffer was divided into 150-mile long segments to show variation along the coast.
(5) The vertices within the linear geometry of each shapefile feature were converted to points. Each point inherited the attributes, including the CVI risk categories (4 = very high risk, 3 = high risk, 2 = medium risk, 1 = low risk), of the original linear feature. All points within the new coastal units were averaged using a spatial join.
(6) The final map of coastal units was created using the average CVI risk values to indicate low, medium, and high vulnerability categories.

#125 Groundwater Reliance

Data Sources (see Appendix C for more details):

- United States Geological Survey (USGS). Water Usage, 1995 http://water.usgs.gov/watuse/spread95/ush895.txt
- Hydrologic Units - http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) Data from USGS were downloaded and imported into ArcMap 9.2.
(2) The water usage data table was joined to the attribute table for the hydrologic units shapefile, using the "HUC_CODE" and "HUC8Code" fields.
(3) The 8-digit HUC regions were aggregated into 4-digit HUCs with the 'dissolve' function in ArcMap. The "SUB" attribute was used as the basis for the dissolve process. During the dissolve operation, summary statistics were calculated for Total Groundwater Withdrawals (TO_WGWTo) and Total Withdrawals (TO_WTotl) attributes.
(4) After the 4-digit HUC shapefile was produced with the dissolve operation, a new field for Groundwater Reliance (GWRel_95) was added to store groundwater reliance values.
(5) Next, the indicator values were calculated using:

$$\text{Groundwater Reliance (GWRel_95)} = \frac{\text{Total Groundwater Withdrawals (TO_WGWTo)}}{\text{Total Withdrawals (TO_WTotl)}}$$

(6) Finally, the Groundwater Reliance data were displayed on the map with symbology to indicate low, medium, and high vulnerability categories.

#165 Meteorological Drought Indices

Data Sources (see Appendix C for more details):

- Palmer Drought Severity Index: National Climatic Data Center. Available online at: http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp#
- NCDC Climate Division Boundaries. Available online at: ftp://ftp.ncdc.noaa.gov/pub/data/divboundaries/gis/
- Hydrologic Units - http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) The drought index data were downloaded for the climate divisions within each of the continental U.S. states as comma-delimited text for the years 2003-2007. The data for each state were imported into a Microsoft Access database and compiled into a single table.
(2) A select query was used to compute average Palmer Drought Severity Index values for each climate division over the 2003-2007 time period using values in the PDSI column. The query results were exported as a .dbf.
(3) The NCDC Climate Division Boundaries shapefile was opened in ArcMap 9.2, along with the hydrologic units and the .dbf containing drought severity values.
(4) The DIVISION_ID attribute was used to join the climate boundaries to the drought index data.
(5) The joined shapefile was intersected with the hydrologic units.

(6) Using the area of the original climate boundaries, the area of the intersected shapes, and the PDSI values, an area-weighted Palmer Drought Severity Index value was calculated for each intersected area.
(7) The shapefile was dissolved by the 4-digit HUC code to reaggregate the 4-digit HUCs. The area-weighted percentages were summed during the 'dissolve' operation.
(8) The final map was created using summed area-weighted percentages in the dissolved shapefile to indicate low, medium, and high vulnerability categories.

*#190 Number of Dry Periods in Grassland/Shrubland Streams and Rivers**

Data Sources (see Appendix C for more details):

- Grassland Stream Sites and Flow Data, 2002-2006: The H. John Heinz III Center for Science, Economics, and the Environment (Heinz Center). 2009. Email message to Cadmus. April 28, 2009. (Filename: GSdry periods_Cadmus.xls).
- Hydrologic Units - http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) The Microsoft Excel spreadsheet containing site and zero-flow data from the Heinz Center was opened in ArcMap, along with the hydrologic units, and Site data.
(2) Grassland sites within the zero-flow table were joined to the site information table using the Site Number field.
(3) An event theme was created for the joined records, using the LON_DD and LAT_DD fields (North American Datum 1983). The event theme was exported as a shapefile.
(4) The sites were aggregated within the 4-digit HUCs using a spatial join. If a HUC contained more than one site, the numeric attributes within the site data were summarized with the "SUM" option. As a result of the spatial join, a new shapefile was created (Ind190_HUC4_Sites.shp).
(5) To determine the average annual percentage of streams with zero-flow period, the proportion of streams with zero flow within each 4-digit HUC was computed for each year, and then the mean of five years (2002-2006) was computed for each HUC.
(6) The final map was created using the Mean_Pct attribute to indicate low, medium, and high vulnerability categories. In 4-digit HUCs where no site data were available, the HUC was assigned to a 'No Data' category.

#218 Ratio of Snow to Total Precipitation

Data Sources (see Appendix C for more details):

- Monthly Climate Data and Observation Station Locations from National Climatic Data Center. Available online at: http://gis.ncdc.noaa.gov/snowfallmo/ (The web site provides access to multiple parameters, including snowfall totals. Data can be downloaded for free from .edu and .gov domains.)
- Hydrologic Units - http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) Climate data for all U.S. observation stations were downloaded and imported into Microsoft Access. (Data were downloaded in two batches due to NCDC file size limits).
(2) The ratio of average annual snowfall (Element Code = 'TSNW') to average annual precipitation (Element Code = 'TPCP') was calculated using a series of queries that summed the monthly snow and precipitation totals for each year, calculated an annual ratio, then averaged the annual ratios across the 1998-2007 time period. The output of the queries was saved as a .dbf and imported into ArcMap 9.2.
(3) Observation station site data were also downloaded and opened as a fixed-width file in Excel. Within this file, latitude and longitude coordinates for the observation stations were in the format of Degrees: Minutes. These values were converted in Microsoft Excel to Decimal Degrees using the formula:

$$\text{Decimal Degrees} = \text{Degrees} + (\text{Minutes}/60)$$

(4) An event theme was created in ArcMap for the Observation Stations using the adjusted Lat/Long coordinates. This theme was joined to the .dbf containing heat sensitivity data using the "COOPID" attribute. Not all Observation Stations had corresponding heat sensitivity data; sites with heat sensitivity data were exported to shapefile and mapped.
(5) The stations (points) were aggregated within each 4-digit HUC (polygon) using a spatial join. If a HUC contained more than one site, the average value across sites was calculated.
(6) The final map was produced using the Avg_RATIO field to indicate low, medium, and high vulnerability categories.

#219 Ratio of Withdrawals to Stream Flow

Data Sources (see Appendix C for more details):

- Mean Annual Precipitation 1971-2000: PRISM Climate Group (Oregon State University). Available online at: http://www.prism.oregonstate.edu/products/matrix.phtml
- Mean Daily Maximum Temperature 1971-2000: PRISM Climate Group (Oregon State University). Available online at: http://www.prism.oregonstate.edu/products/matrix.phtml
- United States Geological Survey (USGS). Water Usage, 1995 http://water.usgs.gov/watuse/spread95/ush895.txt
- Hydrologic Units - http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) PRISM data were downloaded and converted to ESRI© GRID format using the ASCII Text to Grid tool in ArcMap 9.2.
(2) Mean daily temperature was calculated with the raster calculator using the following formula as described by Vogel, 1999: (Max Temp + Min Temp) / 2.
(3) Mean precipitation and mean daily temperature within each 4-digit HUC were calculated using the Zonal Statistics function.

(4) A new attribute for mean annual streamflow was calculated with the field calculator in ArcMap for each HUC-4 unit using the regression equations in Vogel, 1999 (Table 2). The HUC-2 code was used to associate each HUC-4 with the appropriate regional regression equation.
(5) The water usage data table was joined to the attribute table for the hydrologic units shapefile, using the "HUC_CODE" and "HUC8Code" fields.
(6) The 8-digit HUC regions were aggregated into 4-digit HUCs with the 'dissolve' function in ArcMap. The "SUB" attribute was used as the basis for the dissolve process. During the dissolve operation, summary statistics were calculated for Total Withdrawals.
(7) Streamflow and withdrawals were adjusted for some HUC-4 units to account for withdrawals and streamflow that occur upstream.
(8) A new attribute for the ratio of withdrawals to streamflow was calculated with the field calculator. The units for streamflow and withdrawals were converted as needed.
(9) The final map was produced indicating low, medium, and high vulnerability categories.

#284 Stream Habitat Quality

Data Sources (see Appendix C for more details):

- Stream Rapid Assessment Metrics: EPA Wadeable Streams Assessment. (Filename: rapidhabmetrics.csv). Available online at: http://www.epa.gov/owow/streamsurvey/web_data.html
- Stream Site Info: EPA Wadeable Streams Assessment. (Filename: wsa_siteinfo_ts_final.csv). Available online at: http://www.epa.gov/owow/streamsurvey/web_data.html
- Hydrologic Units - http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) The rapid assessment data were downloaded and opened as a comma-delimited text file in ArcMap, along with the stream site data, and the hydrologic units.
(2) This Rapid Assessment and Site Info tables were joined using the SiteID field.
(3) An event theme was mapped for the joined records, using the LON_DD and LAT_DD fields (North American Datum 1983). Only sites with corresponding Rapid Assessment scores were mapped. This event theme was exported to shapefile.
(4) The sites were aggregated within the 4-digit HUCs using a spatial join. If a HUC contained more than one site, the average value for the Rapid Assessment score (RH_SUM) was calculated. As a result of the spatial join, a new shapefile was created (HUC4_RapidAssessment.shp).
(5) The final map was created using the Avg_RH_SUM field to indicate low, medium, and high vulnerability categories. In 4-digit HUCs where no sampling occurred, the HUC was assigned a 'No Data' category.

#348 Erosion Rate

Data Sources (see Appendix C for more details):

- Revised Universal Soil Loss Equation (RUSLE): RUSLE_1980.asc grid file of soil erosion rates estimated for entire globe at 0.5 deg resolution with the RUSLE. Data were obtained from: Dawen YANG, PhD, Professor, Department of Hydraulic Engineering Tsinghua University, Beijing 100084, China; Tel: +86-10-62796976; Fax: +86-10-62796971; E-mail: yangdw@tsinghua.edu.cn
- State Boundaries: Environmental Systems Research Institute (ESRI) Data & Maps. – Projected to Albers map projection)
- Hydrologic Units - http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) The ASCII file containing RUSLE data was converted to raster grid using ASCII to Raster tool in ArcMap.
(2) Using the raster calculator, the grid values were multiplied by 1,000,000 to facilitate conversion to polygons. The raster type was changed to integer.
(3) The raster was converted to a polygon layer using the Raster to Polygon tool in ArcMap.
(4) A new field called RUSLE = grid/1,000,000 was created in the polygon layer.
(5) The Intersect tool was used to combine the HUC4 layer with the RUSLE polygon layer to create a new layer called HUC4_RUSLE_Intersect.
(6) A new field called AREAXRUSLE = AREA · RUSLE was created.
(7) Summarized HUC4_RUSLE_Intersect layer on the HUC ID field (SUB), and calculating the sum of AREAXRUSLE
(8) The summarized data table was joined to the HUC4 polygon layer and exported as a new layer called HUC4_RUSLE.
(9) In HUC4_RUSLE, a new field RUSLE = AREAXRUSLE / AREA was created.
(10) The final map was created using the "RUSLE" attribute in the HUC4_RUSLE.shp shapefile to indicate low, medium, and high vulnerability categories.

#351 In-Stream Use / Total Streamflow

Data Sources (see Appendix C for more details):

- United States Geological Survey (USGS). Water Usage, 1995 http://water.usgs.gov/watuse/spread95/ush895.txt
- Hydrologic Units - http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml
- Mean Annual Runoff: U.S. Geological Survey. Available online at: http://water.usgs.gov/GIS/metadata/usgswrd/XML/runoff.xml
- Groundwater Recharge - WRC (U.S. Water Resources Council), 1978. The Nation's Water Resources: 1975-2000 (Vol. 2). U.S. Government Printing Office, Washington D.C.

Processing Steps:

(1) The water usage data table was joined to the attribute table for the hydrologic units shapefile, using the "HUC_CODE" and "HUC8Code" fields.
(2) The 8-digit HUC regions were aggregated into 4-digit HUCs with the 'dissolve' function in ArcMap. The "SUB" attribute was used as the basis for the dissolve process. During

the dissolve operation, summary statistics were calculated for the Total Groundwater Withdrawals attribute.

(3) After the 4-digit HUC shapefile was produced with the dissolve operation, surface water withdrawal values were converted from megagallons per day to gallons per year.

(4) The isopleths in the mean annual runoff dataset were opened in ArcMap. The Spatial Analyst extension was used to interpolate continuous runoff values across the country.

(5) Mean runoff values within each 4-digit HUC were calculated using the Zonal Statistics function.

(6) An attribute for groundwater recharge rates was added and groundwater overdraft values were calculated based on the definition in the WRC (1978) report: (Groundwater Recharge – Groundwater Withdrawals)

(7) An attribute for in-stream use was added and calculated based on the definition in the WRC (1978) report: (Streamflow * 0.6)

(8) Indicator values were calculated using the formula described in WRC (1978). Streamflow is assumed to be equal to runoff:

In-stream use / (Streamflow – Groundwater overdraft)

(9) Finally, the indicator values were displayed on the map with symbology to indicate low, medium, and high vulnerability categories.

#352 Total Use / Total Streamflow

Data Sources (see Appendix C for more details):

- United States Geological Survey (USGS). Water Usage, 1995 http://water.usgs.gov/watuse/spread95/ush895.txt
- Hydrologic Units - http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml
- Mean Annual Runoff: U.S. Geological Survey. Available online at: http://water.usgs.gov/GIS/metadata/usgswrd/XML/runoff.xml
- Groundwater Recharge - WRC (U.S. Water Resources Council), 1978. The Nation's Water Resources: 1975-2000 (Vol. 2). U.S. Government Printing Office, Washington D.C.

Processing Steps:

(1) The water usage data table was joined to the attribute table for the hydrologic units shapefile, using the "HUC_CODE" and "HUC8Code" fields.

(2) The 8-digit HUC regions were aggregated into 4-digit HUCs with the 'dissolve' function in ArcMap. The "SUB" attribute was used as the basis for the dissolve process. During the dissolve operation, summary statistics were calculated for the Total Consumptive Use and Total Groundwater Withdrawals attributes.

(3) After the 4-digit HUC shapefile was produced with the dissolve operation, surface water withdrawal values were converted from megagallons per day to gallons per year.

(4) The isopleths in the mean annual runoff dataset were opened in ArcMap. The Spatial Analyst extension was used to interpolate continuous runoff values across the country.

(5) Mean runoff values within each 4-digit HUC were calculated using the Zonal Statistics function.

(6) An attribute for groundwater recharge rates was added and groundwater overdraft values were calculated based on the definition in the WRC (1978) report: (Groundwater Recharge – Groundwater Withdrawals)
(7) An attribute for in-stream use was added and calculated based on the definition in the WRC (1978) report: (Streamflow * 0.6)
(8) Indicator values were calculated using the formula described in WRC (1978). Streamflow is assumed to be equal to runoff:
(In-stream use + Total Consumptive Use) / (Streamflow – Groundwater overdraft)
(9) Finally, the indicator values were displayed on the map with symbology to indicate low, medium, and high vulnerability categories.

#364 Pesticide Toxicity Index (PTI)

Data Sources (see Appendix C for more details):

- Pesticide (herbicides and insecticide) Concentrations: USGS NAWQA Program. "The Quality of Our Nation's Waters Pesticides in the Nation's Streams and Ground Water, 1992-2001" (USGS Circular 1291). Available online at: http://water.usgs.gov/nawqa/pnsp/pubs/circ1291/appendix6/appendix6a.txt
- USEPA. 2009. ECOTOX Database. Available online at: http://cfpub.epa.gov/ecotox/. Accessed September 11, 2009.
- NAWQA Sites: USGS. NAWQA Data Warehouse: SiteFile Master. shttp://infotrek.er.usgs.gov/nawqa_queries/sitemaster/index.jsp
- Hydrologic Units: http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) EC50 values for all *Daphnia* species for pesticides measured by NAWQA were downloaded from EPA's ECOTOX database. For each pesticide, the mean *Daphnia* EC50 value was calculated.
(2) Pesticide concentration data were downloaded and imported into Microsoft Excel.
(3) In Excel, the concentration of each pesticide at each sample event was divided by its mean Daphnia EC50 value to calculate its toxicity quotient.
(4) The toxicity quotients for all pesticides were summed for each sampling event to calculate that event's PTI. The toxicity quotients for constituents that were not measured or were below detection levels were assumed to be zero.
(5) The PTIs for all sampling events at each site were summed to calculate a site PTI. This table was imported into ArcMap.
(6) The PTI table was joined to the NAWQA Sites using the "STAID" attribute. In some cases, the STAID value required minor edits to correctly join the tables. A total of 187 sites with pesticide concentration data were successfully joined to the NAWQA spatial data.
(7) NAWQA spatial data were displayed as an event theme, using the Latitude and Longitude variables (North American Datum of 1983).
(8) Next, the hydrologic units (4-digit HUCs) were added to the ArcMap project and joined using a spatial join to the NAWQA points. If more than one site with pesticide data was located within a 4-digit HUC, the PTI values were averaged across sites. In some cases, there were no sites with pesticide data within a 4-digit HUC.

