Appendix G. Descriptions of Example Indicator Maps by HUC-4 Watershed

This appendix describes the 25 example maps of vulnerability indicators presented in Appendix F. Descriptions of U.S. geographical regions and are based on the definitions provided by the U.S. Census Bureau. Subregions were based on U.S. Census definitions, but modified slightly for clarity.

1. **Northeast**
   a. New England
      i. Connecticut
      ii. Maine
      iii. Massachussetts
      iv. New Hampshire
      v. Rhode Island
      vi. Vermont
   b. Middle Atlantic
      i. New Jersey
      ii. New York
      iii. Pennsylvania
2. **Midwest**
   a. Great Lakes
      i. Indiana
      ii. Illinois
      iii. Michigan
      iv. Ohio
      v. Wisconsin
   b. Western Midwest
      i. Iowa
      ii. Kansas
      iii. Minnesota
      iv. Missouri
      v. Nebraska
      vi. North Dakota
      vii. South Dakota
3. **South**
   a. South Atlantic
      i. Delaware
      ii. Distric of Columbia
      iii. Maryland
      iv. North Carolina
      v. South Carlolina
      vi. Virgina
      vii. West Virginia
   b. Southeast
      i. Florida
      ii. Georgia
      iii. Kentucky
      iv. Alabama
      v. Mississippi
      vi. Tennessee
   c. Central South
      i. Texas
      ii. Oklahoma
      iii. Arkansas
      iv. Louisiana
4. **West**
   a. Mountain West
      i. Arizona
      ii. Colorado
      iii. Idaho
      iv. New Mexico
      v. Montana
      vi. Utah
      vii. Nevada
      viii. Wyoming
   b. Pacific West
      i. California
      ii. Oregon
      iii. Washington

#1 Acid Neutralizing Capacity

This continental U.S. indicator map shows the percentage of sites with Acid Neutralizing Capacity (ANC) less than 100 millieq/L in each HUC-4 area. Data were available for the vast majority of lower-48 watersheds. The majority of watersheds are at 0%. Most of the watersheds with less ANC are a narrow band which spans from the Southeast to the Northeast. Only six watersheds are in the lowest category of ANC (25.01 - 100% of sites <100 millieq/L).

#22 At-Risk Freshwater Plant Communities

The continental U.S. map for this indicator shows the percentage of freshwater plant communities that are considered at-risk in each HUC-4 area. Data were available for all lower-48 watersheds. The regions with the highest percentages of freshwater plant communities at risk (56.51 - 100.0% at risk) for this indicator occur in the South Atlantic, Southeast, Northwest, large parts of Kansas, Missouri, Indiana, Ohio, and Louisiana. Relatively high percentages of plant communities at risk (52.25 - 56.50%) occur in Texas and in parts of the Mountain West and Midwest, extending eastward from Wyoming to Ohio.

Moderate percentages of plant communities at risk (48.03 - 52.24%) occur in a contiguous band in the Southwest, and in large parts of Montana, South Dakota, and Arkansas. Relatively lower percentages of communities at risk (38.92 - 48.02%) occur in two vertical bands in the northern Midwest region, and a horizontal band in the Southwest, including parts of Arizona, New Mexico, and small parts of Texas and Oklahoma. The Northeast and parts of Minnesota, Iowa, and Arizona have the lowest percentages (8.708 - 38.91%) of at-risk freshwater plant communities.

#24 At-Risk Native Freshwater Species

This continental U.S. indicator map shows the percentage of at-risk native freshwater species in each HUC-4 area. Data were available for all lower-48 watersheds. This map displays a very clear pattern. Homogenous blocks of high percentages of risk (12.23 - 25.25%) are found in the Southwest, East Texas, and the Southeast. With very few exceptions, risk is a steady gradation from these areas to New England and the central U.S., which are at very low percentages of risk (2.135 - 4.032%). The Chesapeake Bay is also an area with low percentage of species at risk.

#51 Coastal Vulnerability Index– CVI

This continental U.S. indicator map shows the Coastal Vulnerability Index (CVI) for coastline areas. Data were available for all lower-48 coastlines. Areas of high vulnerability (3.19 - 3.97) include parts of the California, Texas, and North Carolina, as well as the entire Mississippi Delta coastline and the Chesapeake Bay. Areas of moderate (2.84 - 3.18), medium (2.42 - 2.83), and low (1.78 - 2.41) vulnerability are interspersed along the coastline. Very low (1.00 - 1.77) vulnerability occurs mostly on the Northeast coastline.

#125 Groundwater Reliance

This continental U.S. indicator map shows the percentage of groundwater reliance in each HUC-4 area. Data were available for all lower-48 watersheds. A high level (54.95 - 99.94%) of groundwater reliance is mainly observed in a vertical band in the Midwest, stretching from parts of North Dakota to much of West Texas, as well as in two clusters in the Southwest and along the Mississippi River. Moderate to low (4.285 - 54.94%) groundwater reliance is observed scattered across the nation. The main area with almost no groundwater reliance (0.080 - 4.284%) is in the Mountain West, and stretches from Montana to the Four Corners. Other watersheds with almost no groundwater reliance are scattered across the nation, most notably in central Texas; which is in direct contrast with adjacent watersheds with high groundwater reliance.

#165 Meteorological Drought Indices

This continental U.S. indicator map shows the average Palmer Drought Severity Index (PDSI) in each HUC-4 area. Data were available for all lower-48 watersheds. A high PDSI values (1.39 to 15) are observed mainly in the Northeast. Moderate and low PDSI values (0.308 to 1.38, and -0.214 to 0.307) are observed in the central Midwestern states. Very low and extremely low PDSI values (-0.931 to -0.215, and -7.33 to -0.932) are observed mainly in the Northwest, southern Mountain West, Central South, and the Southeast.

#218 Ratio of Snow to Total Precipitation

This continental U.S. indicator map shows the ratio of total snowfall to total precipitation in each HUC-4 area. Data were available for all lower-48 watersheds. Unsurprisingly, this map shows a strong north-south trend, with the highest ratios (0.20 - 0.47) in the northen and mountainous regions, including the West, Great Lakes region, and parts of New England. These high ratios are surrounded by graded bands of moderate (0.12 - 0.19), low (0.037 - 0.11), and very low (0.0041 - 0.036) snowfall to total precipitation ratios. Parts of California and Arizona have a ratio of zero, as does the Gulf Region.

#219 Ratio of Water Withdrawals to Annual Streamflow

This continental U.S. indicator map shows the ratio of water withdrawals to annual streamflow in each HUC-4 area. Data were available for all lower-48 watersheds. High ratios (1.6 - 59) are almost exclusively found in the West (with small exceptions in the Lower Peninsula of Michigan and the Buffalo region). Moderate ratios (0.54 - 1.5) are found largely in the West, along the Middle Atlantic Corridor, in Florida, and in the Great Lakes region. Low (0.17 - 0.53) and very low (0.056 - 0.16) ratios are scattered throughout the country, but with higher prevalence in the East. Ratios of almost zero (0.00068 - 0.055) are found largely near the Mississippi River or tributaries, in the Pacific Northwest, and in New England.

#284 Stream Habitat Quality

This continental U.S. indicator map shows stream habitat quality, as defined by the average rapid bioassessment protocol score, in each HUC-4 area. Data were available for the vast majority of lower-48 watersheds. The highest scores (147.1 - 190.0 and 135-.7 - 147.0) are scattered throughout the country, with clusters found in the South Atlantic and Northeast, the northern Mountain West, and the Pacific Northwest. Moderate scores (125.1 - 135.6 and 109.3 - 125.0) are also found throughout the country, with clusters in the Northwest and Great Lakes Region. The lowest scores (40.0 - 109.2) are found in Georgia and a vertical band in the Midwest.

#326 Wetland and Freshwater Species at Risk

This continental U.S. indicator map shows the number of wetland and freshwater species that are at risk in each HUC-4 area. Data were available for all lower-48 watersheds. A large number (29 - 161) of species are at risk in most of the watersheds in the Southeast, and in a few watersheds in the Northeast and West. Watersheds with a moderate (16 - 28) number of species at risk are largely found near watersheds with a high number of species at risk. Watersheds with a low (11 - 15) and very low (6 - 10) number of species at risk are found everywhere but the

Southeast. Watersheds with almost no (0 - 5) species at risk are mostly found in the northern Mountain West and Western Midwest

#348 Erosion Rate

This continental U.S. indicator map shows the average erosion rate in each HUC-4 area. Data were available for all lower-48 watersheds. High (9.595 - 25.57 tons/ha/year) and moderate (5.862 - 9.594 tons/ha/year) soil loss is found principally in the West, Middle Atlantic, and parts of the Southeast. Lower (0.5391 - 5.861 tons/ha/year) soil loss rates are found scattered about the country and in a vertical band from Montana to Texas.

#351 Instream Use/Total Streamflow

This continental U.S. indicator map shows the ratio of in stream use to total streamflow in each HUC-4 area. Data were available for all lower-48 watersheds. All watersheds but one fall in the 0.60 to 1.00 category, with one watershed in Oklahoma and Kansas in the 1.01 to 1.09 category.

#352 Total Use / Total Streamflow

This continental U.S. indicator map shows the ratio of total use to total streamflow in each HUC-4 area. Data were available for all lower-48 watersheds. Most watersheds fall in the 0.60 to 1.00 category. However there are a few in the Southwest and southern Midwest in the 1.01 to 17.82 category.

#364 Pesticide Toxicity Index

This continental U.S. indicator map shows the Daphnia species pesticide toxicity index in each HUC-4 area. Data were not available for many of the lower-48 watersheds. Available data is insufficient to infer geographic patterns.

#367 Herbicide Concentrations in Streams

This continental U.S. indicator map shows herbicide concentrations in streams in each HUC-4 area. Data were not available for many of the lower-48 watersheds. Available data is insufficient to infer geographic patterns.

#369 Insecticide Concentrations in Streams

This continental U.S. indicator map shows insecticide concentrations in streams in each HUC-4 area. Data were not available for many of the lower-48 watersheds. Available data is insufficient to infer geographic patterns.

#371 Organochlorines in Bed Sediment

This continental U.S. indicator map shows organochlorine concentrations in streambed sediment in each HUC-4 area. Data were not available for many of the lower-48 watersheds. Available data is insufficient to infer geographic patterns.

#373 Herbicides in Groundwater

This continental U.S. indicator map shows herbicide concentrations in groundwater in each HUC-4 area. Data were available for many of the lower-48 watersheds. Available data is insufficient to infer geographic patterns.

#374 Insecticides in Groundwater

This continental U.S. indicator map shows insecticide concentrations in groundwater in each HUC-4 area. Data were not available for many of the lower-48 watersheds. Available data is insufficient to infer geographic patterns, but does indicate the possibility of higher concentrations in the Middle Atlantic Corridor.

#437 Precipitation Elasticity of Streamflow

This continental U.S. indicator map shows the precipitation elasticity of streamflow in each HUC-4 area. Data were available for all lower-48 watersheds. Every watershed has elasticity in the higher range (1.1 - 3.0) except for a few scattered throughout the Midwest and one in Texas, which have elasticity in the lower range (0.0 - 1.0).

#449 Ratio of Reservoir Storage to Mean Annual Runoff

This continental U.S. indicator map shows the ratio of reservoir storage to mean annual runoff in each HUC-4 area. Data were available for all lower-48 watersheds. High (1,408,421 - 73,371,814 acre-feet/inch) ratios are largely found in the vertical band between North Dakota and Texas. Moderate ratios (394,810 - 1,408,420 acre-feet/inch) are largely found in the Midwest and the West. Low (133,419 - 394,809 acre-feet/inch), very low (53,513 - 133,418 acre-feet/inch), and extremely low (0 - 53,512 acre-feet/inch) ratios are largely found in coastal and Great Lakes watersheds.

#453 Runoff Variability

This continental U.S. indicator map shows the coefficient of variation of annual runoff in each HUC-4 area. Data were available for all lower-48 watersheds. A high (0.427 - 1.111) coefficient is observed in clusters covering much of the West, an area in the Midwest centered on Iowa, and part of Texas. Watersheds with a moderate (0.336 - 0.426) ratio are observed adjacent to those clusters as well as in Maine and the Chesapeake region. Watersheds with a low (0.294 - 0.335) and very low (0.251 - 0.293) ratio are observed across the country. The watersheds with the lowest ratio (0.170 - 0.250) are south of the Great Lakes, in New England, and the lower Mississippi Basin.

#460 Macroinvertebrate Index of Biotic Condition

This continental U.S. indicator map shows the macroinvertebrate index of biotic condition in each HUC-4 area. Data were available for the vast majority of lower-48 watersheds. There is no discernable geographic pattern to the distribution of categories of watersheds.

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

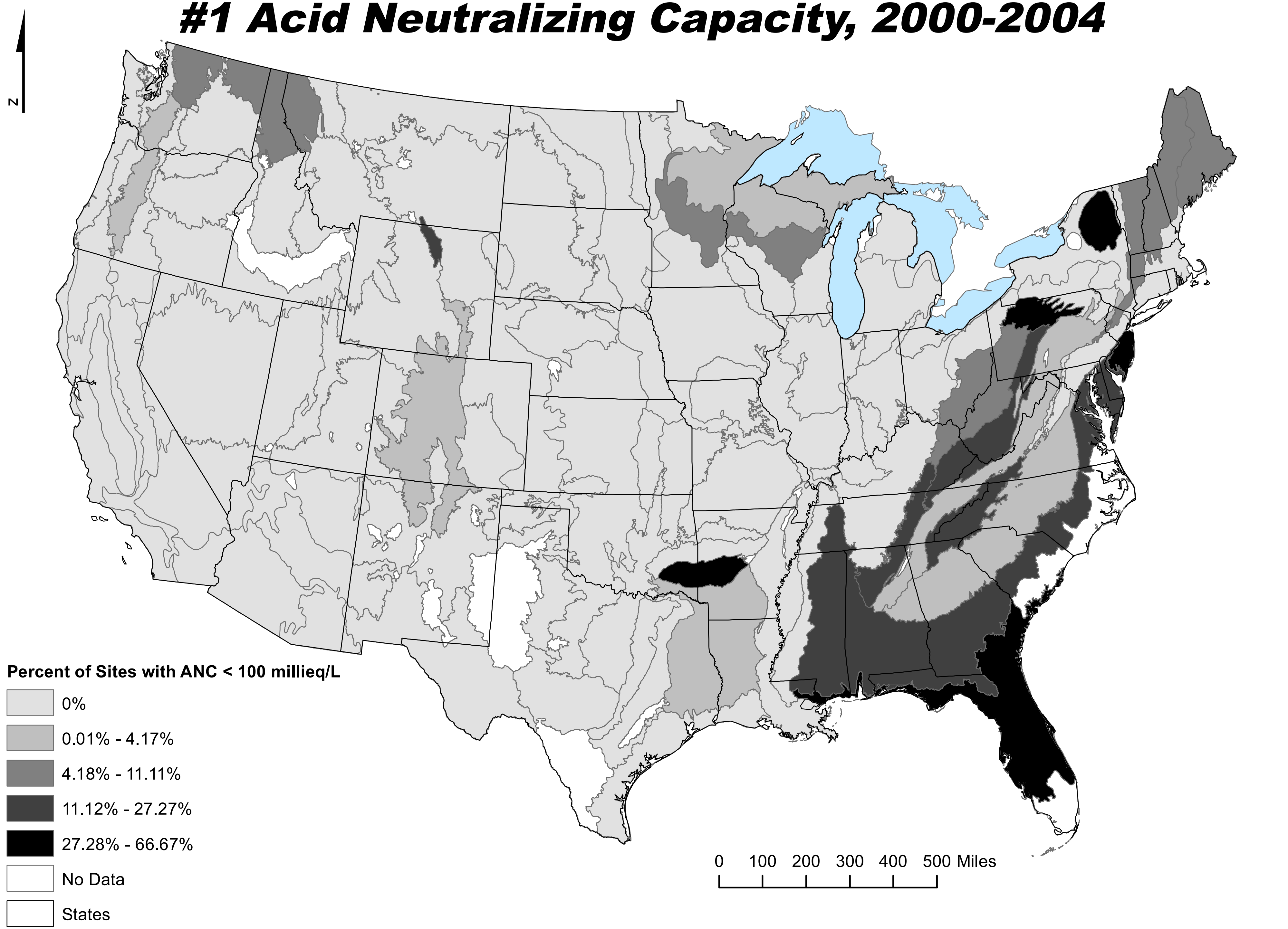
This continental U.S. indicator map shows the observed taxa as a percentage of the expected macroinvertebrate taxa in each HUC-4 area. Data were available for the vast majority of lower-48 watersheds. This map shows a certain amount of spatial heterogeneity. The highest ratios (96.88% - 127%) occur mostly along the West Coast, in the Pacific Northwest, the Midwest, and New England. Moderate ratios (87.46% - 96.87%) are found in large parts of California, parts of the Northwest, Great Lakes, and South and Middle Atlantic regions. The remaining ratio categories (20.19% - 71.11%, 71.12% - 80.95%, and 80.96% - 87.45%) have no discernable geographic distribution.

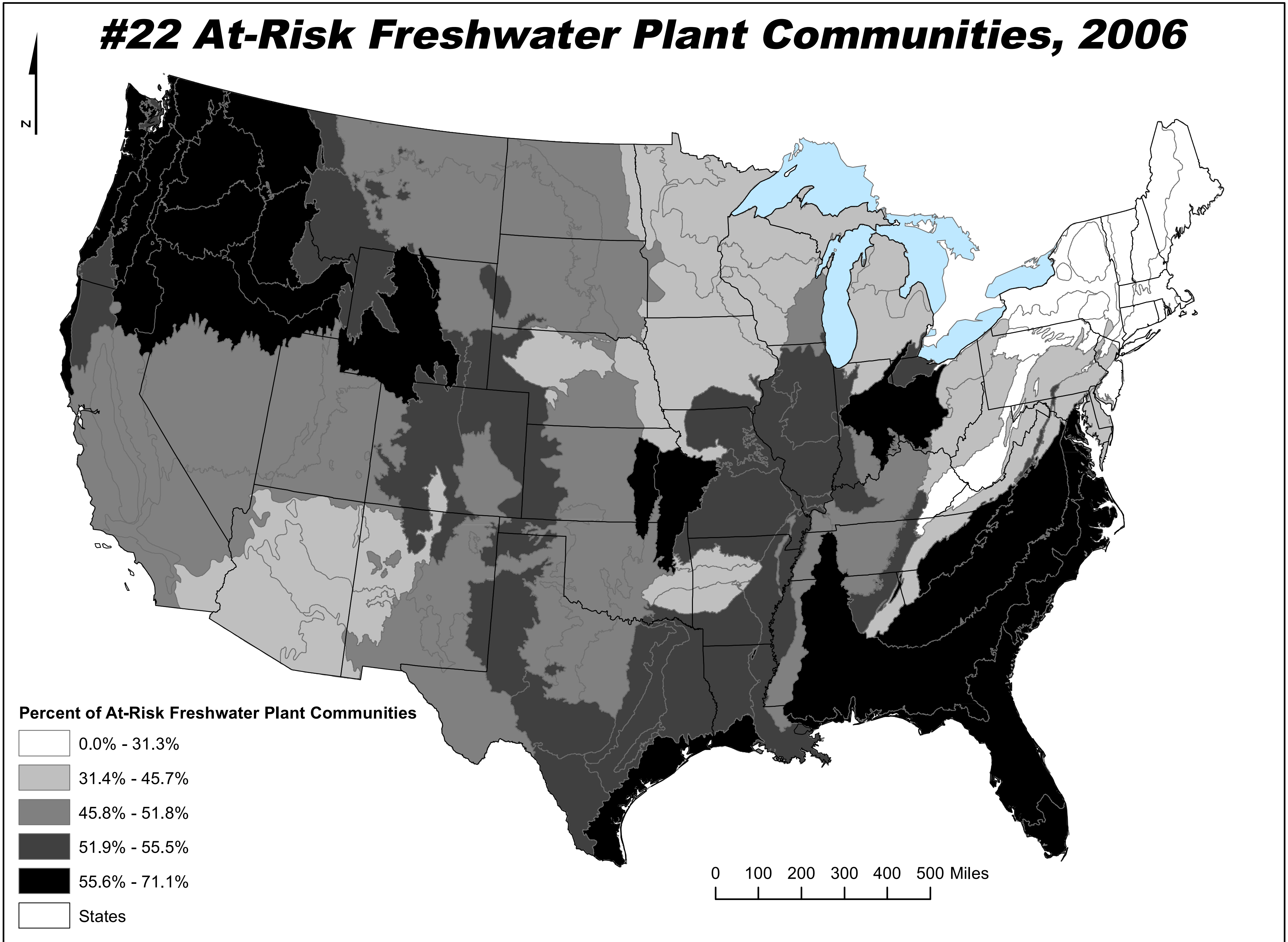
#623 Water Availability: Net Streamflow per Capita

This continental U.S. indicator map shows the net streamflow per capita in each HUC-4 area. Data were available for all lower-48 watersheds. High flow per capita (24,220 - 1,779,536 gpd/capita) watersheds are found in the Pacific Northwest, Colorado and Utah, the Mississippi Basin, and Maine. Moderate streamflow per capita (2,438 - 7,464 gpd/capita) watersheds are found mostly around high streamflow per capita watersheds. Very low streamflow per capita (1 - 2,437 gpd/capita) watersheds are found in the Great Lakes region, the Middle Atlantic Corridor, Florida, and the West. Zero net streamflow per capita watersheds are found in the Great Lakes Region, and throughout the West.