(9) The final map was created using symbology to indicate low, medium, and high vulnerability categories for each 4-digit HUC. In 4-digit HUCs where no sampling occurred, the HUC was assigned a 'No Data' category.

Note: Pesticide concentrations in agricultural areas, urban areas, and mixed land use areas were combined for this indicator, although the USGS reports these land use types separately.

#367 Herbicide Concentrations in Streams

Data Sources (see Appendix C for more details):

- Herbicide Concentrations: USGS NAWQA Program. "The Quality of Our Nation's Waters Pesticides in the Nation's Streams and Ground Water, 1992-2001" (USGS Circular 1291). Available online at: http://water.usgs.gov/nawqa/pnsp/pubs/circ1291/appendix6/appendix6a.txt
- NAWQA Sites: USGS. NAWQA Data Warehouse: SiteFile Master. shttp://infotrek.er.usgs.gov/nawqa_queries/sitemaster/index.jsp
- Hydrologic Units: http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) Herbicide data were downloaded and imported into Microsoft Excel.
(2) In Excel, measured values for herbicides, herbicide degradates, and fungicides were identified and summed for each sampling event. Constituents that were not measured or were below detection levels were assumed to be zero.
(3) The herbicide concentration table was imported into ArcMap. For each sampling site, the average of these total concentrations was calculated for all sampling events that occurred at that site using the "Summarize" function.
(4) The summarized herbicide table and was joined to the NAWQA Sites using the "STAID" attribute. In some cases, the STAID value required minor edits to correctly join the tables. A total of 182 sites with herbicide concentration data were successfully joined to the NAWQA spatial data.
(5) NAWQA spatial data were displayed as an event theme, using the Latitude and Longitude variables (North American Datum of 1983).
(6) Next, the hydrologic units (4-digit HUCs) were added to the ArcMap project and joined using a spatial join to the NAWQA points. If more than one site with herbicide data was located within a 4-digitt HUC, the concentration values were averaged across sites. In some cases, there were no sites with herbicide data within a 4-digit HUC.
(7) The final map was created using symbology to indicate low, medium, and high vulnerability categories for each 4-digit HUC. In 4-digit HUCs where no sampling occurred, the HUC was assigned a 'No Data' category.

Note: Herbicide concentrations in agricultural areas, urban areas, and mixed land use areas were combined for this indicator, although the USGS reports these land use types separately.

#369 Insecticide Concentrations in Streams

Data Sources (see Appendix C for more details):

- Insecticide Concentrations: USGS NAWQA Program. "The Quality of Our Nation's Waters Pesticides in the Nation's Streams and Ground Water, 1992-2001" (USGS Circular 1291). Available online at: http://water.usgs.gov/nawqa/pnsp/pubs/circ1291/appendix6/appendix6a.txt
- NAWQA Sites: USGS. NAWQA Data Warehouse: SiteFile Master. Available online at: shttp://infotrek.er.usgs.gov/nawqa_queries/sitemaster/index.jsp
- Hydrologic Units: http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) Data were downloaded (see data sources) and imported into Microsoft Excel.
(2) In Excel, measured values for insecticides, insecticide degradates, and acaricides were identified and summed for each sampling event. Constituents that were not measured or were below detection levels were assumed to be zero.
(3) The insecticide concentration table was imported into ArcMap. For each sampling site, the average of these total concentrations was calculated for all sampling events that occurred at that site using the "Summarize" function.
(4) The summarized insecticide table and was joined to the NAWQA Sites using the "STAID" attribute. In some cases, the STAID value required minor edits to correctly join the tables. A total of 182 sites with insecticide concentration data were successfully joined to the NAWQA spatial data.
(5) NAWQA spatial data were displayed as an event theme, using the Latitude and Longitude variables (North American Datum of 1983).
(6) Next, the hydrologic units (4-digit HUCs) were added to the ArcMap project and joined using a spatial join to the NAWQA points. If more than one site with insecticide data was located within a 4-digitt HUC, the concentration values were averaged across sites. In some cases, there were no sites with insecticide data within a 4-digit HUC.
(7) The final map was created using symbology to indicate low, medium, and high vulnerability categories for each 4-digit HUC. In 4-digit HUCs where no sampling occurred, the HUC was assigned a 'No Data' category.

Note: Insecticide concentrations in agricultural areas, urban areas, and mixed land use areas were combined for this indicator, although the USGS reports these land use types separately.

#371 Organochlorines in Bed Sediment

Data Sources (see Appendix C for more details):

- Organochlorine Concentrations: USGS NAWQA Program. "The Quality of Our Nation's Waters Pesticides in the Nation's Streams and Ground Water, 1992-2001" (USGS Circular 1291). Available online at: http://water.usgs.gov/nawqa/pnsp/pubs/circ1291/appendix6/appendix6c.txt
- NAWQA Sites: USGS. NAWQA Data Warehouse: SiteFile Master. Available online at: shttp://infotrek.er.usgs.gov/nawqa_queries/sitemaster/index.jsp
- Hydrologic Units: http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) Organochlorine concentration data were downloaded and imported into Microsoft Excel.
(2) In Excel, measured values for all parameters except P49271 (organic carbon in sediment) were summed for each site. Only one sampling event occurred at each site, so aggregation at the site level was not conducted. Constituents that were not measured or were below detection levels were assumed to be zero.
(3) The organochlorine occurrence data were imported into ArcMap, and joined to the NAWQA Sites using the "STAID" attribute. A total of 1,015 sites with organochlorine concentration data were successfully joined to the NAWQA spatial data.
(4) NAWQA spatial data were displayed as an event theme, using the Latitude and Longitude variables (North American Datum of 1983).
(5) The hydrologic units (4-digit HUCs) were opened in ArcMap and joined to the NAWQA points using a spatial join. If more than one site with organochlorine data was located within a 4-digit HUC, the total concentration values were averaged across sites. In some cases, there were no sites with organochlorine data within a 4-digit HUC.
(6) The final map was created using symbology to indicate low, medium, and high vulnerability categories for each 4-digit HUC. In 4-digit HUCs where no sampling occurred, the HUC was assigned a 'No Data' category.

Note: Organochlorine concentrations in agricultural areas, urban areas, and mixed land use areas were combined for this indicator, although the USGS reports these land use types separately.

#373 Herbicide Concentrations in Groundwater

Data Sources (see Appendix C for more details):

- Herbicide Concentrations: USGS NAWQA Program. "The Quality of Our Nation's Waters Pesticides in the Nation's Streams and Ground Water, 1992-2001" (USGS Circular 1291). Available online at: http://water.usgs.gov/nawqa/pnsp/pubs/circ1291/appendix6/appendix6b.txt
- Hydrologic Units: http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) Herbicide concentration data were downloaded and imported into Microsoft Excel.
(2) In Excel, measured values for herbicides, herbicide degradates, and acaricides were identified and summed for each sampling event. Constituents that were not measured or were below detection levels were assumed to be zero.
(3) These herbicide occurrence data were imported into ArcMap and displayed as an event theme, using the Latitude and Longitude variables (North American Datum of 1983).
(4) Next, the hydrologic units (4-digit HUCs) were added to the ArcMap project and joined using a spatial join to the sampling event points. If more than one sampling event with herbicide data occurred within a 4-digit HUC, the concentration values were averaged across events. In some cases, no herbicide collection events occurred within a 4-digit HUC.

(5) The final map was created using symbology to indicate low, medium, and high vulnerability categories for each 4-digit HUC. In 4-digit HUCs where no sampling occurred, the HUC was assigned a 'No Data' category.

Note: Herbicide concentrations in agricultural and urban areas were combined for this indicator, although the USGS reports these land use types separately.

#374 Insecticide Concentrations in Groundwater

Data Sources (see Appendix C for more details):

- Insecticide Concentrations: USGS NAWQA Program. "The Quality of Our Nation's Waters Pesticides in the Nation's Streams and Ground Water, 1992-2001" (USGS Circular 1291). Available online at: http://water.usgs.gov/nawqa/pnsp/pubs/circ1291/appendix6/appendix6b.txt
- Hydrologic Units: http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) Insecticide concentration data were downloaded and imported into Microsoft Excel.
(2) In Excel, measured values for insecticides, insecticide degradates, and acaricides were identified and summed for each sampling event. Constituents that were not measured or were below detection levels were assumed to be zero.
(3) These insecticide concentration data were imported into ArcMap and displayed as an event theme, using the Latitude and Longitude variables (North American Datum of 1983).
(4) Next, the hydrologic units (4-digit HUCs) were added to the ArcMap project and joined using a spatial join to the sampling event points. If more than one sampling event with insecticide data occurred within a 4-digit HUC, the concentration values were averaged across events. In some cases, no insecticide collection events occurred within a 4-digit HUC.
(5) The final map was created using symbology to indicate low, medium, and high vulnerability categories for each 4-digit HUC. In 4-digit HUCs where no sampling occurred, the HUC was assigned a 'No Data' category.

Note: Insecticide concentrations in agricultural and urban areas were combined for this indicator, although the USGS reports these land use types separately.

#437 Precipitation Elasticity of Streamflow

Data Sources (see Appendix C for more details):

- Precipitation Elasticity of Streamflow: Adapted from Figure 4 *in* Sankarasubramanian et al. (2001). Water Resources Research 37(6).
- Hydrologic Units - http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) An image of Figure 4 was imported into ArcMap and georeferenced.

(2) Using the Spatial Analyst extension, the isopleths in Figure 4 were digitized and used to interpolate continuous elasticity values across the country.
(3) Mean elasticity values within each 4-digit HUC were calculated using the Zonal Statistics function.
(4) The final map was created using symbology to indicate low, medium, and high vulnerability categories for each 4-digit HUC.

Note: For the purposes of mapping this indicator with relative ease, Figure 4 in the original literature source, Sankarasubramanian et al., 2001 (see Appendix A for full reference) was used. However, the complete original data set could also be recalculated for mapping purposes using the data sources listed in Appendix C.

#449 Ratio of Storage to Runoff

Data Sources (see Appendix C for more details):

- Reservoir Storage: National Inventory of Dams (from the National Atlas). Available online at: http://www.nationalatlas.gov/mld/dams00x.html
- Mean Annual Runoff: U.S. Geological Survey. Available online at: http://water.usgs.gov/GIS/metadata/usgswrd/XML/runoff.xml
- Hydrologic Units - http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) The isopleths in the mean annual runoff dataset were opened in ArcMap. The Spatial Analyst extension was used to interpolate continuous runoff values across the country.
(2) Mean runoff values within each 4-digit HUC were calculated using the Zonal Statistics function.
(3) The shapefile containing data for dams was opened in ArcMap. The total maximum reservoir storage capacity was calculated by joining the 4-digit HUCs to the dam data using a spatial join. If more than one reservoir occurred within a 4-digit HUC, the storage capacity was summed.
(4) The ratio of storage capacity to mean annual runoff was calculated within each 4-digit HUC and saved within a new attribute.
(5) The final map was created using symbology to indicate low, medium, and high vulnerability categories for each 4-digit HUC.

#453 Runoff Variability

Data Sources (see Appendix C for more details):

- Global Runoff, 1980-1993. Available online at: http://www.hydro.washington.edu/SurfaceWaterGroup/Data/vic_global.html
  Specific data file: ftp://ftp.hydro.washington.edu/pub/CE/HYDRO/nijssen/vic_global/calibrated/runoff.calibrated.monthly.1980_1993.nc.gz
- Hydrologic Units - http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) The modeled runoff data were downloaded and decompressed.
(2) The NetCDF file, containing monthly runoff data, was imported into ArcMap. Monthly grids were exported from the NetCDF format for all months during the 1984-1993 time period (120 months).
(3) Annual runoff was calculated by aggregating the monthly values for each year.
(4) The mean and standard deviation of the annual runoff within each 2˚ x 2˚ grid cell was calculated using the 10 annual values.
(5) The coefficient of variance was calculated by dividing mean annual runoff into the standard deviation for each grid cell.
(6) The mean coefficient of variation within the 4-digit HUCs was calculated using the Zonal Statistics function.
(7) The final map was created using symbology to indicate low, medium, and high vulnerability categories for each 4-digit HUC.

#460 Macroinvertebrate Index of Biotic Condition

Data Sources (see Appendix C for more details):

- Stream Water Benthic Macroinvertebrate Metrics: EPA Wadeable Streams Assessment. (Filename: wsa_benmet300_ts_final.csv). Available online at: http://www.epa.gov/owow/streamsurvey/web_data.html
- Stream Site Info: EPA Wadeable Streams Assessment (Filename: wsa_siteinfo_ts_final.csv). Available online at: http://www.epa.gov/owow/streamsurvey/web_data.html
- Hydrologic Units - http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) Benthic macroinvertebrate data were downloaded and opened as a comma-delimited text file in Microsoft Excel. The columns containing the SiteID and Macroinvertebrate Index (MMI_WSA) attributes were saved as a new comma-delimited text file.
(2) The text file with macroinvertebrate data, the hydrologic units, and Site Info were opened in ArcMap 9.2. The macroinvertebrate and Site Info tables were joined using the SiteID attribute.
(3) An event theme was mapped for the joined records with corresponding macroinvertebrate data, using the LON_DD and LAT_DD fields (North American Datum 1983). This event theme was exported as a shapefile.
(4) The sites were aggregated within the 4-digit HUCs using a spatial join. If a HUC contained more than one site, the average value for the Macroinvertebrate Index was calculated.
(5) The final map was created using the Avg_MMI_WS field to indicate low, medium, and high vulnerability categories. In 4-digit HUCs where no sampling occurred, the HUC was mapped assigned a 'No Data' category.

#461 Macroinvertebrate Observed / Expected Ratio of Taxa Loss

Data Sources (see Appendix C for more details):

- Stream Water Benthic Macroinvertebrate Metrics: EPA Wadeable Streams Assessment. (Filename: wsa_benmet300_ts_final.csv). Available online at: http://www.epa.gov/owow/streamsurvey/web_data.html
- Stream Site Info: EPA Wadeable Streams Assessment. (Filename: wsa_siteinfo_ts_final.csv). Available online at: http://www.epa.gov/owow/streamsurvey/web_data.html
- Hydrologic Units - http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) Benthic macroinvertebrate data were downloaded and opened as a comma-delimited text file in Microsoft Excel. The columns containing the SiteID and Macroinvertebrate O/E Ratio (OE_5_3REG) attributes were saved as a new comma-delimited text file.
(2) The text file with macroinvertebrate data, the hydrologic units, and Site Info were opened in ArcMap 9.2. The macroinvertebrate and Site Info tables were joined using the SiteID attribute.
(3) An event theme was mapped for the joined records with corresponding macroinvertebrate data, using the LON_DD and LAT_DD fields (North American Datum 1983). This event theme was exported as a shapefile.
(4) The sites were aggregated within the 4-digit HUCs using a spatial join. If a HUC contained more than one site, the average value for the O/E Ratio was calculated.
(5) The final map was created using the Avg_OE_5_3 field to indicate low, medium, and high vulnerability categories. In 4-digit HUCs where no sampling occurred, the HUC was mapped assigned a 'No Data' category.