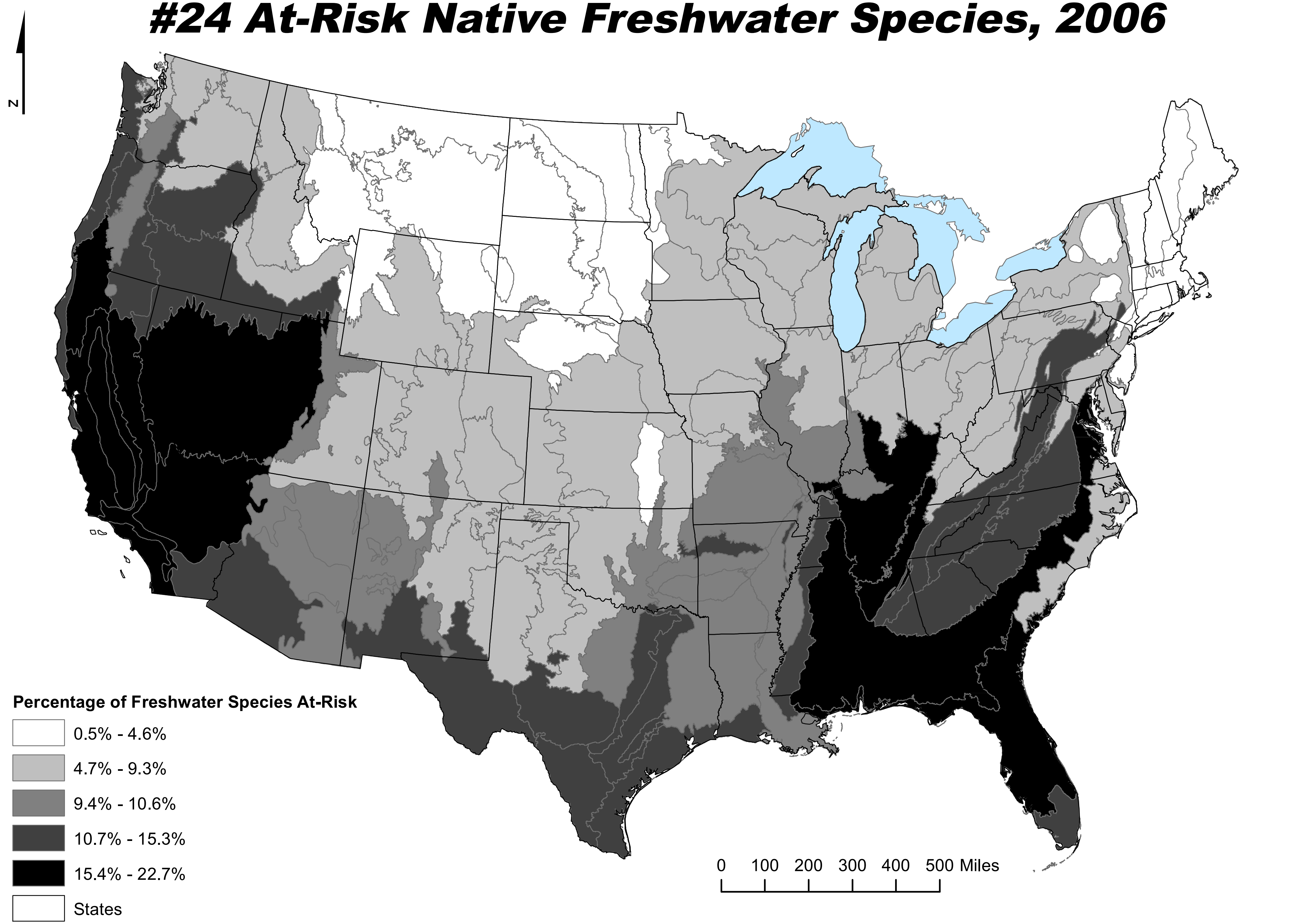
Appendix H. Example Maps for Indicators of Water Quality and Aquatic Ecosystem Vulnerability by Ecoregion

#1 Acid Neutralizing Capacity, 2000-2004

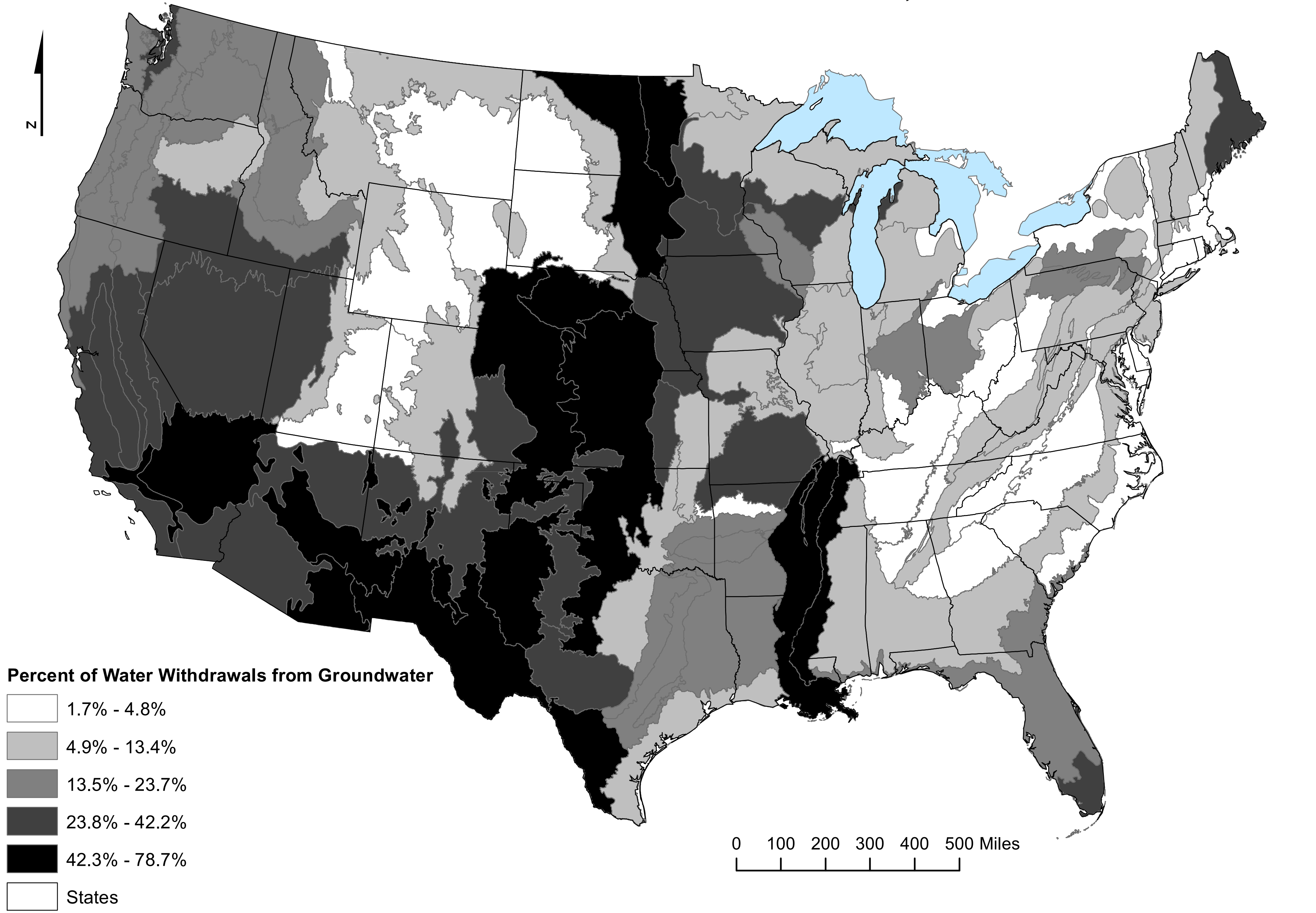



#22 At-Risk Freshwater Plant Communities, 2006
N
Percent of At-Risk Freshwater Plant Communities
0.0% - 31.3%
31.4% - 45.7%
45.8% - 51.8%
51.9% - 55.5%
55.6% - 71.1%
States
0 100 200 300 400 500 Miles

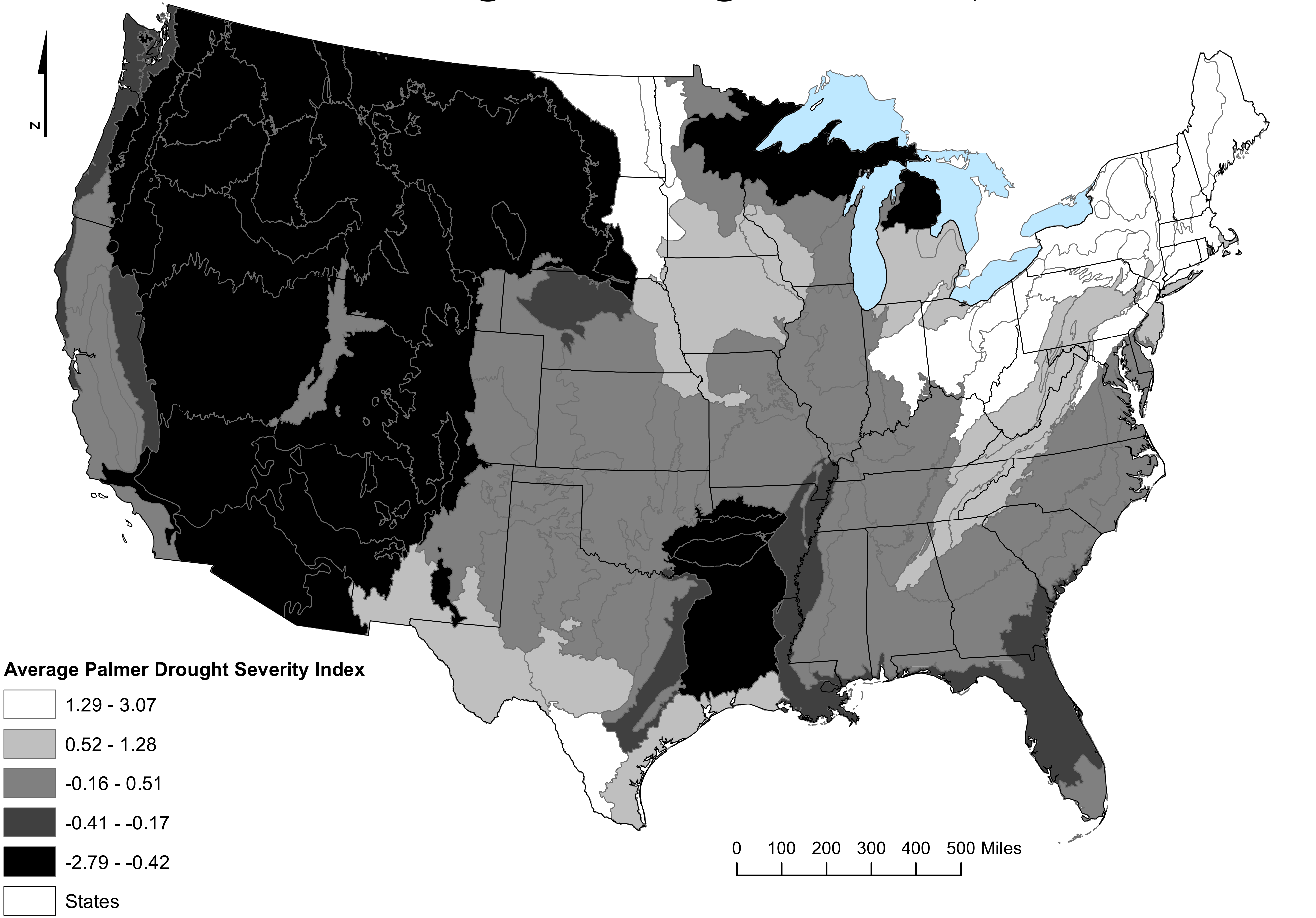
#24 At-Risk Native Freshwater Species, 2006



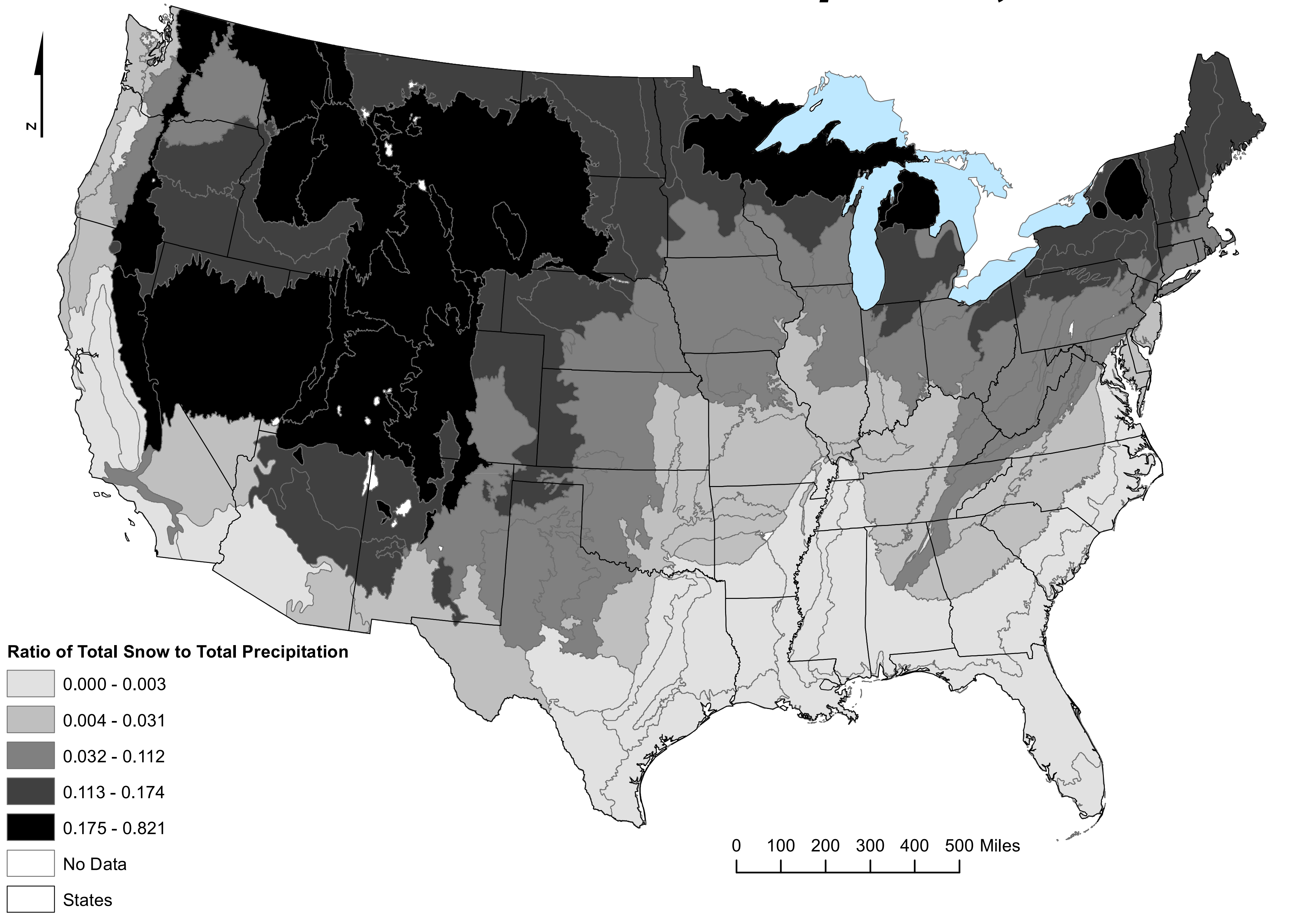
#125 Groundwater Reliance, 1995

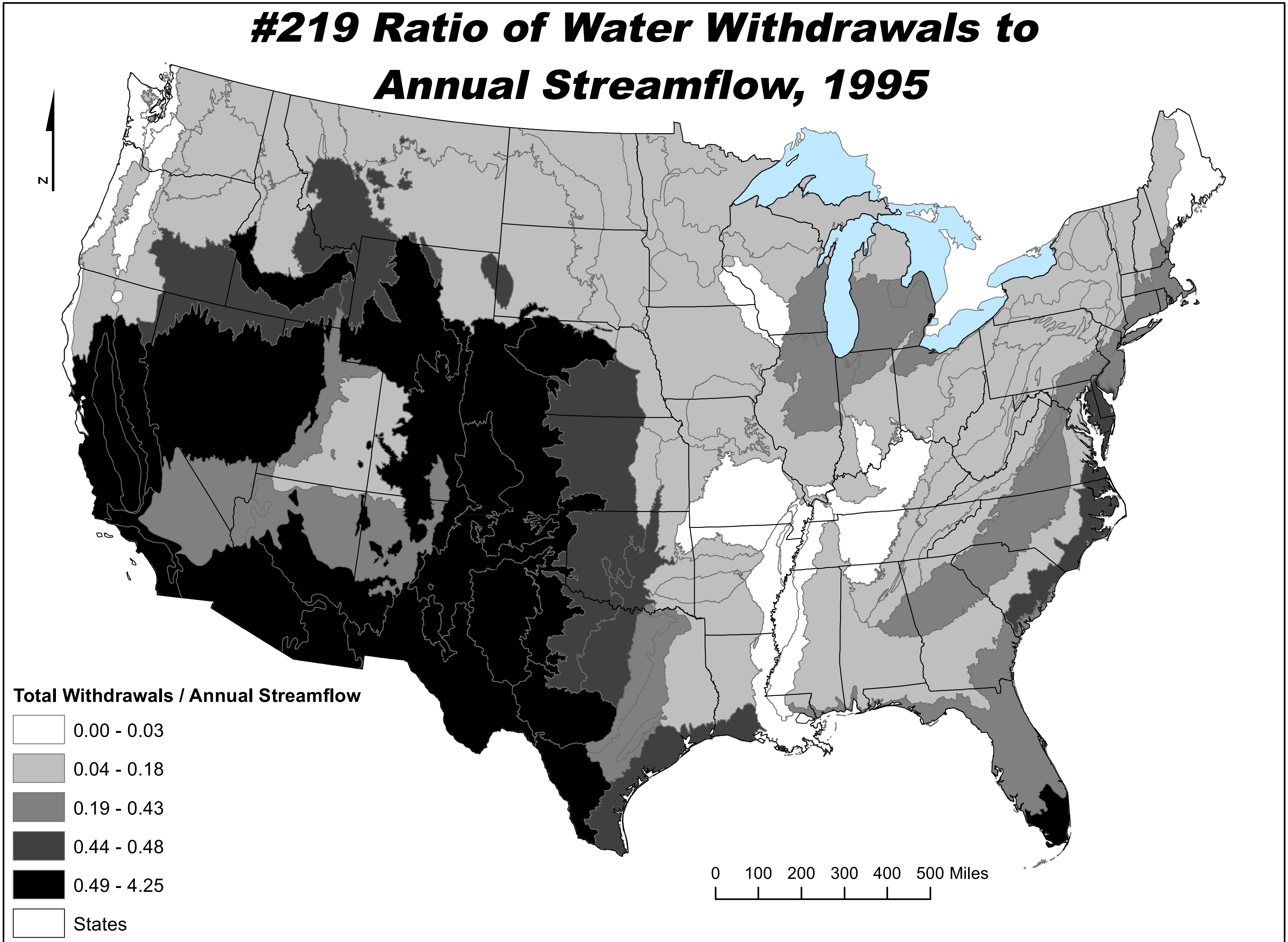


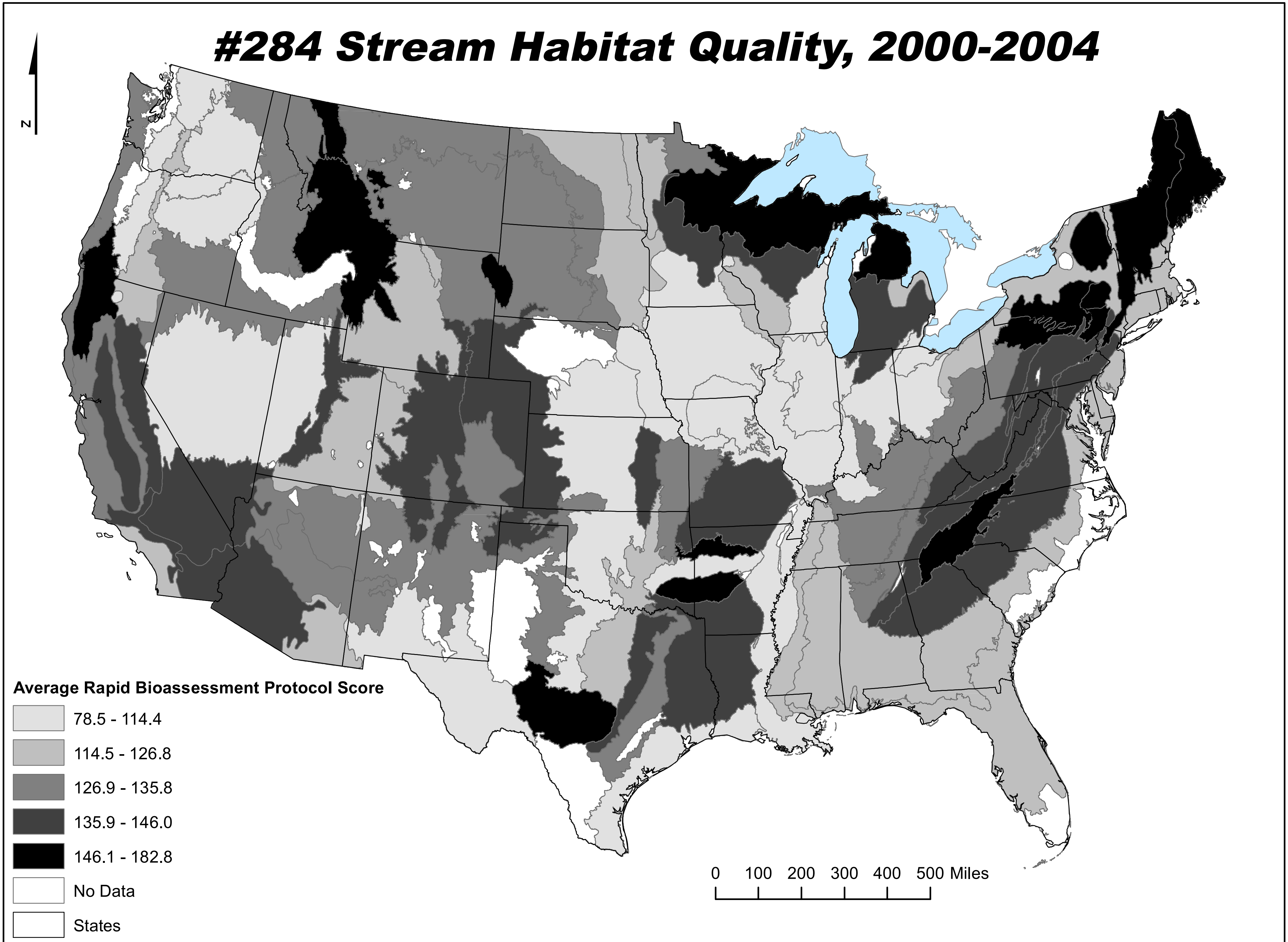
#165 Meteorological Drought Indices, 2003-2007



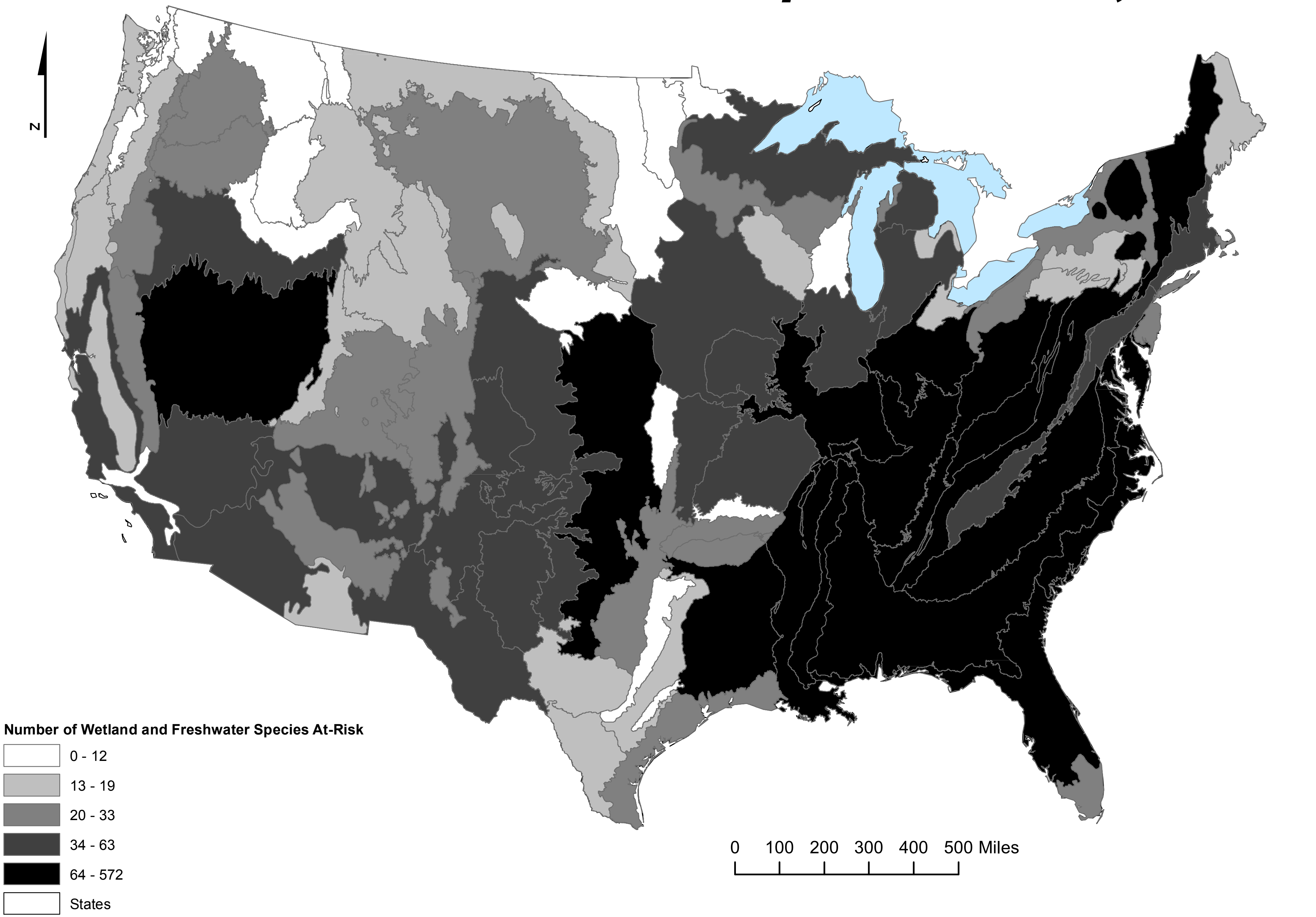