#623 Water Availability: Net Streamflow per Capita

Data Sources (see Appendix C for more details):

- Mean Annual Precipitation 1971-2000: PRISM Climate Group (Oregon State University). Available online at: http://www.prism.oregonstate.edu/products/matrix.phtml
- Mean Daily Maximum Temperature 1971-2000: PRISM Climate Group (Oregon State University). Available online at: http://www.prism.oregonstate.edu/products/matrix.phtml
- United States Geological Survey (USGS). Water Usage, 1995 http://water.usgs.gov/watuse/spread95/ush895.txt
  This data set includes population within each HUC-8 unit.
- Hydrologic Units - http://water.usgs.gov/GIS/metadata/usgswrd/XML/huc250k.xml

Processing Steps:

(1) PRISM data were downloaded and converted to ESRI© GRID format using the ASCII Text to Grid tool in ArcMap 9.2.
(2) Mean daily temperature was calculated with the raster calculator using the following formula as described by Vogel, 1999: (Max Temp + Min Temp) / 2.

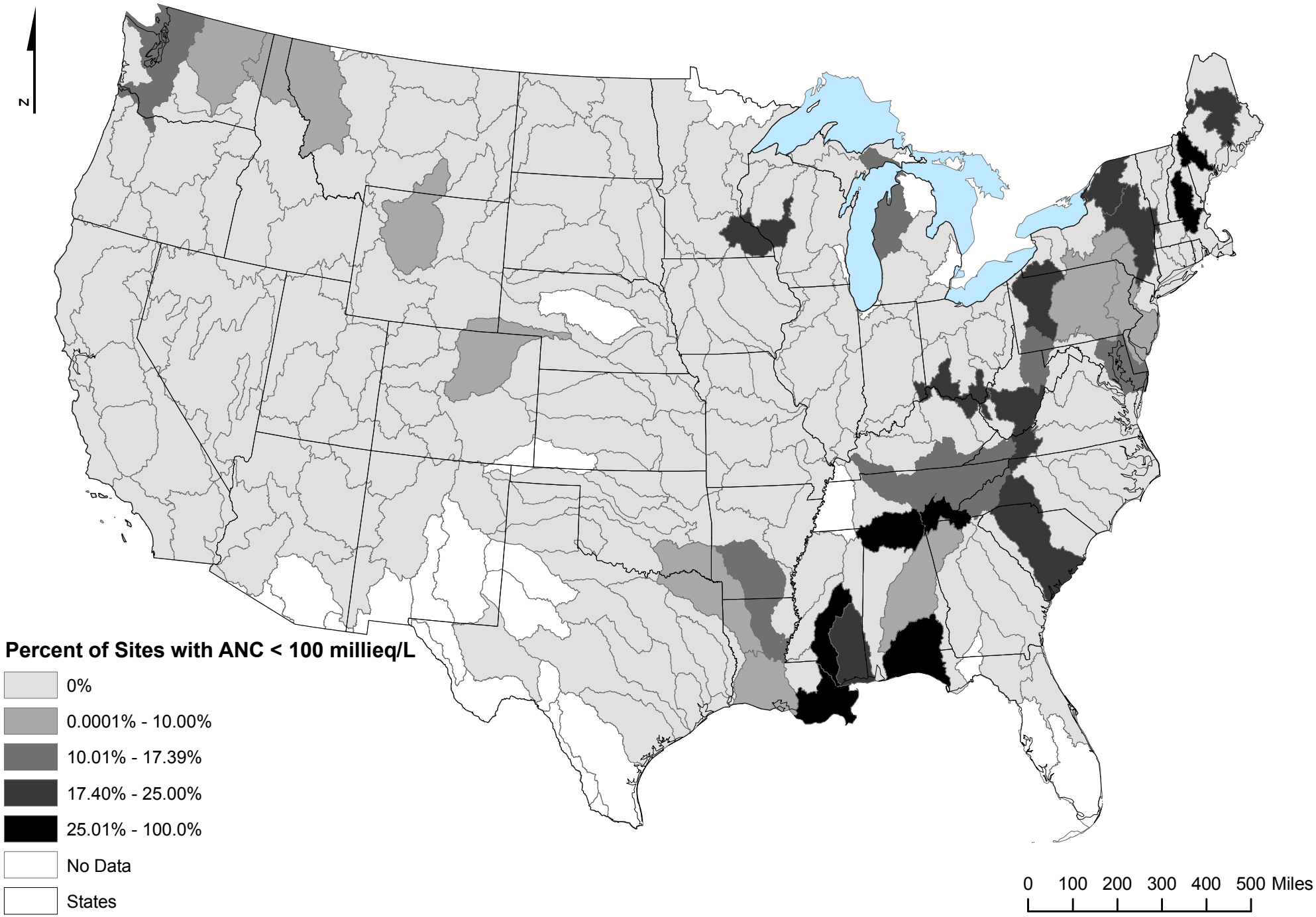
(3) Mean precipitation and mean daily temperature within each 4-digit HUC were calculated using the Zonal Statistics function.
(4) A new attribute for mean annual streamflow was calculated with the field calculator in ArcMap for each HUC-4 unit using the regression equations in Vogel, 1999 (Table 2). The HUC-2 code was used to associate each HUC-4 with the appropriate regional regression equation.
(5) The water usage data table was joined to the attribute table for the hydrologic units shapefile, using the "HUC_CODE" and "HUC8Code" fields.
(6) The 8-digit HUC regions were aggregated into 4-digit HUCs with the 'dissolve' function in ArcMap. The "SUB" attribute was used as the basis for the dissolve process. During the dissolve operation, summary statistics were calculated for total population and total withdrawals.
(7) Streamflow and withdrawals were adjusted for some HUC-4 units to account for streamflow and withdrawals upstream of the HUC-4 unit.
(8) A new attribute for net per capita streamflow was calculated with the field calculator, using the following equation:

$$(\text{Streamflow} - \text{Withdrawals}) / \text{Population}$$

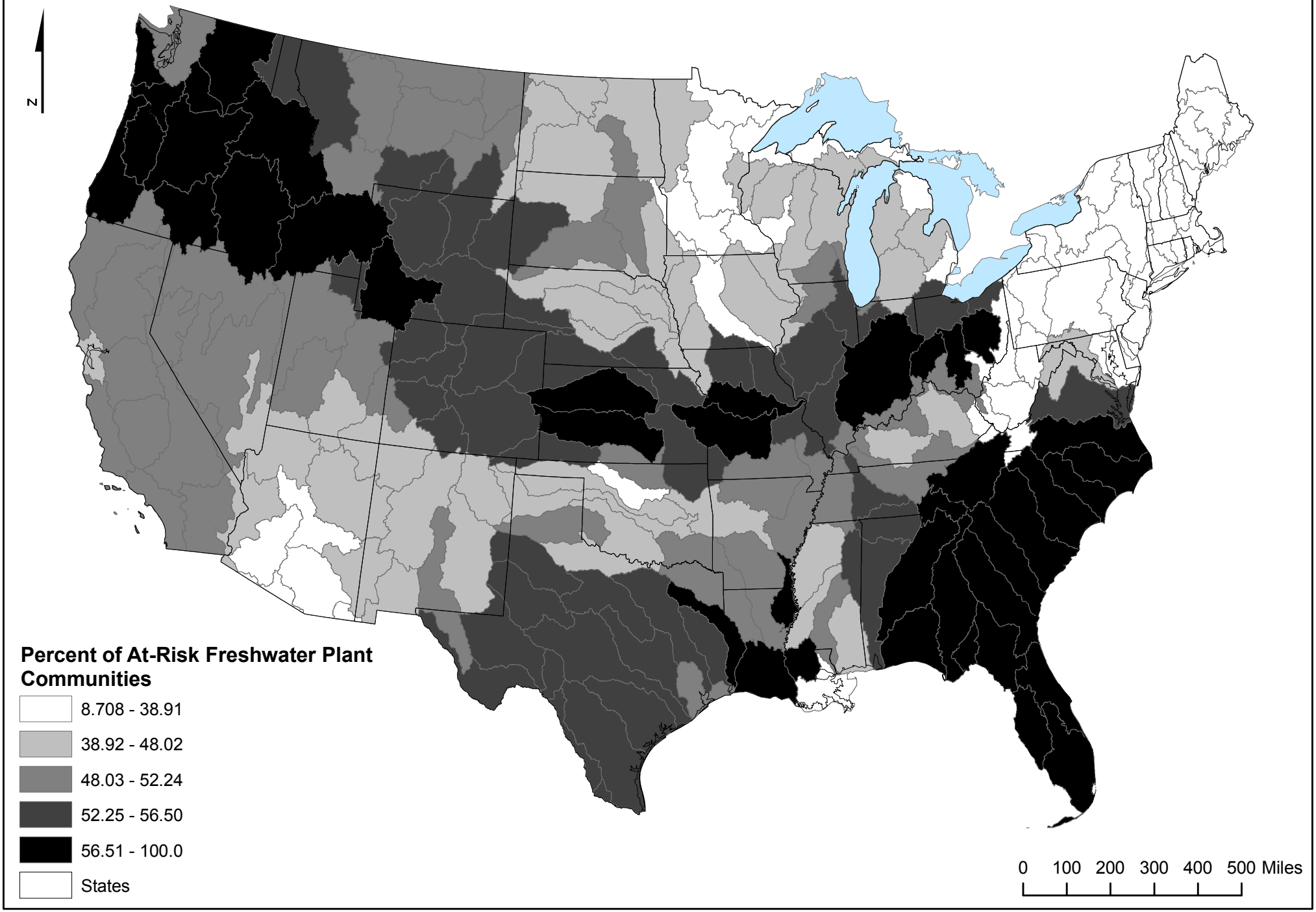
The units for streamflow and population were converted as needed.
(9) The final map was produced indicating low, medium, and high vulnerability categories.

Appendix F. Example Maps for Indicators of Water Quality and Aquatic Ecosystem Vulnerability by HUC-4 Watershed

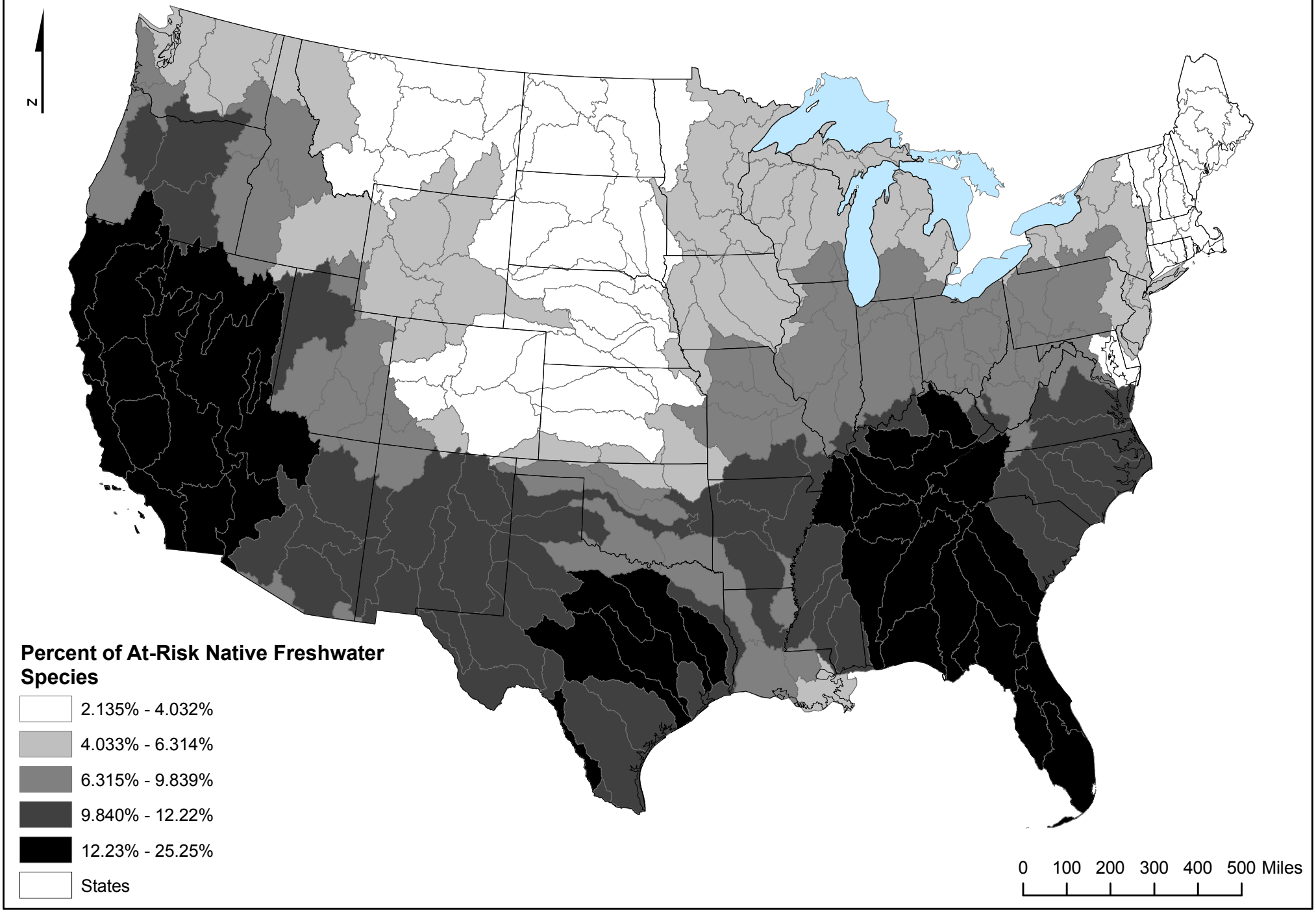
#1 Acid Neutralizing Capacity, 2000-2004



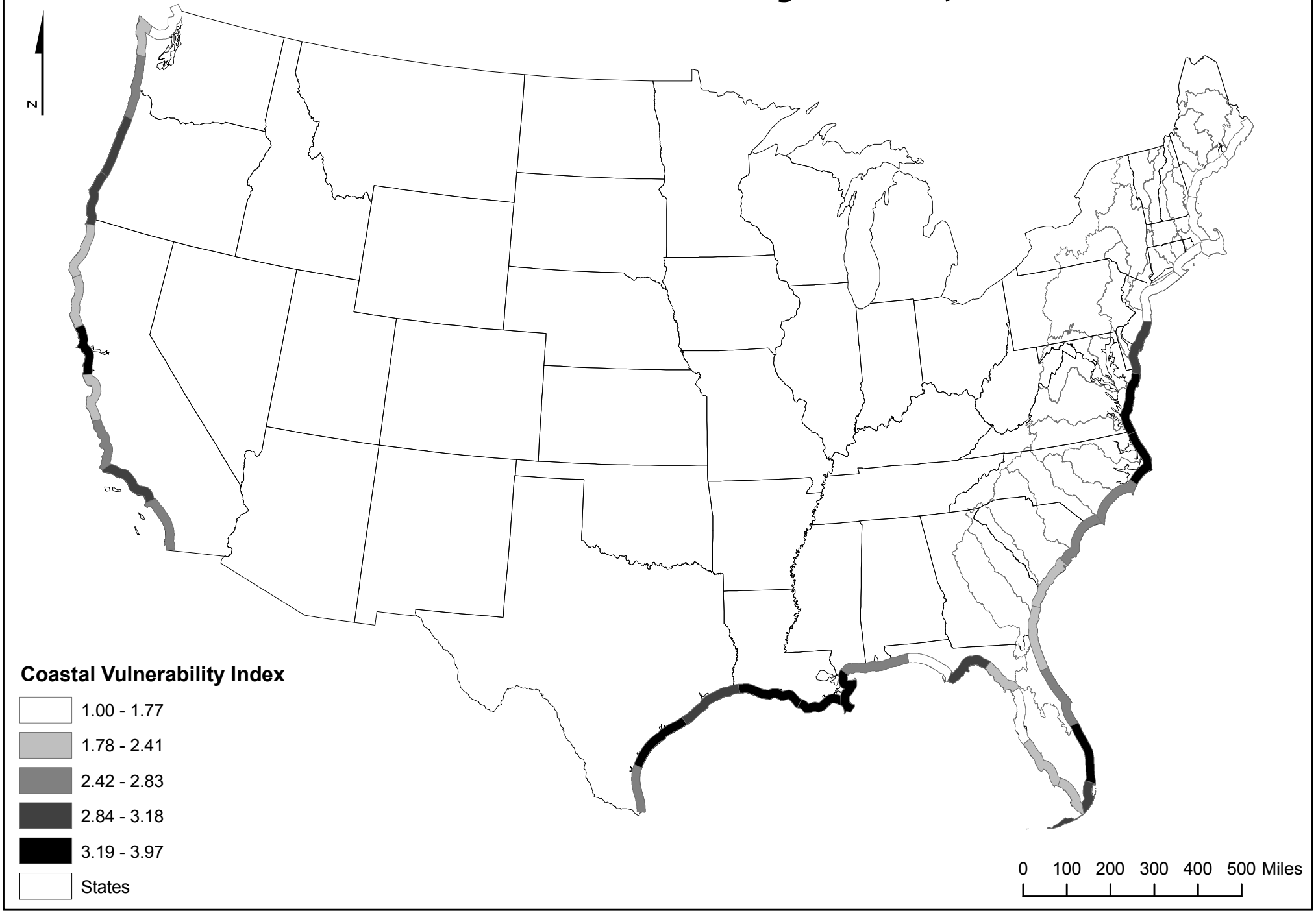
#22 At-Risk Freshwater Plant Communities, 2006



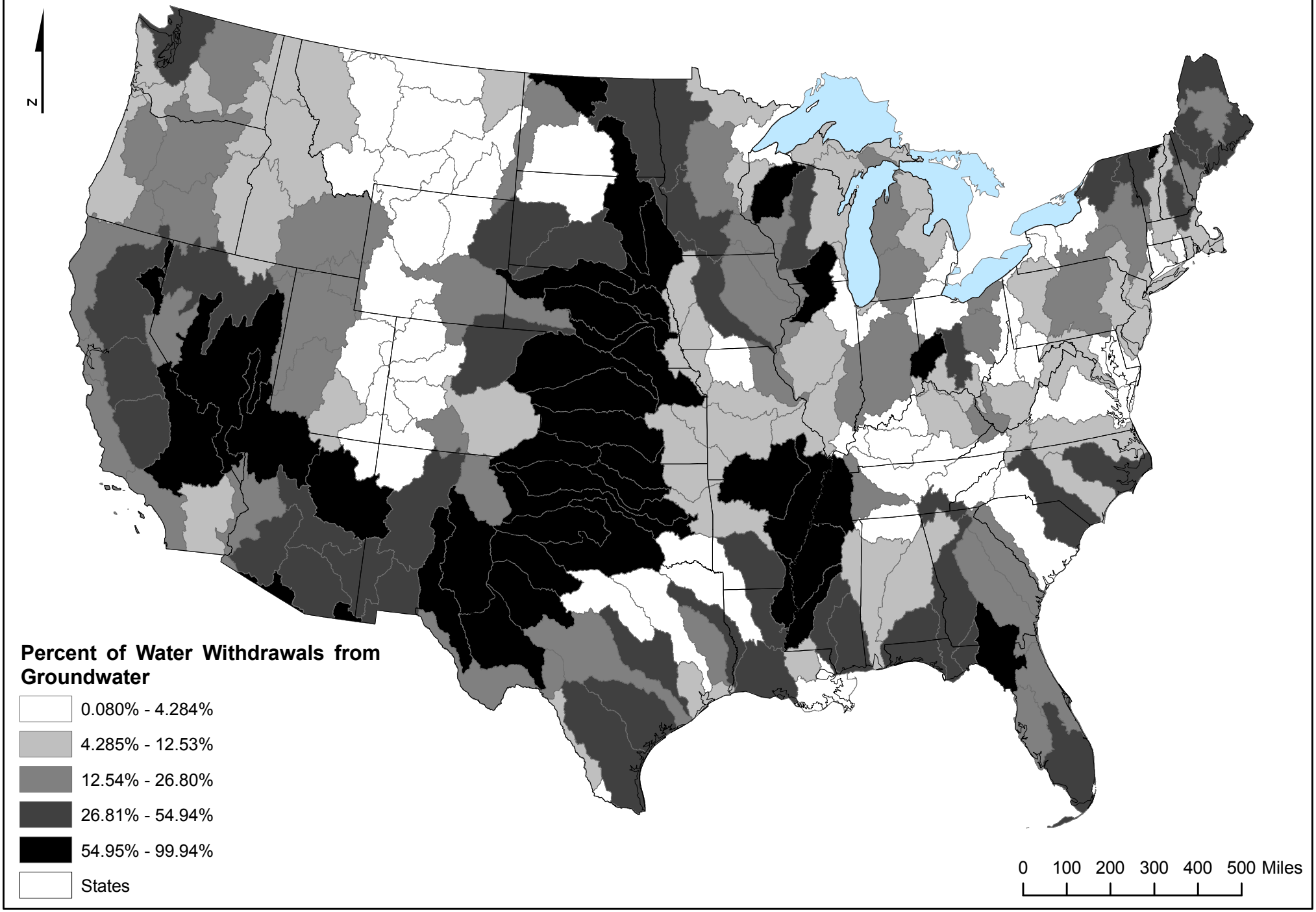
#24 At-Risk Native Freshwater Species, 2009



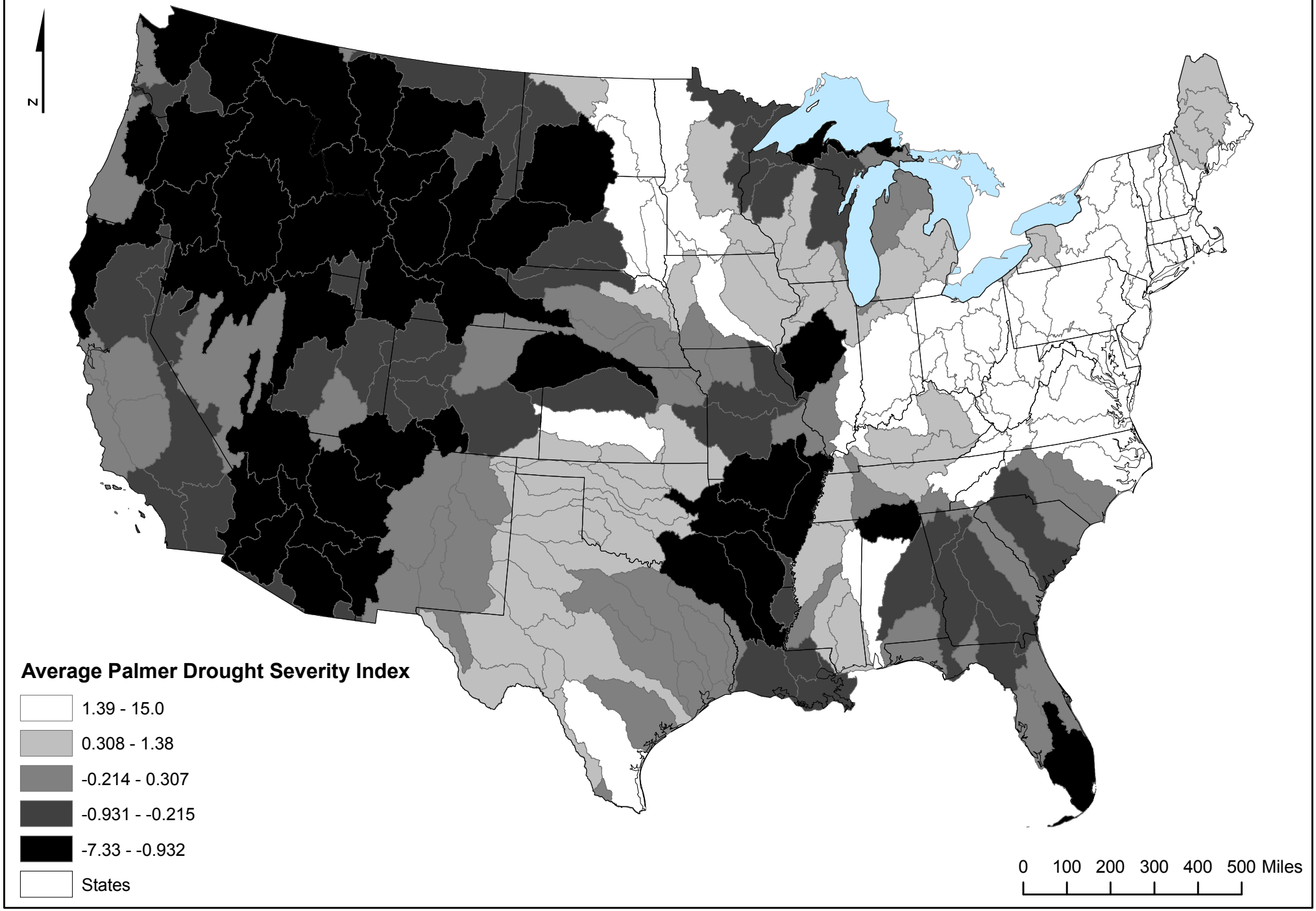
#51 Coastal Vulnerability Index, 2001



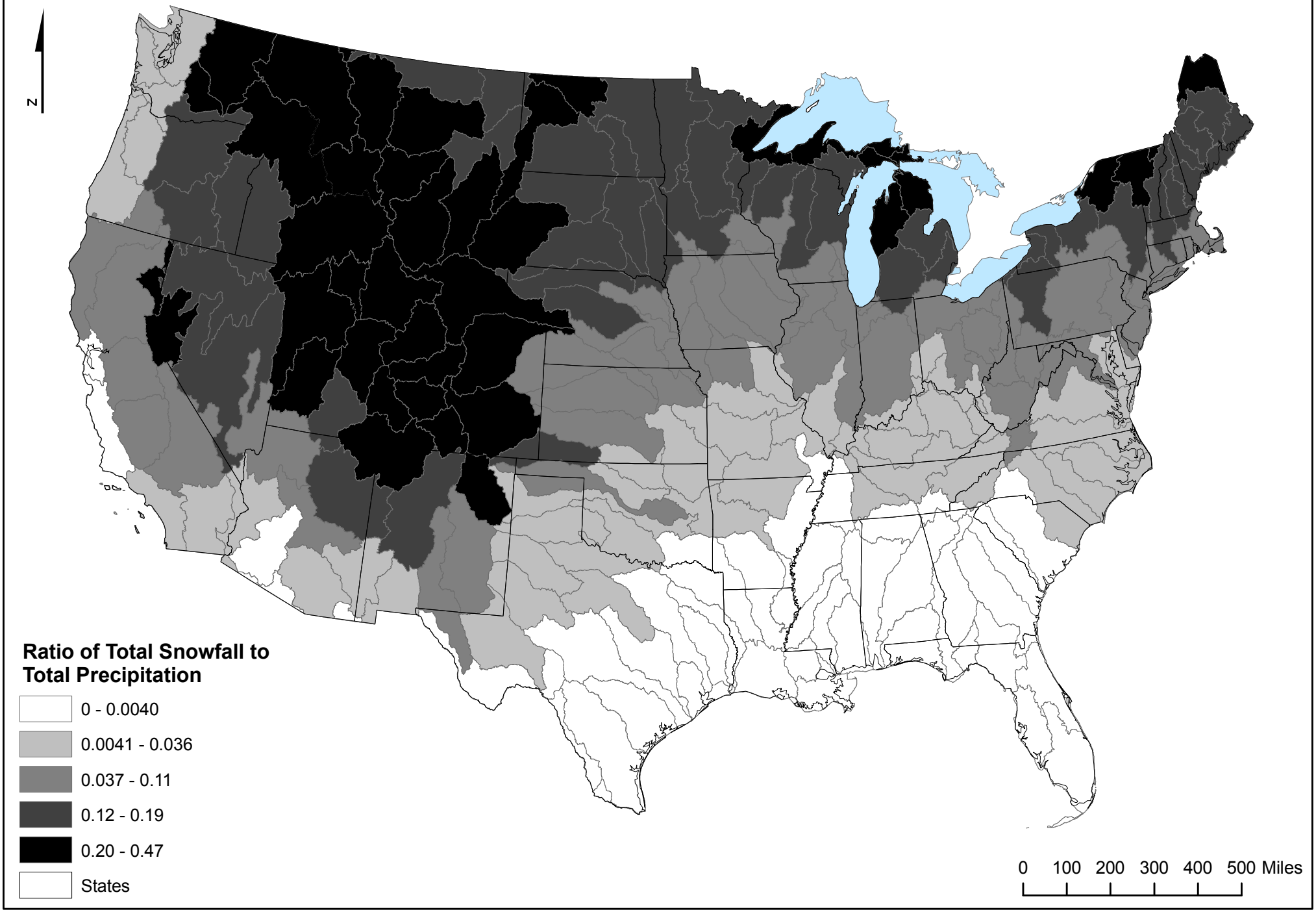
#125 Groundwater Reliance, 1995



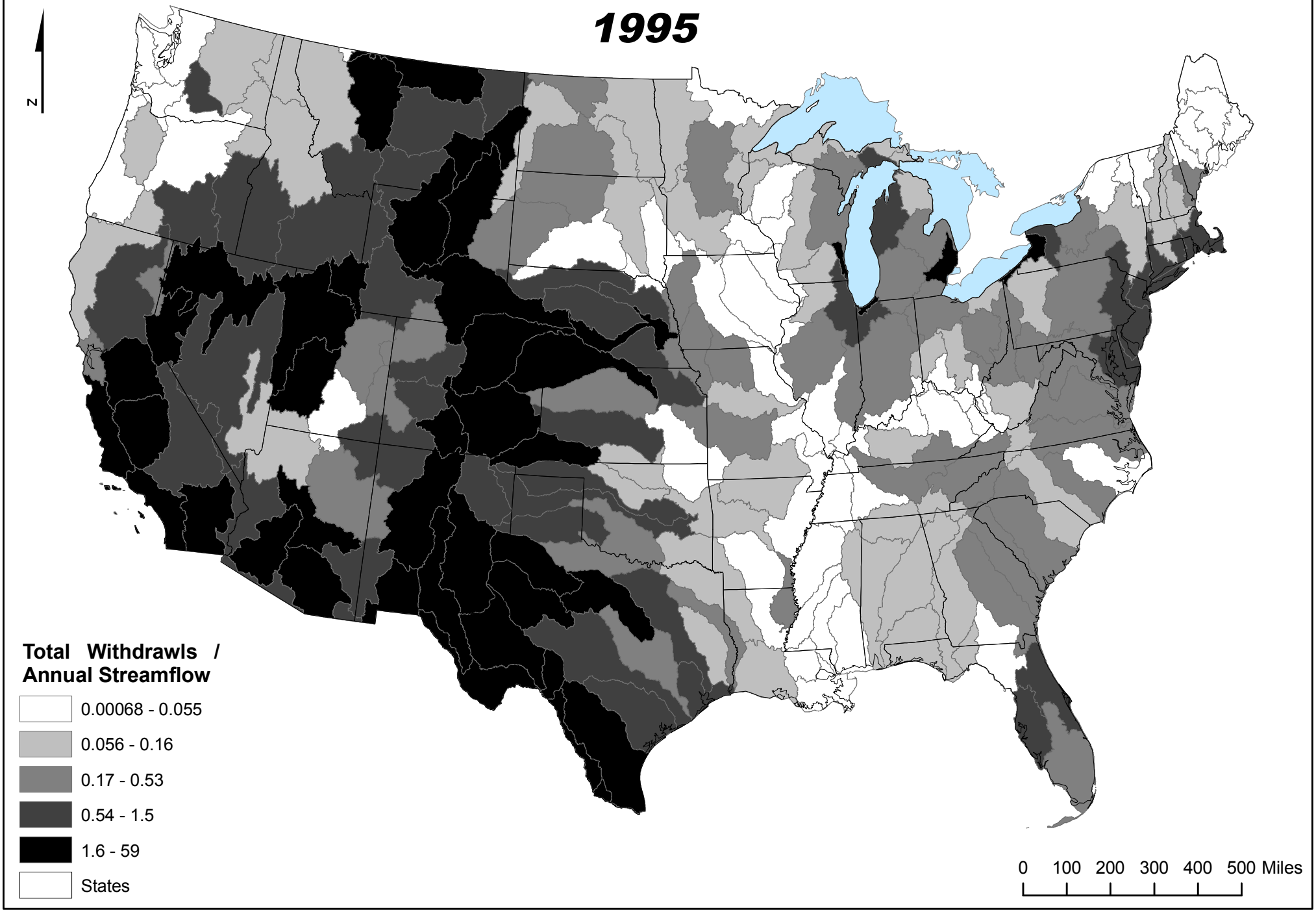
#165 Meteorological Drought Indices, 2003-2007