#218 Ratio of Snow to Total Precipitation, 1998-2007



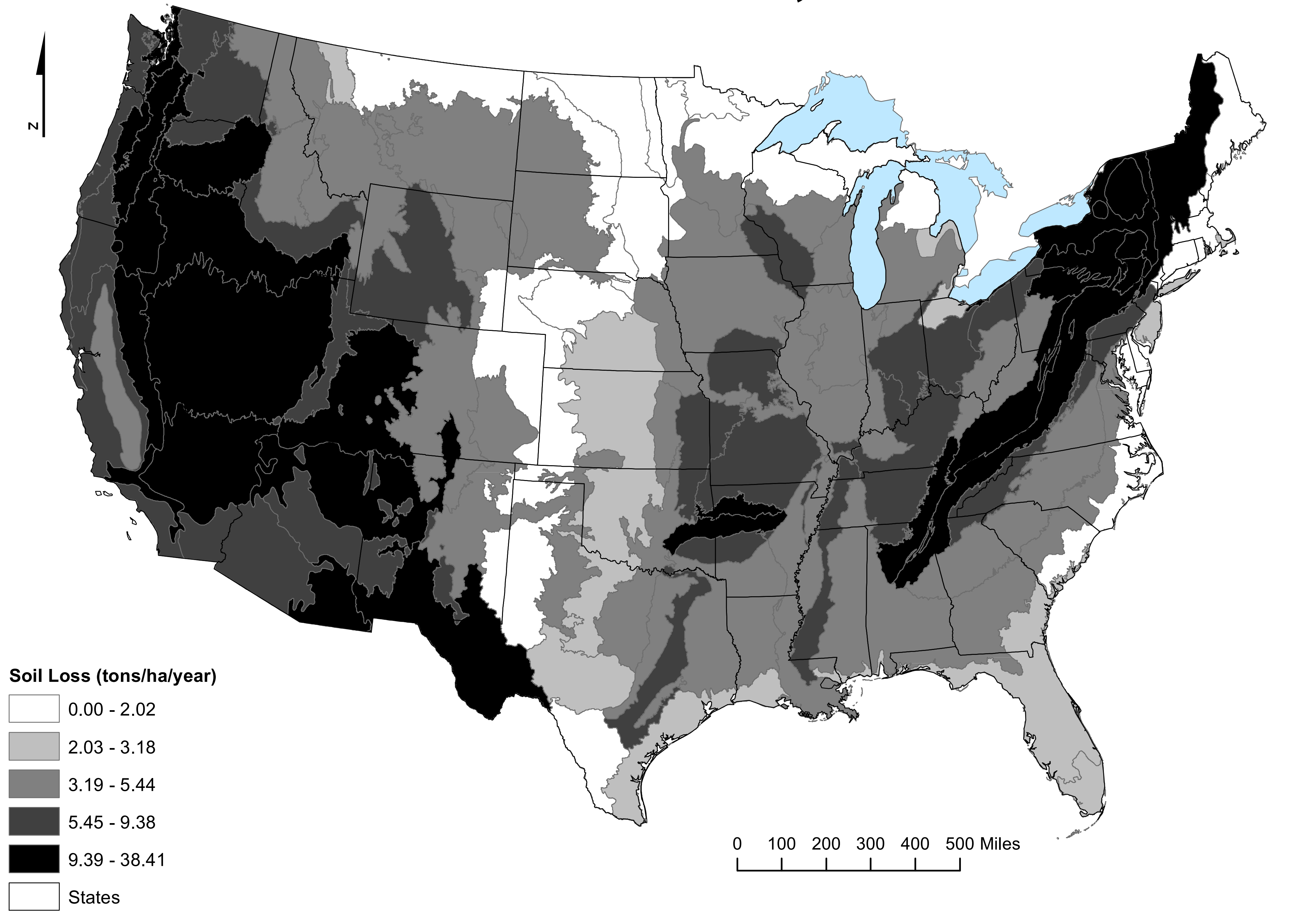

#219 Ratio of Water Withdrawals to
Annual Streamflow, 1995
N
Total Withdrawals / Annual Streamflow
0.00 - 0.03
0.04 - 0.18
0.19 - 0.43
0.44 - 0.48
0.49 - 4.25
States
0 100 200 300 400 500 Miles

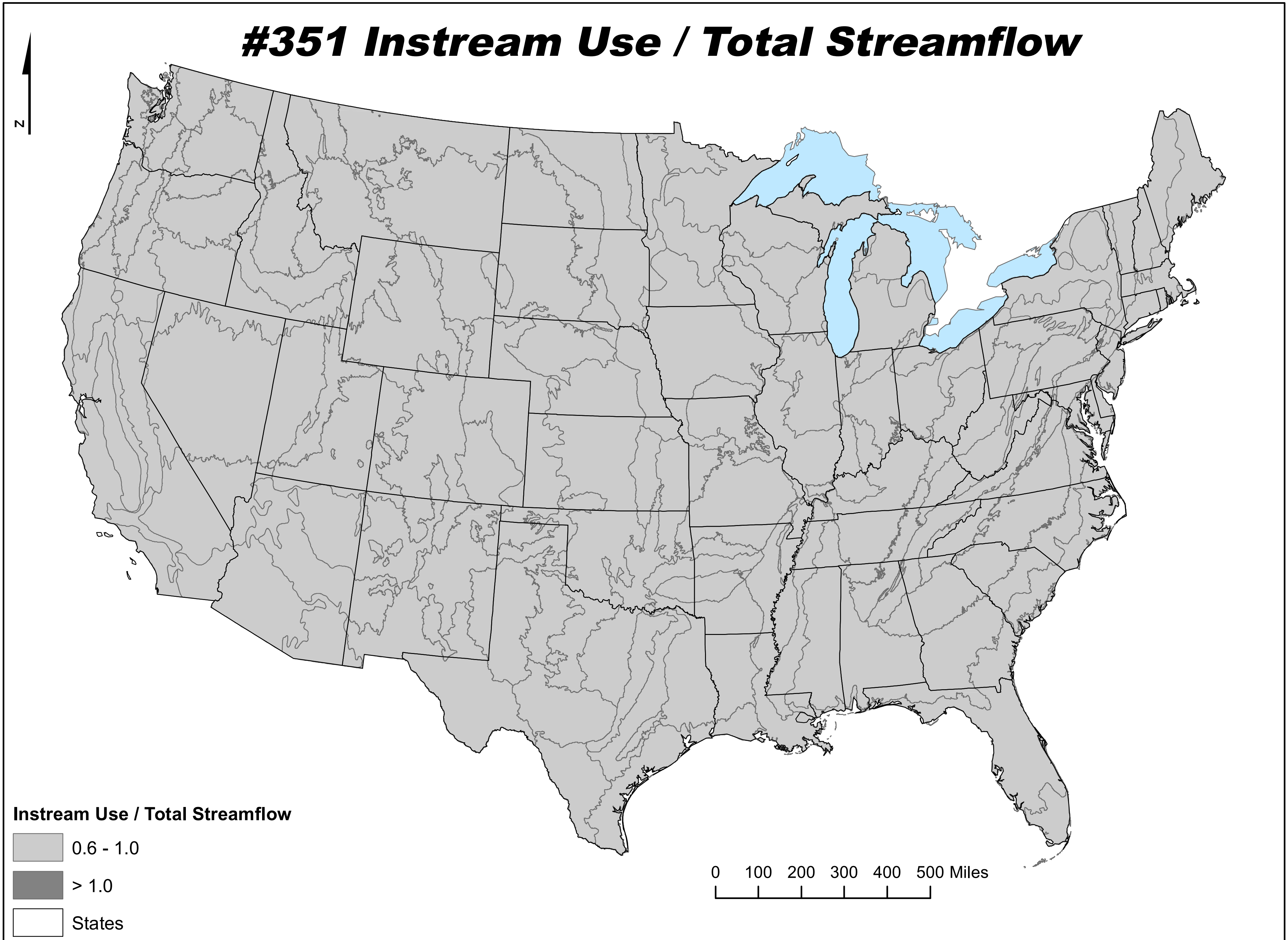

#284 Stream Habitat Quality, 2000-2004
N
Average Rapid Bioassessment Protocol Score
78.5 - 114.4
114.5 - 126.8
126.9 - 135.8
135.9 - 146.0
146.1 - 182.8
No Data
States
0 100 200 300 400 500 Miles

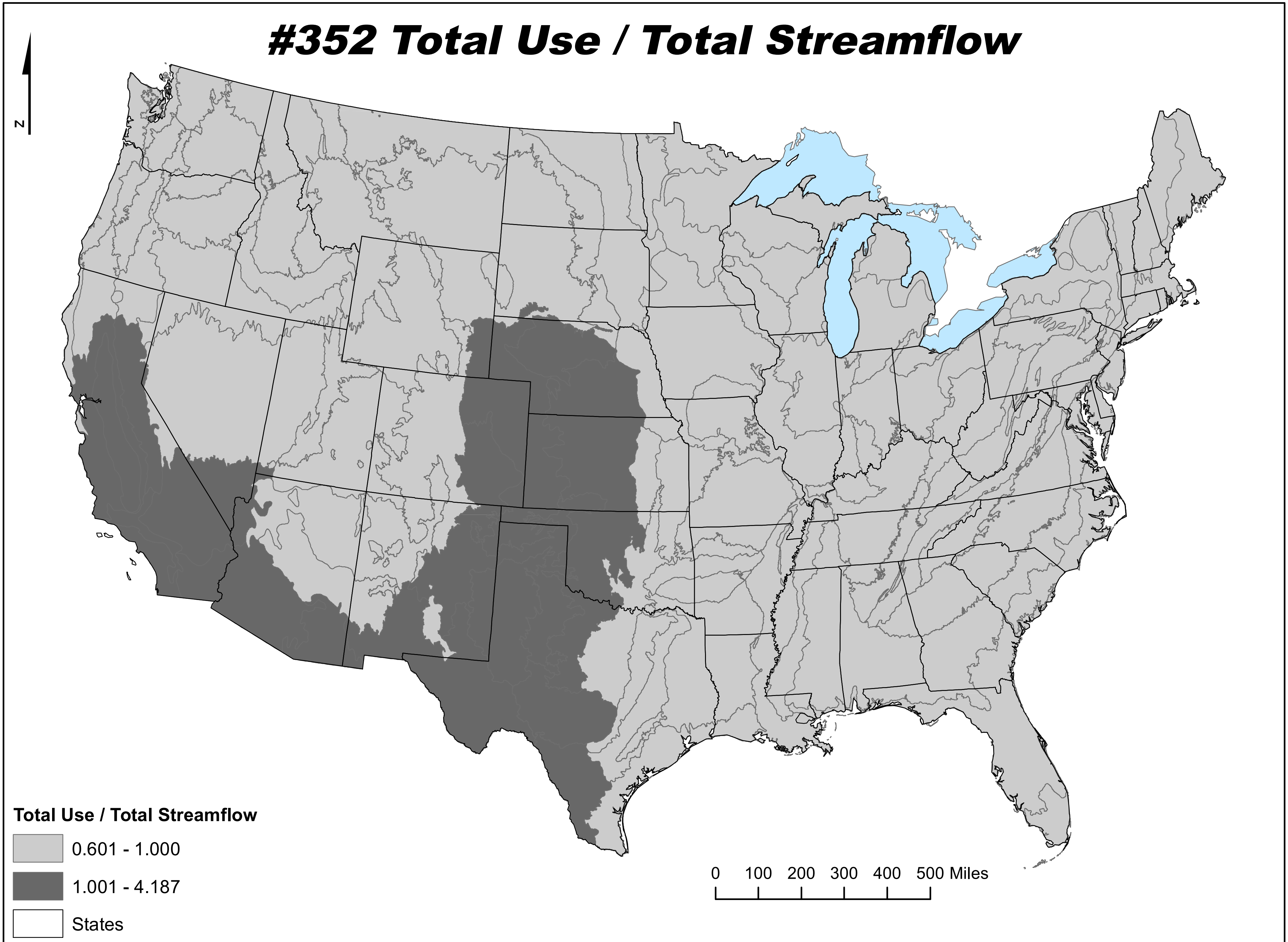
#326 Wetland and Freshwater Species At-Risk, 2006