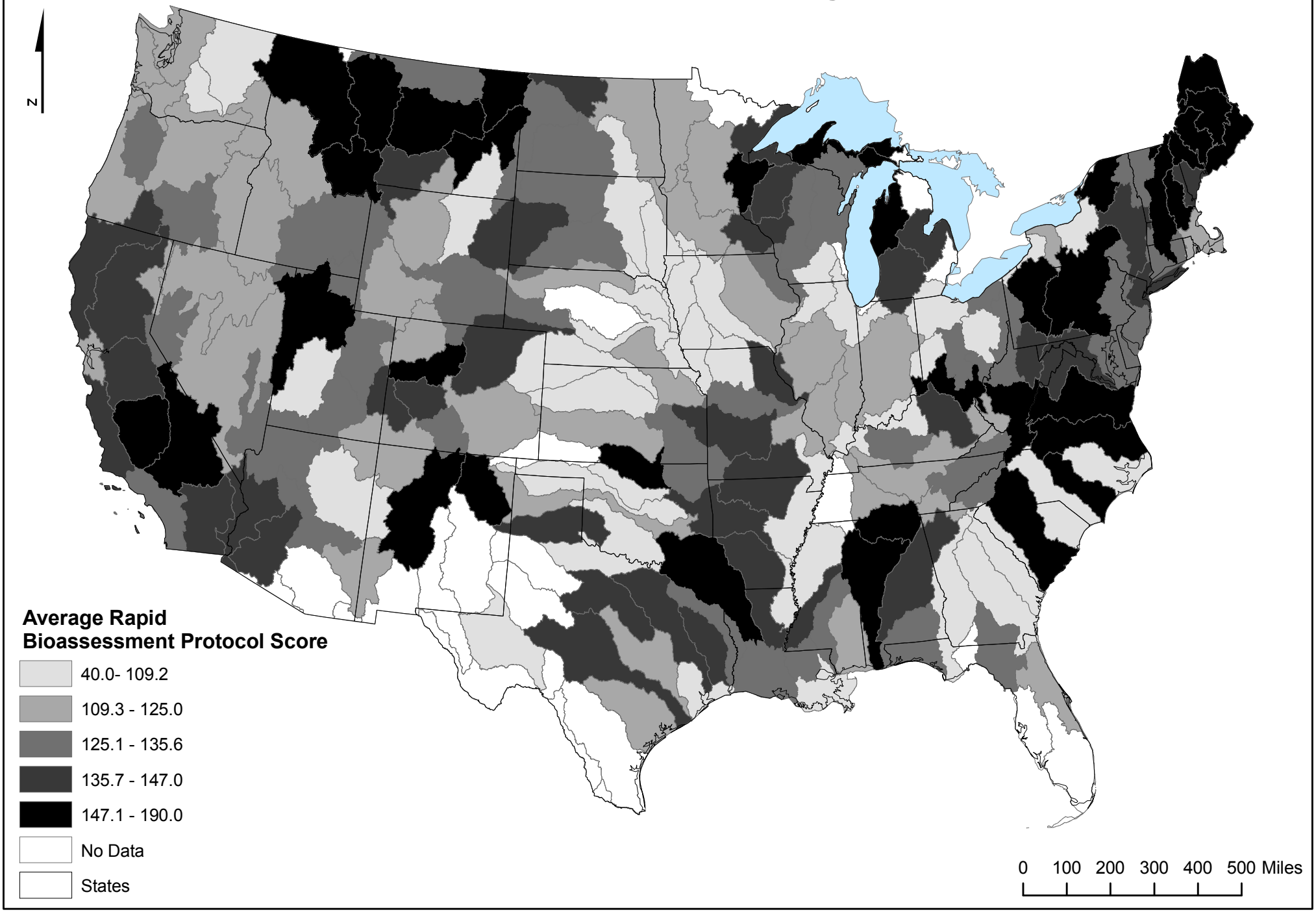
#218 Ratio of Snow to Total Precipitation, 1998-2007



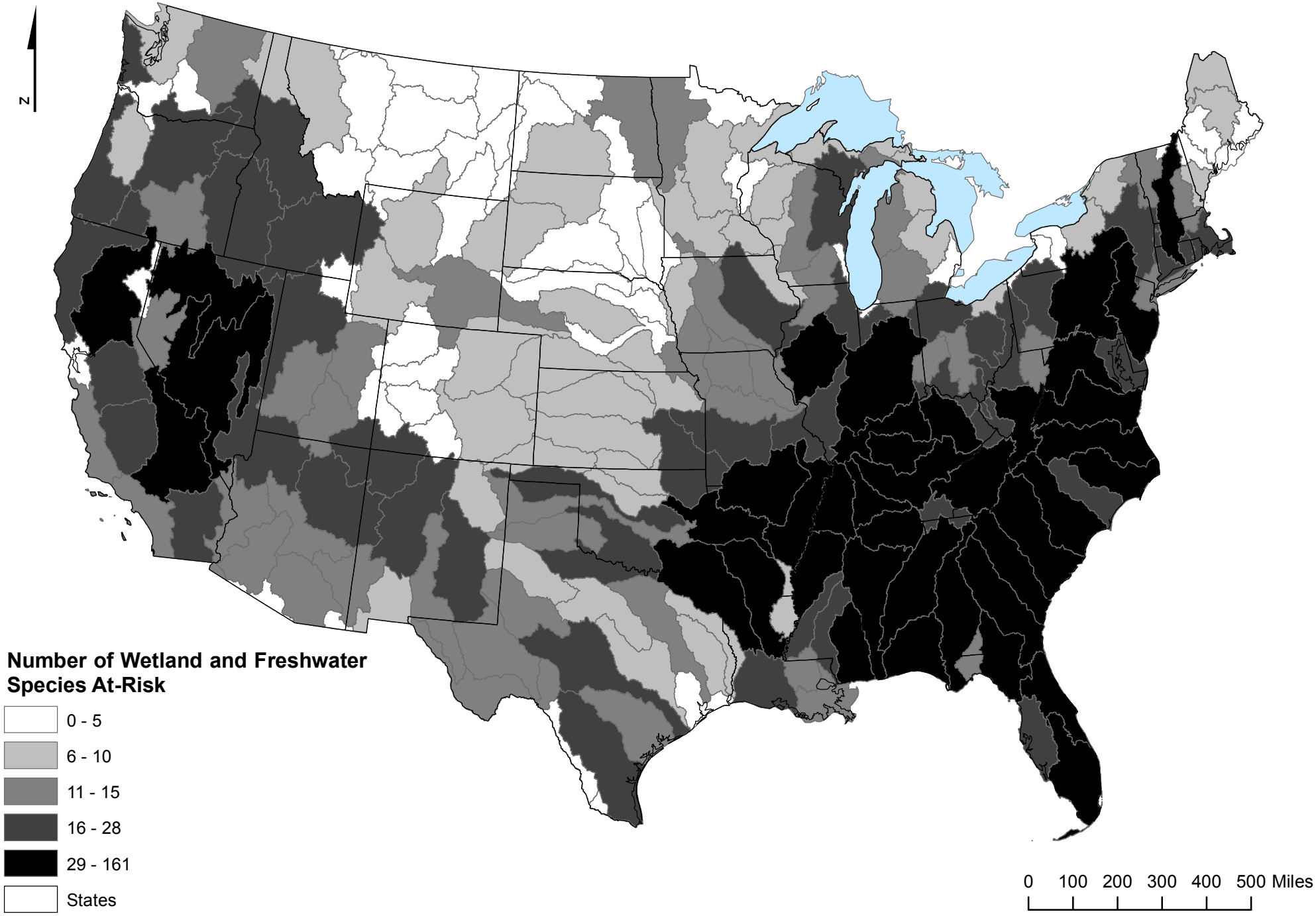
#219 Ratio of Water Withdrawls to Annual Streamflow, 1995



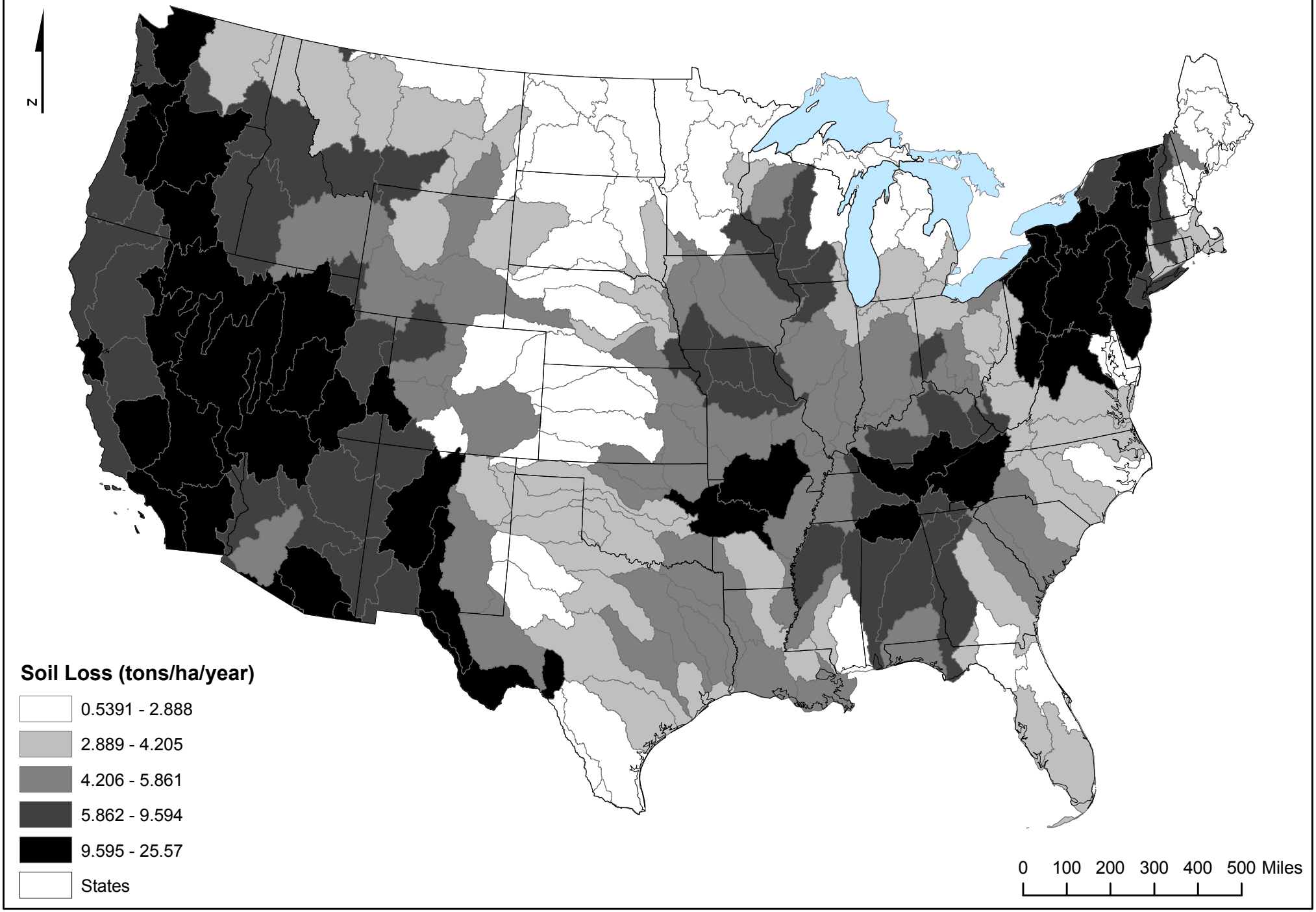
#284 Stream Habitat Quality, 2000-2004



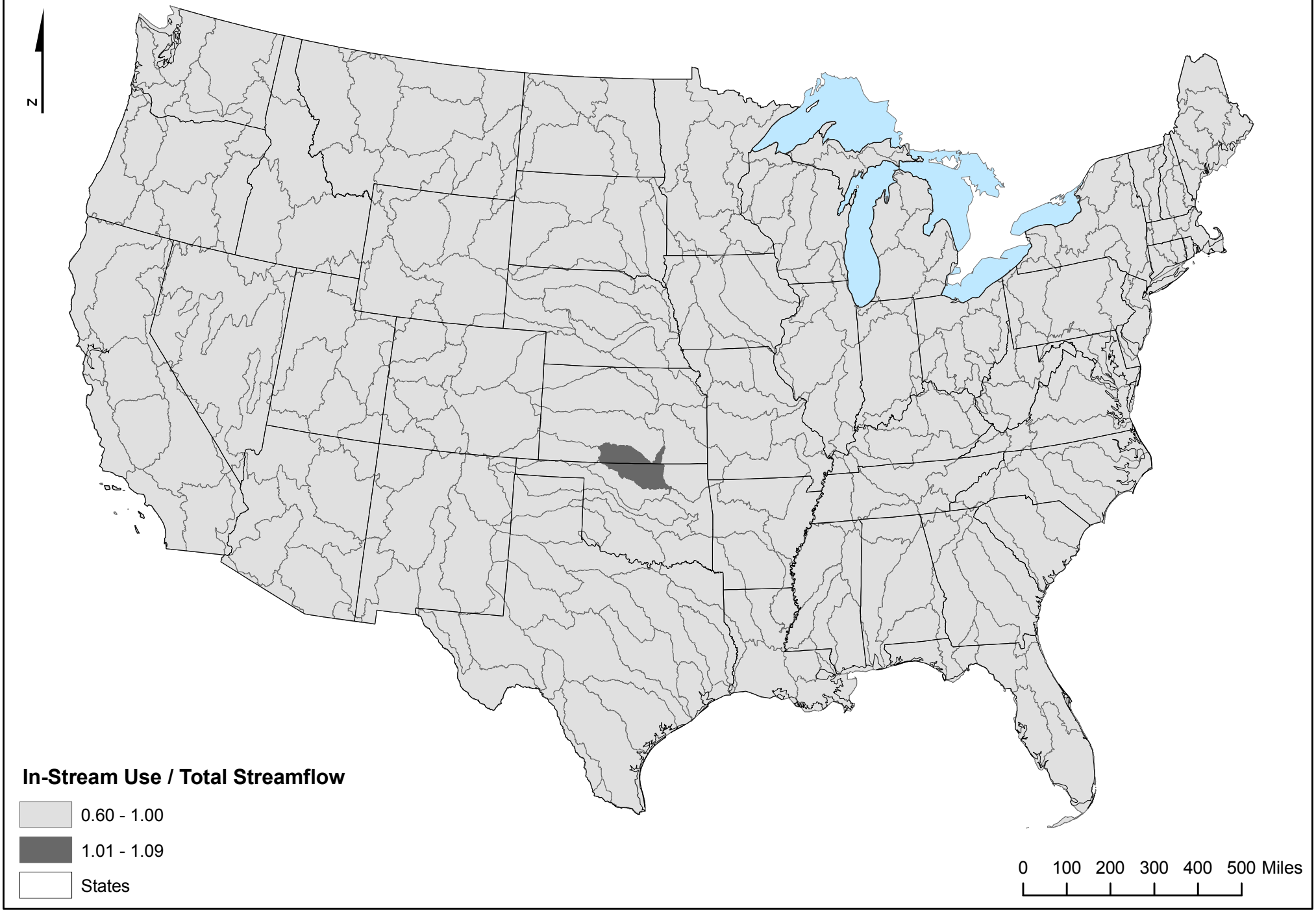
#326 Wetland and Freshwater Species At-Risk, 2006