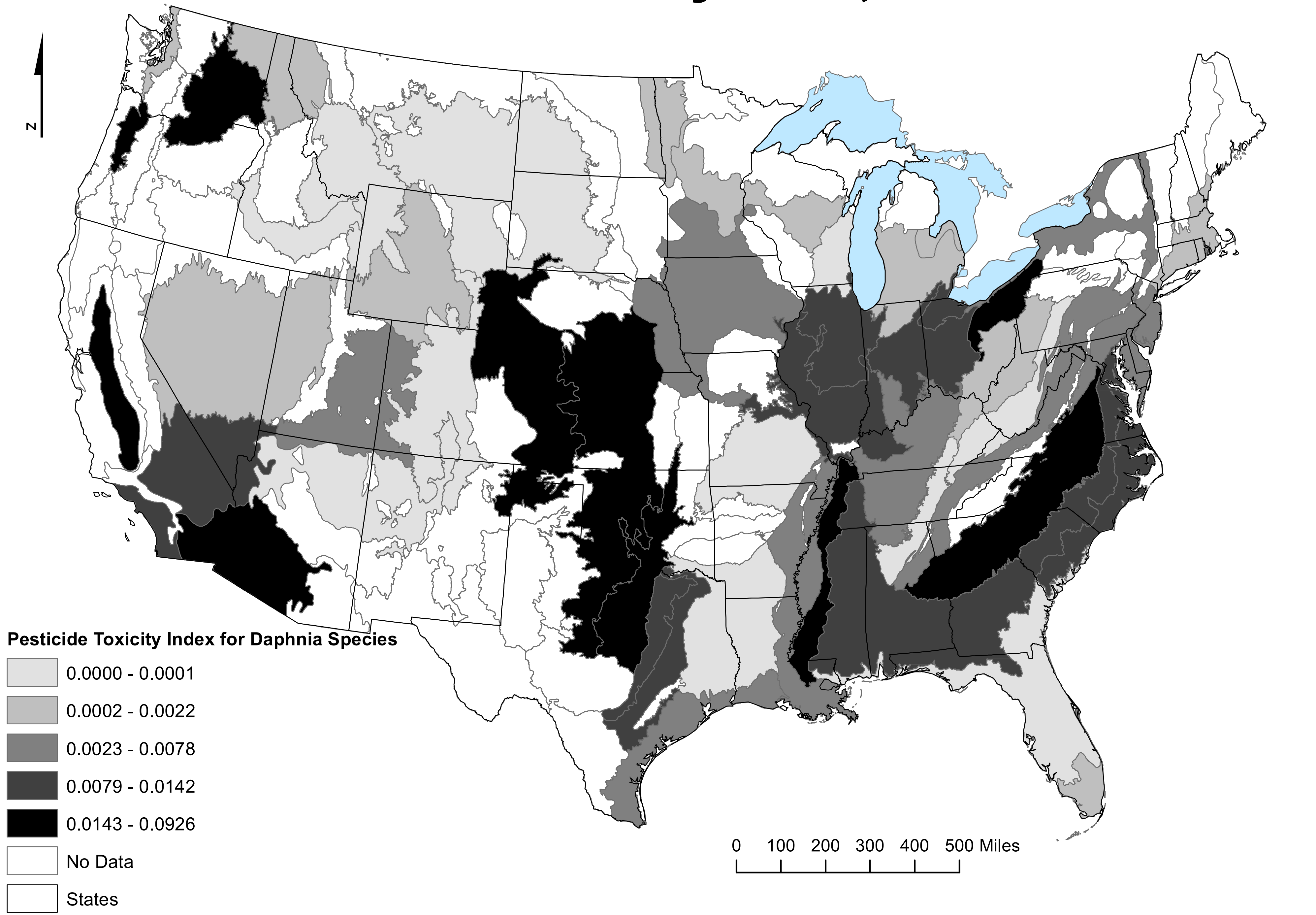
#348 Erosion Rate, 1980



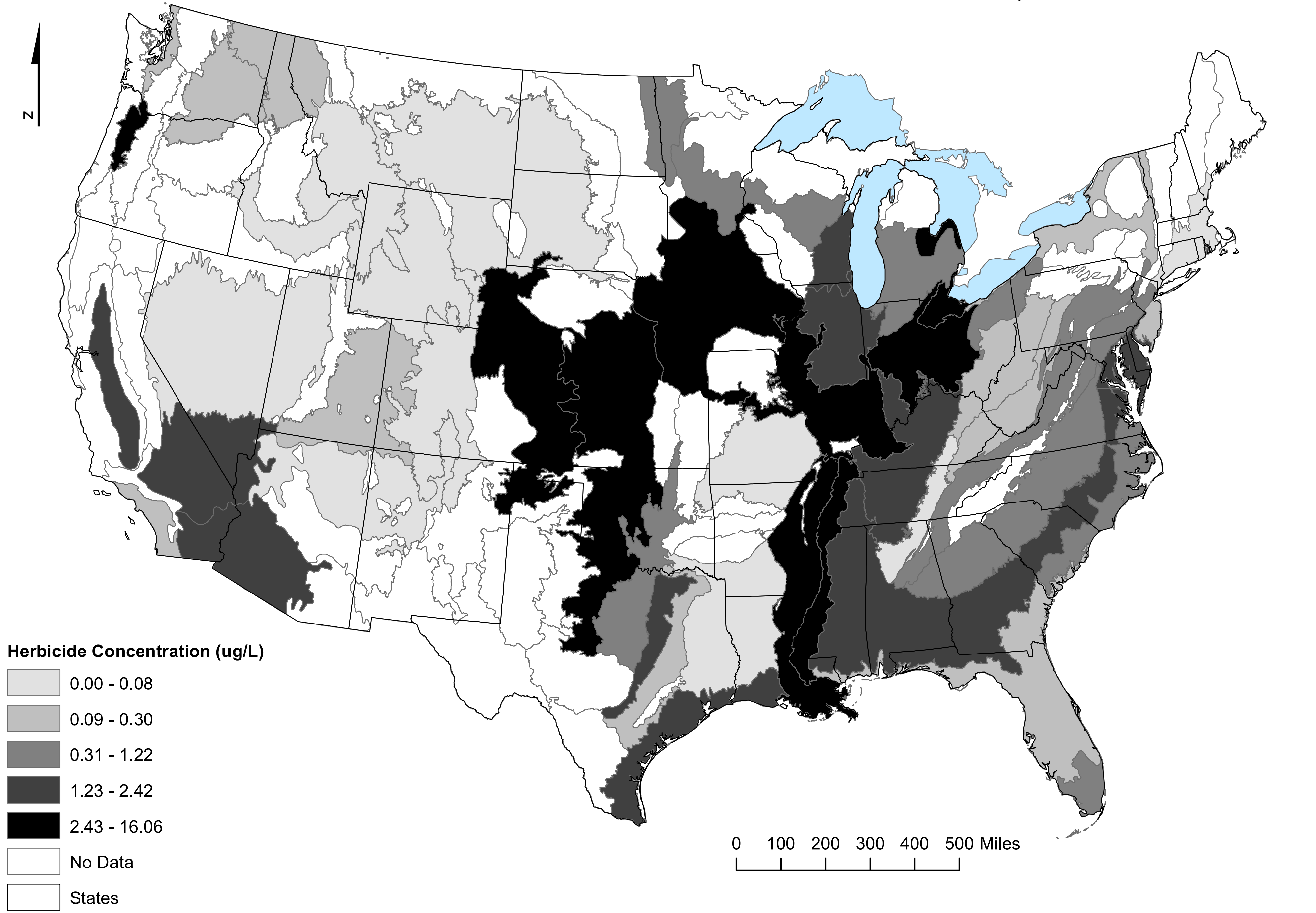

#351 Instream Use / Total Streamflow
N
Instream Use / Total Streamflow
0.6 - 1.0
> 1.0
States
0 100 200 300 400 500 Miles

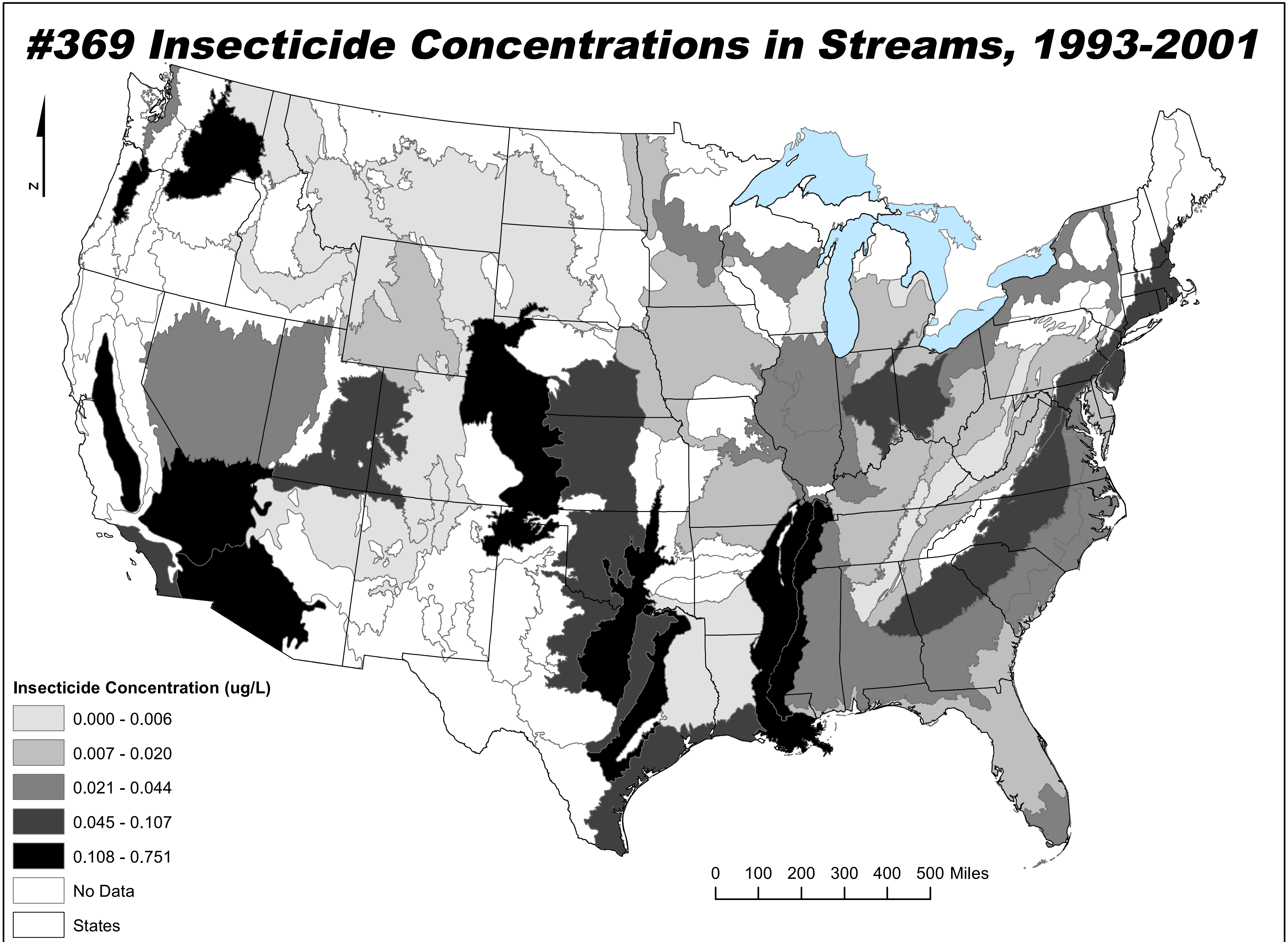

#352 Total Use / Total Streamflow
N
Total Use / Total Streamflow
0.601 - 1.000
1.001 - 4.187
States
0 100 200 300 400 500 Miles