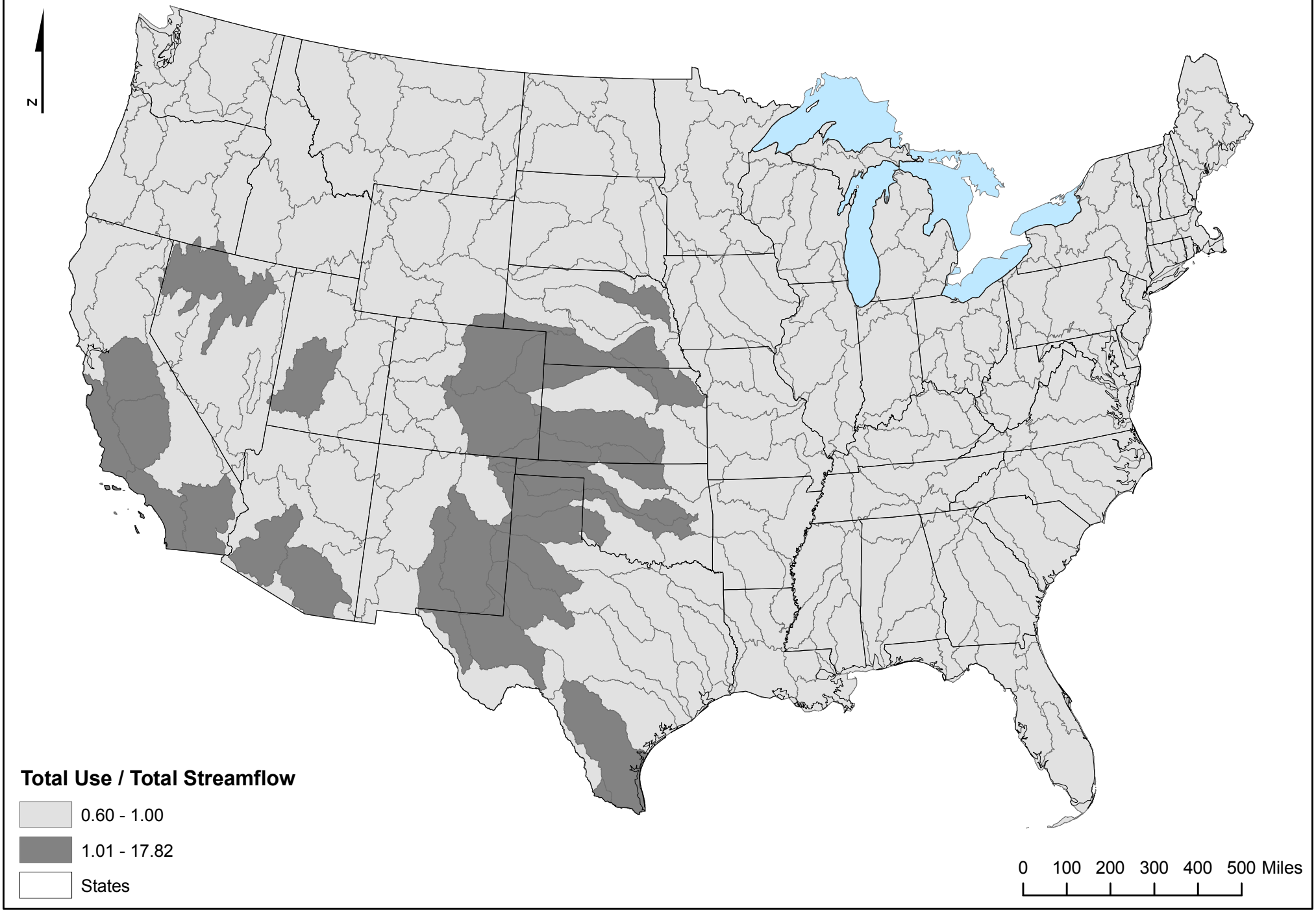
#348 Erosion Rate, 1980



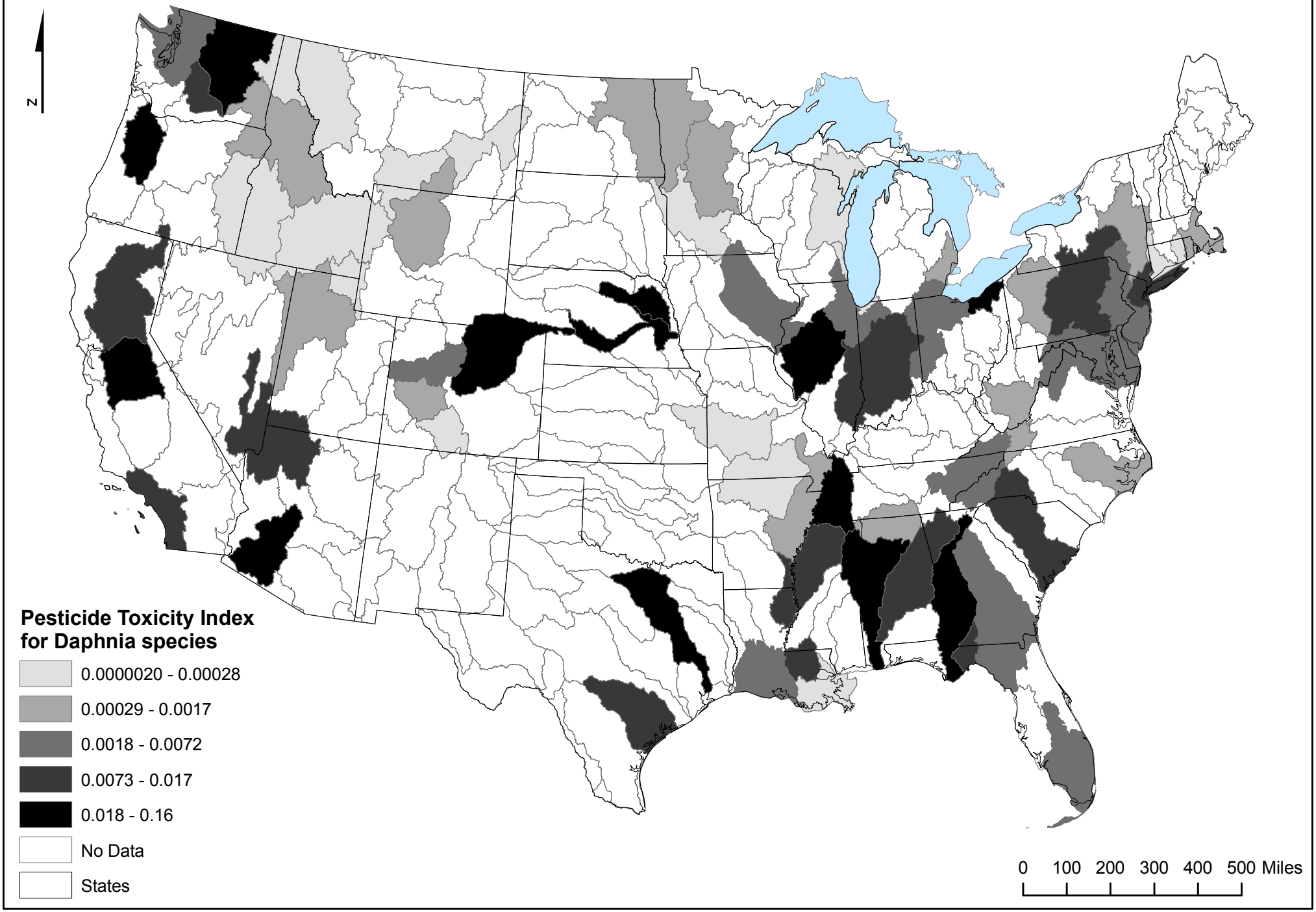
#351 In-Stream Use / Total Streamflow



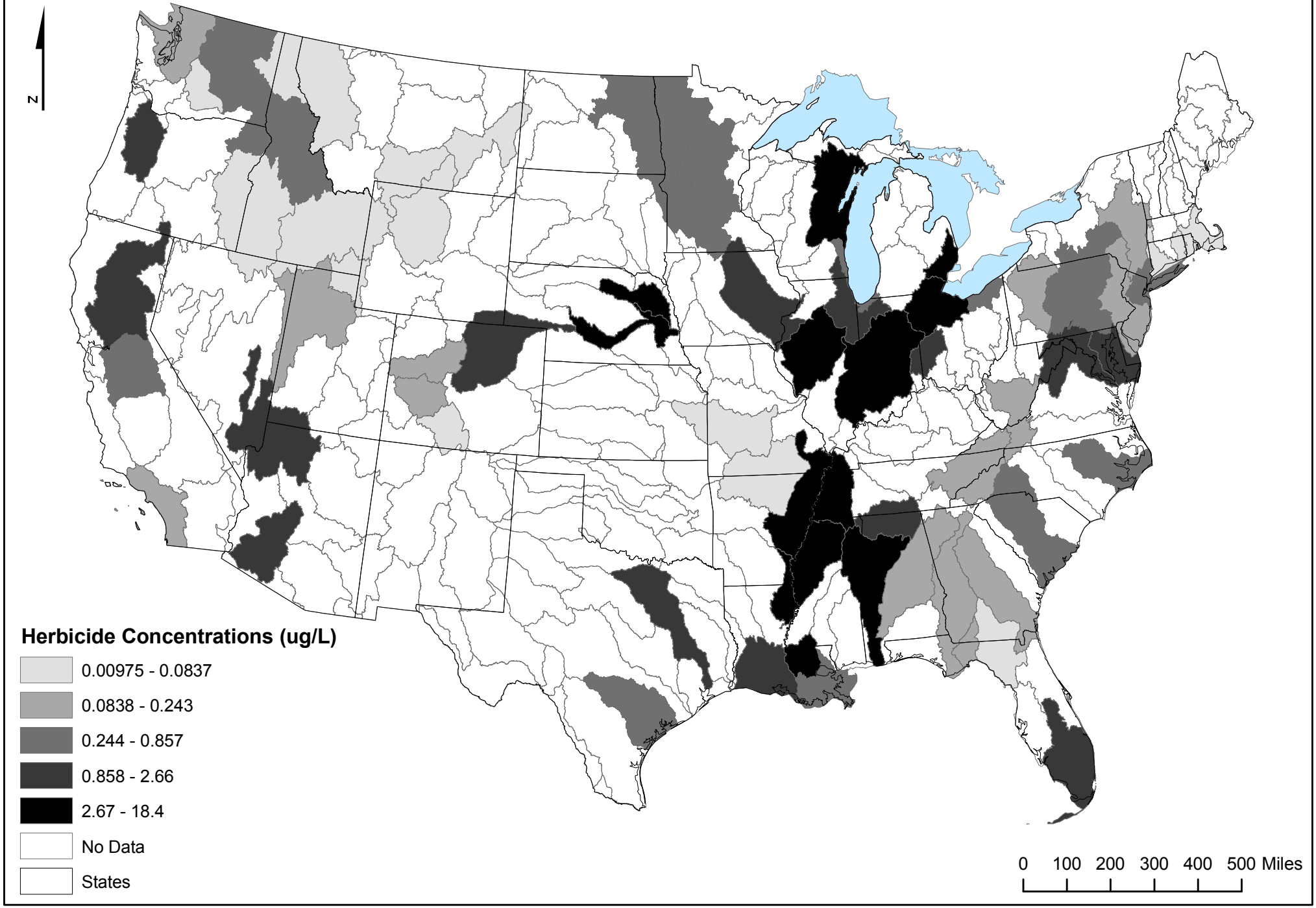
#352 Total Use / Total Streamflow



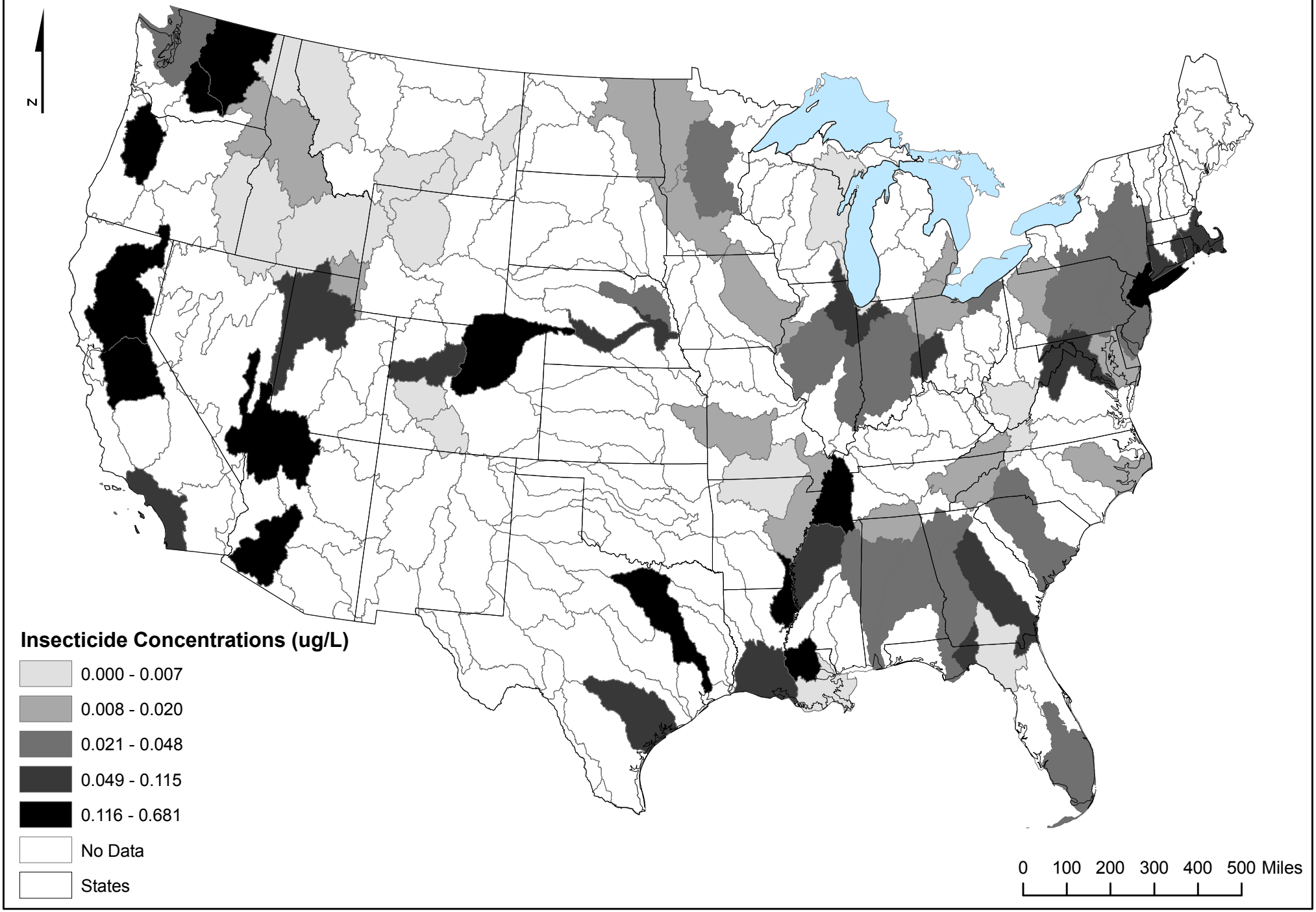
#364 Pesticide Toxicity Index, 1992-2001



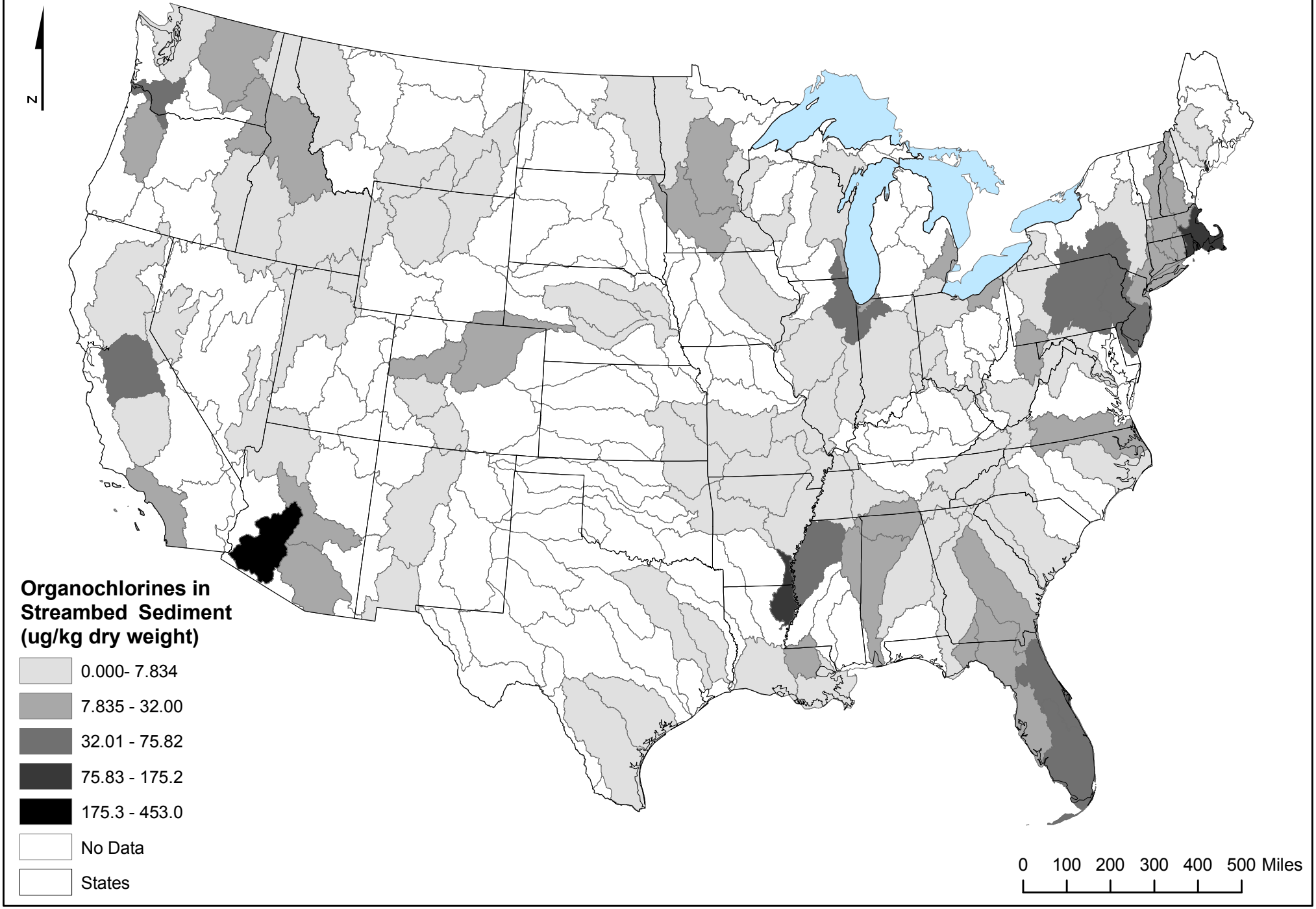
#367 Herbicide Concentrations in Streams, 1993-2001



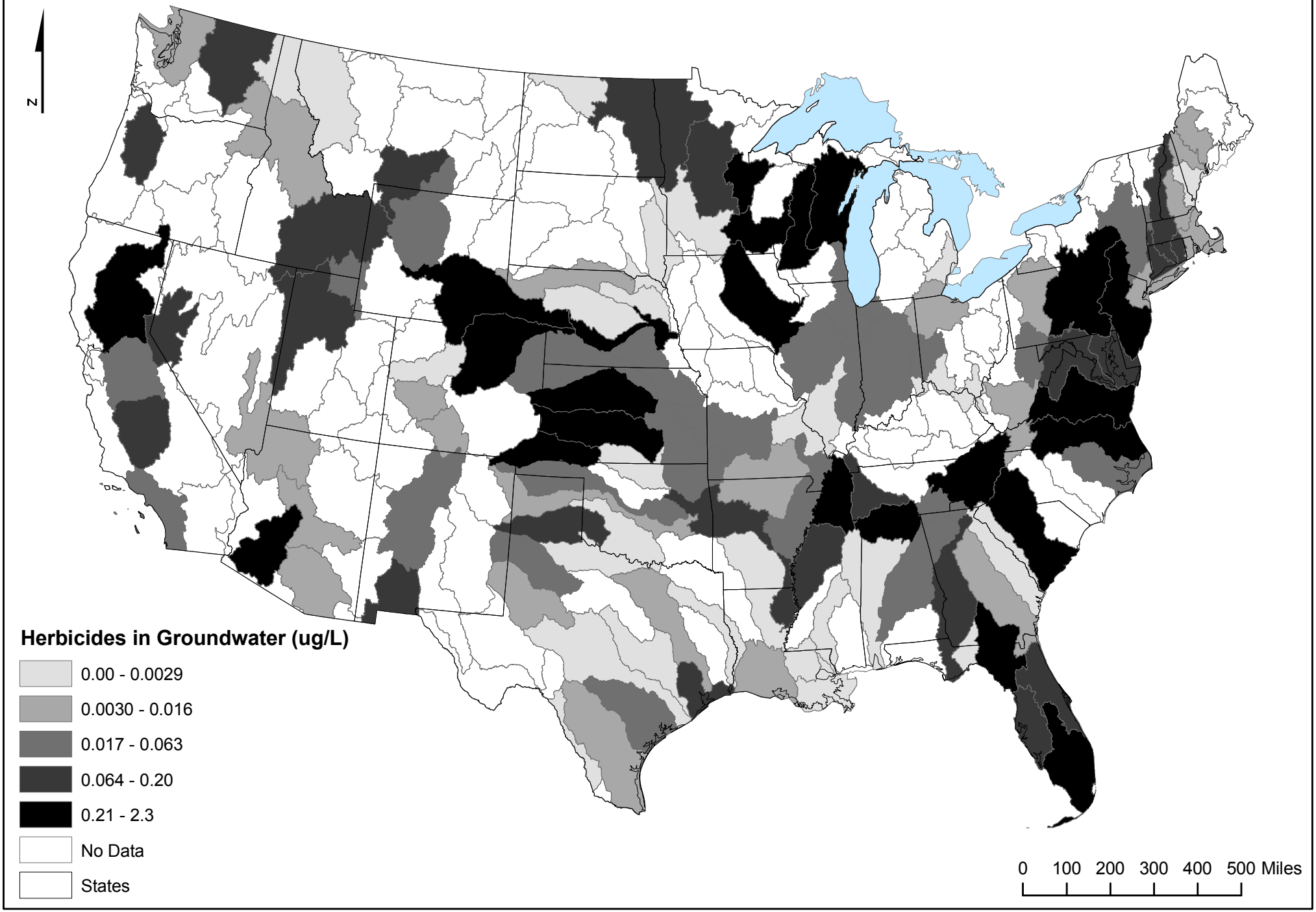
#369 Insecticide Concentrations in Streams, 1993-2001



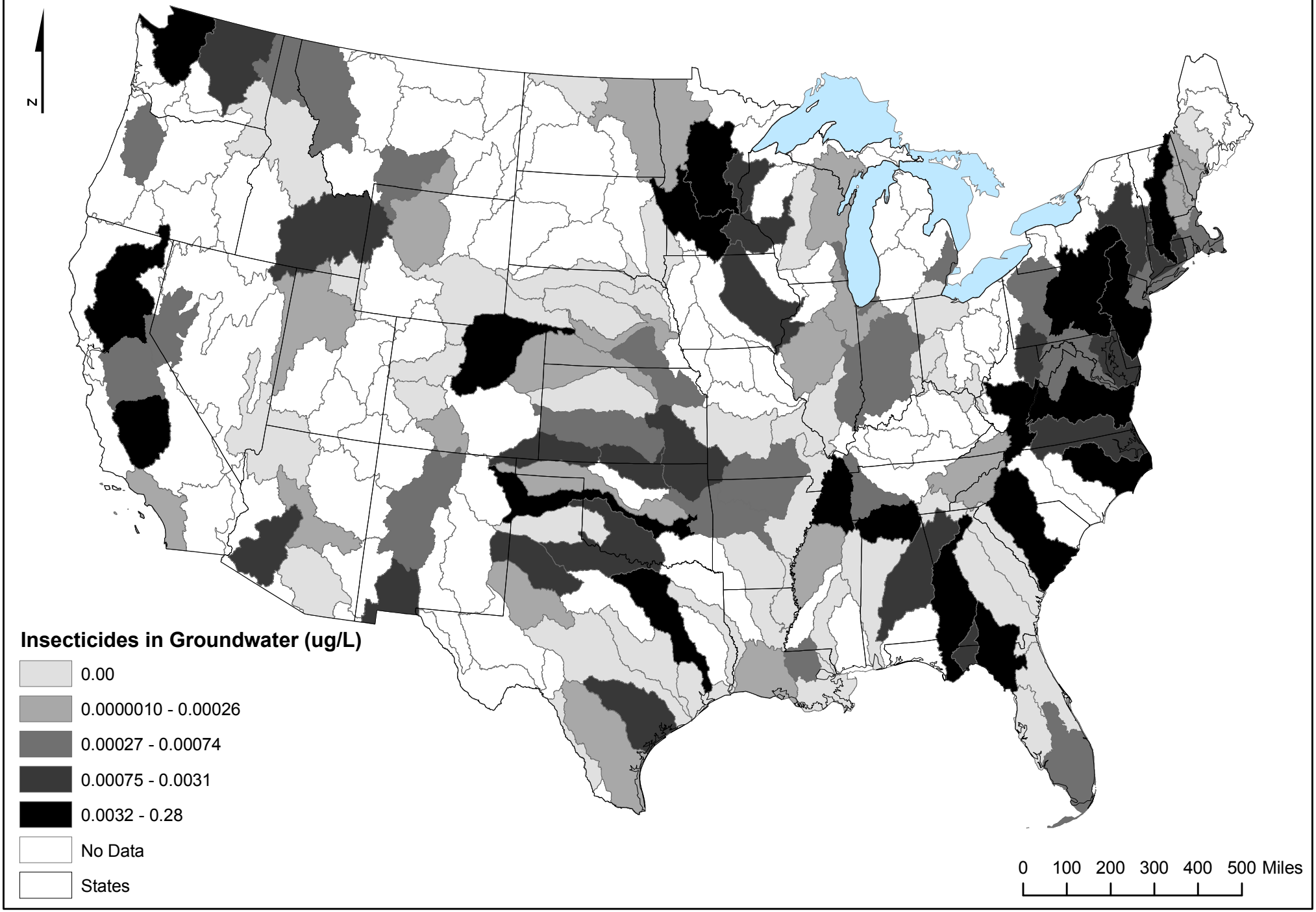
#371 Organochlorines in Bed Sediment, 1991-1997



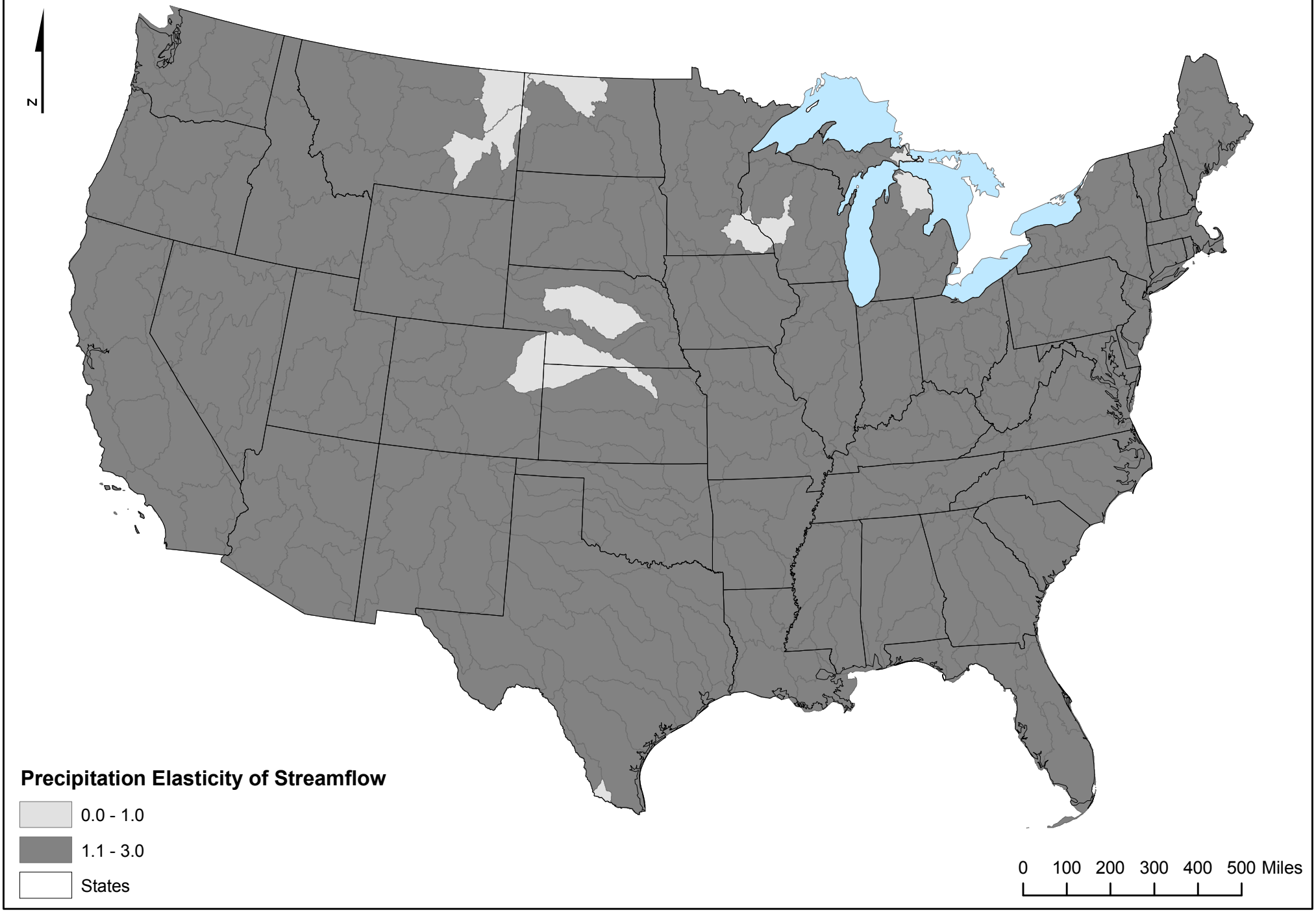
#373 Herbicides in Groundwater, 1992-2003



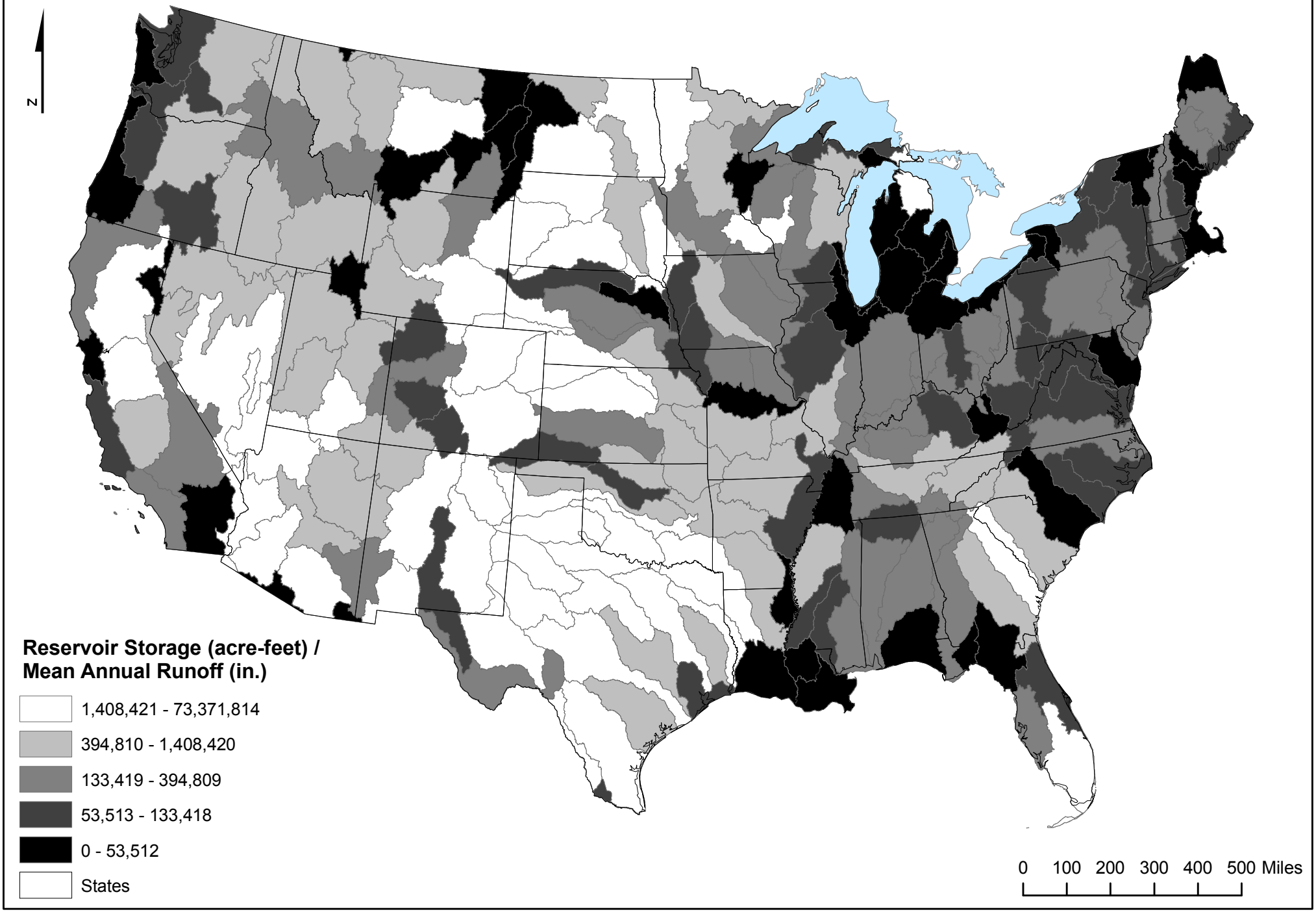
#374 Insecticides in Groundwater, 1992-2003



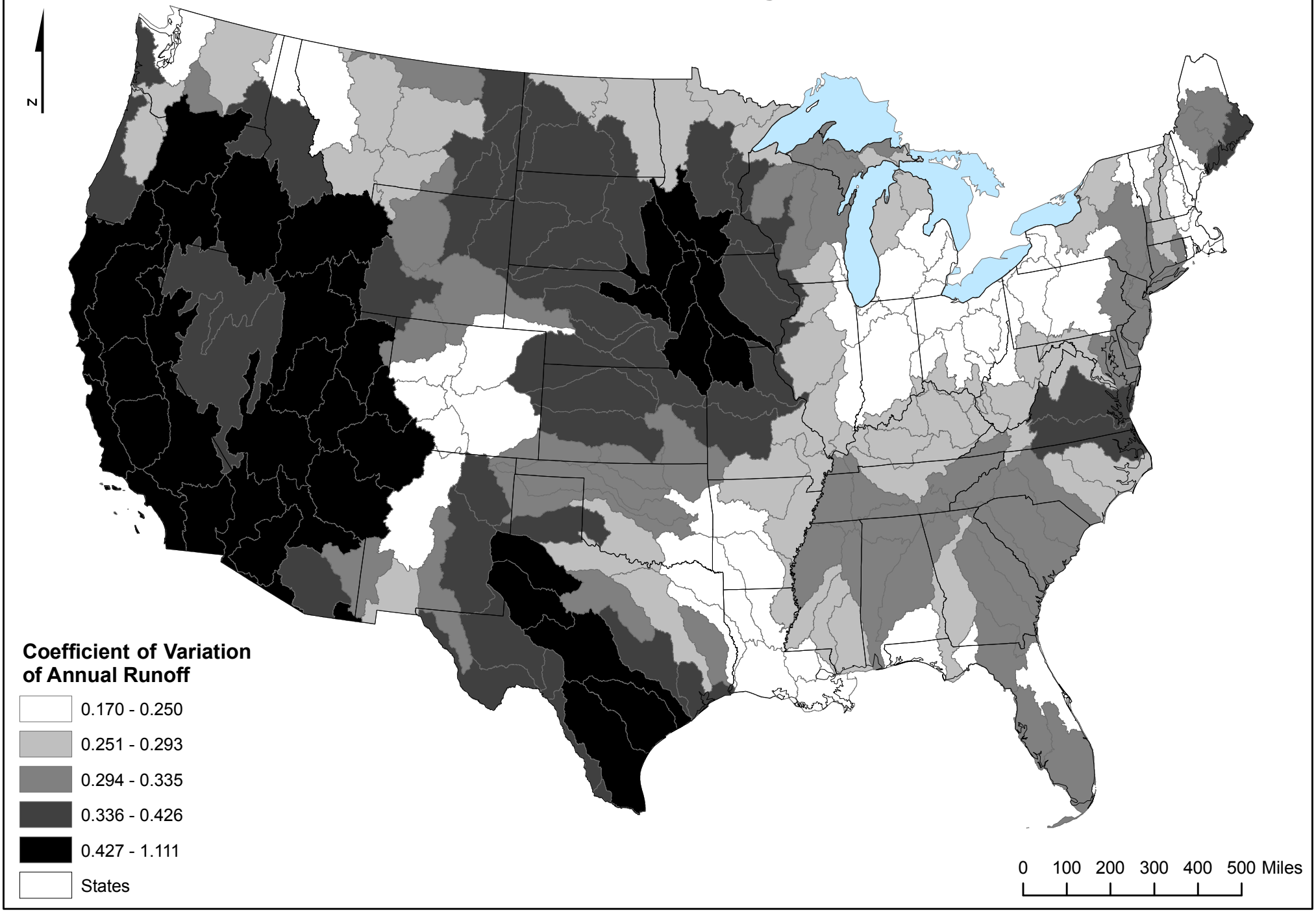
#437 Precipitation Elasticity of Streamflow, 1951-1988



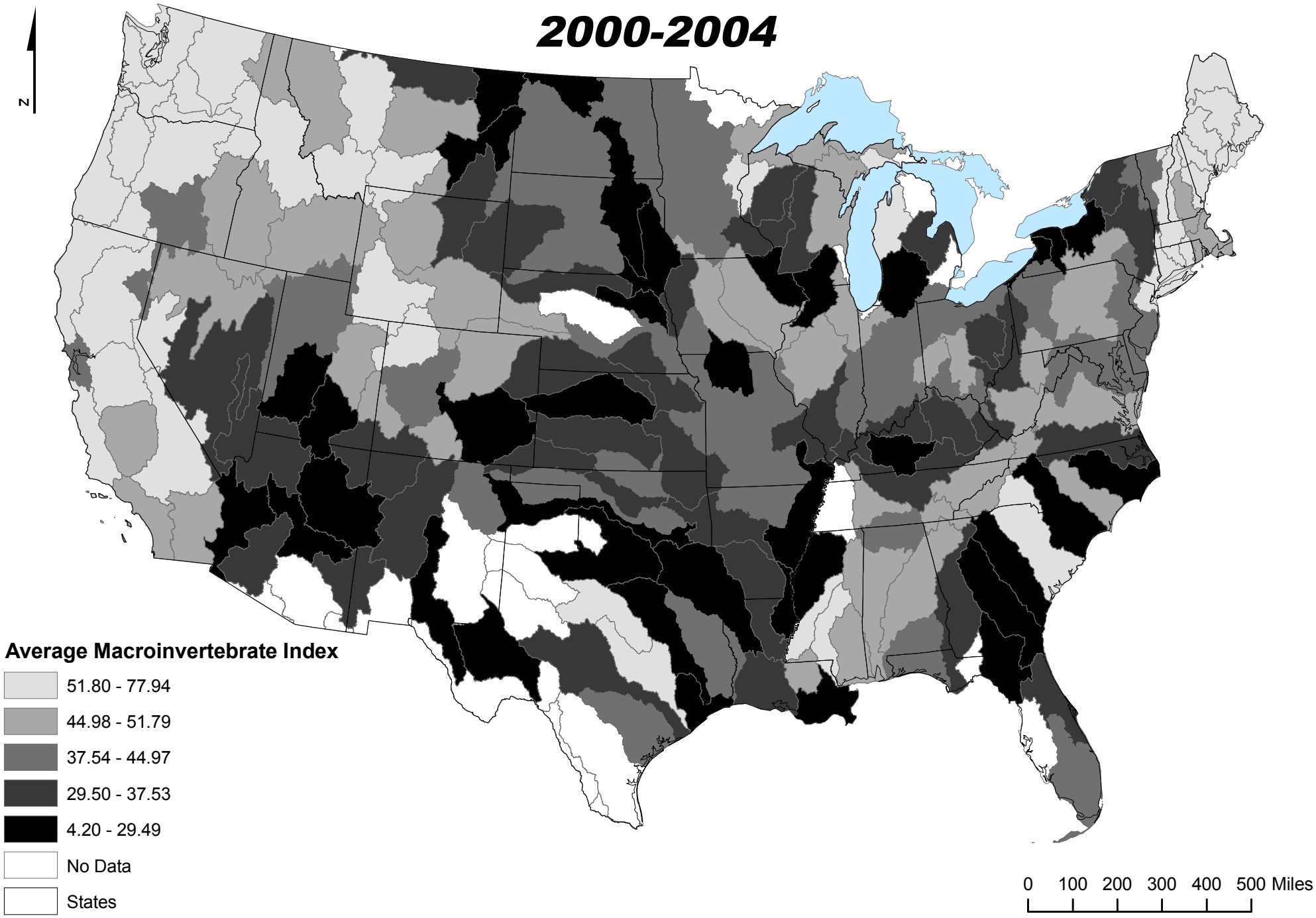
#449 Ratio of Reservoir Storage to Mean Annual Runoff



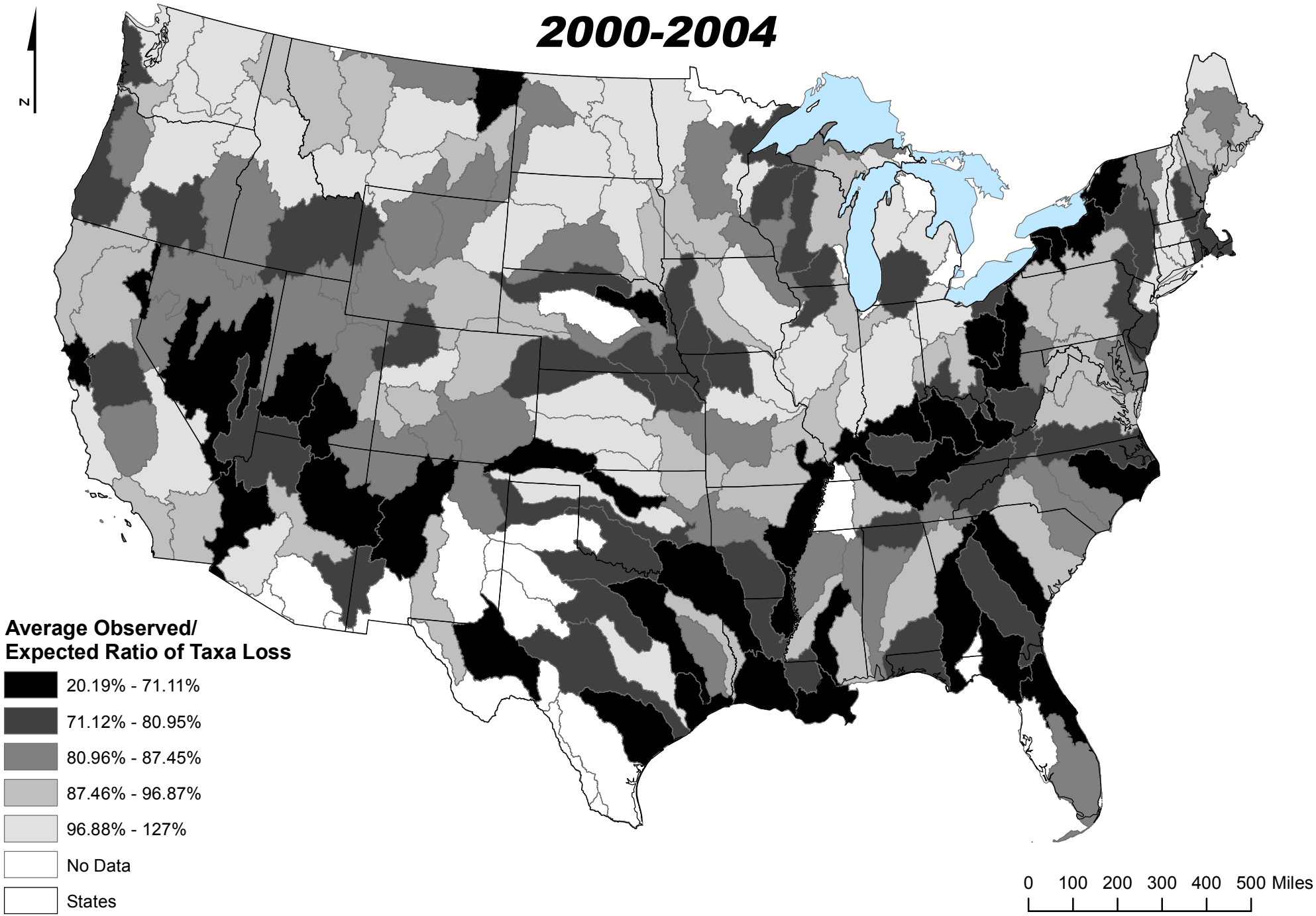
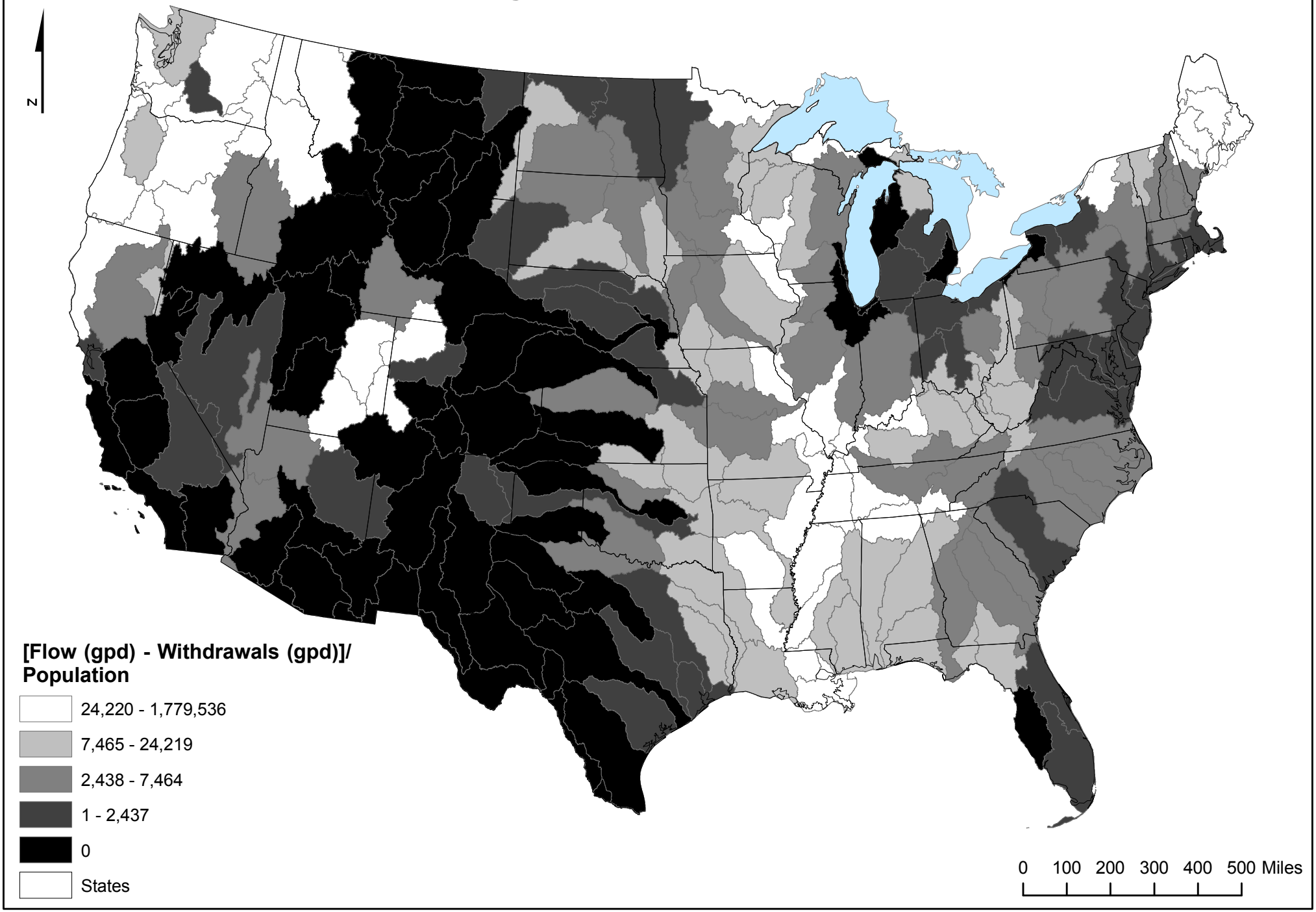
#453 Runoff Variability, 1984-1993



#460 Macroinvertebrate Index of Biotic Condition, 2000-2004



#461 Macroinvertebrate O/E Ratio of Taxa Loss, 2000-2004



#623 Water Availability: Net Streamflow per Capita, 1995