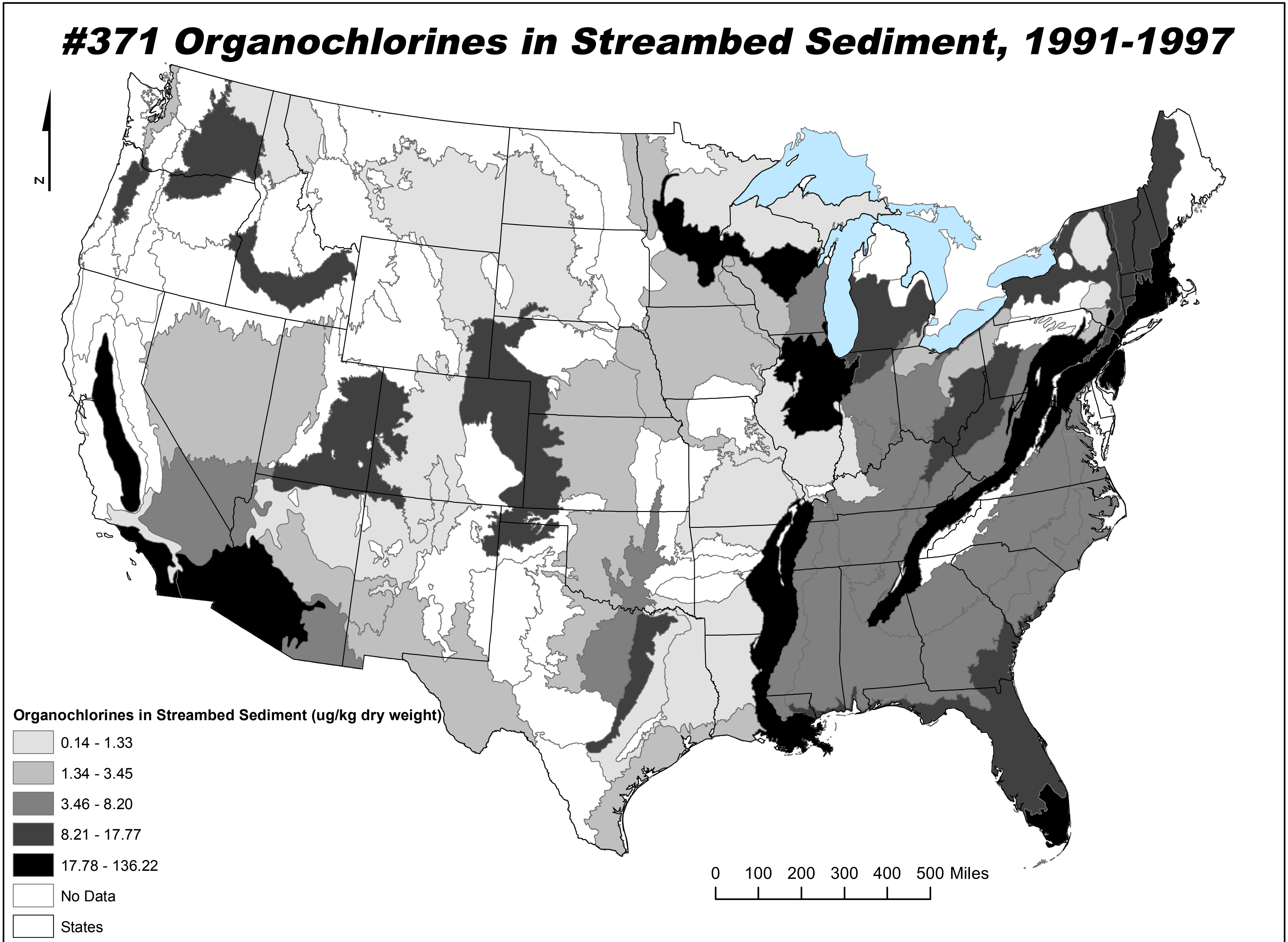
#364 Pesticide Toxicity Index, 1992-2001

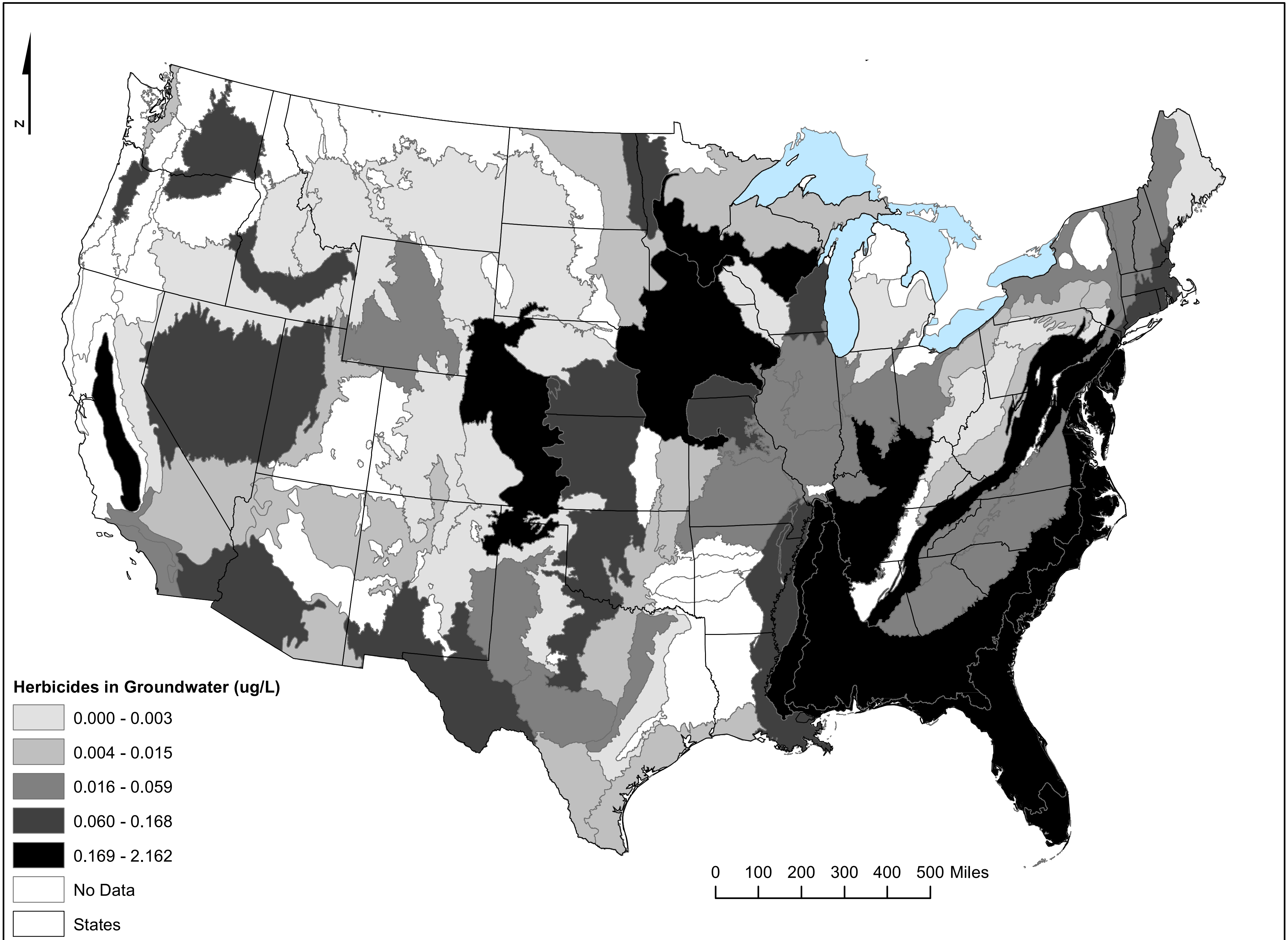


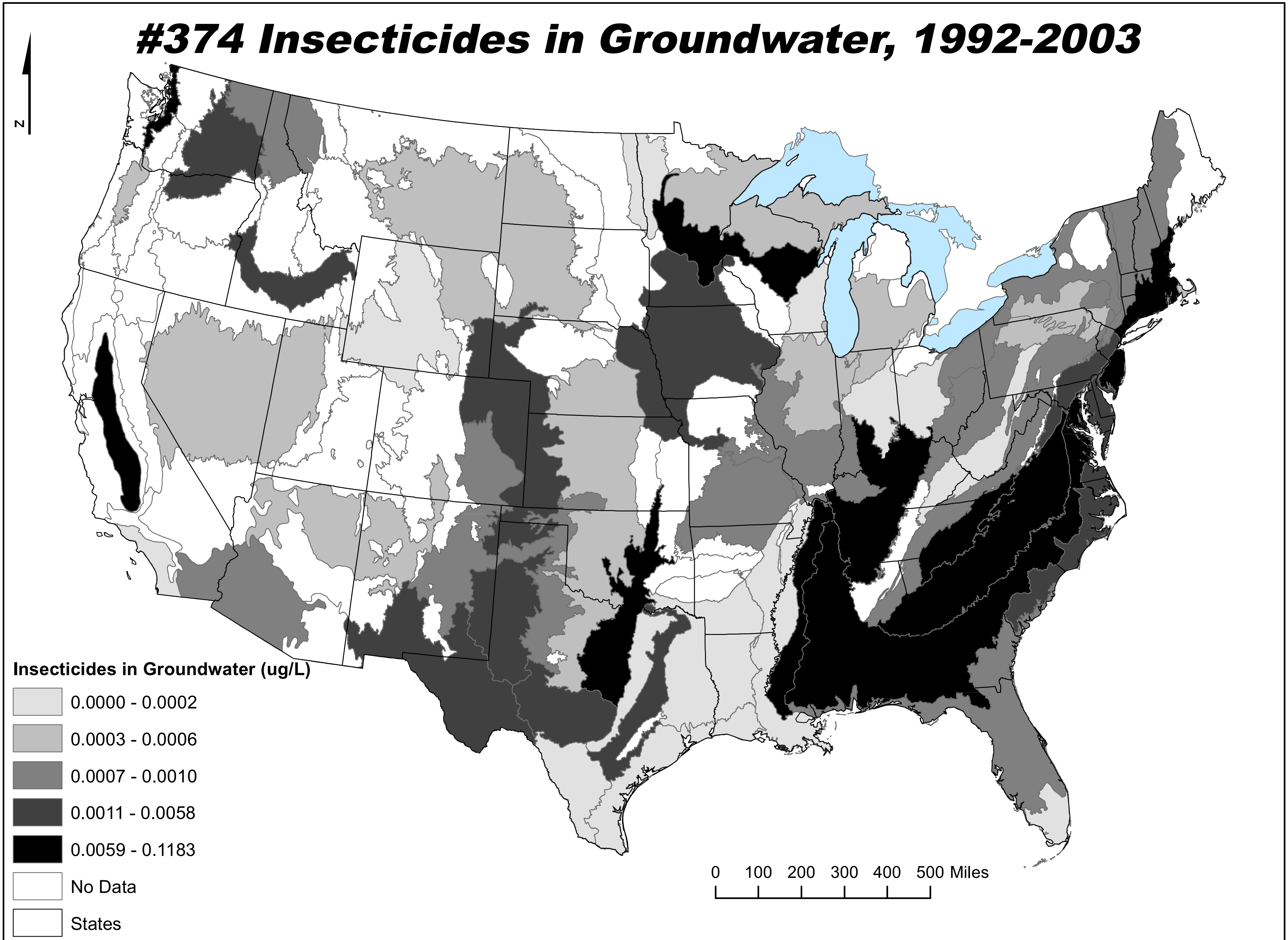
#367 Herbicide Concentrations in Streams, 1993-2001



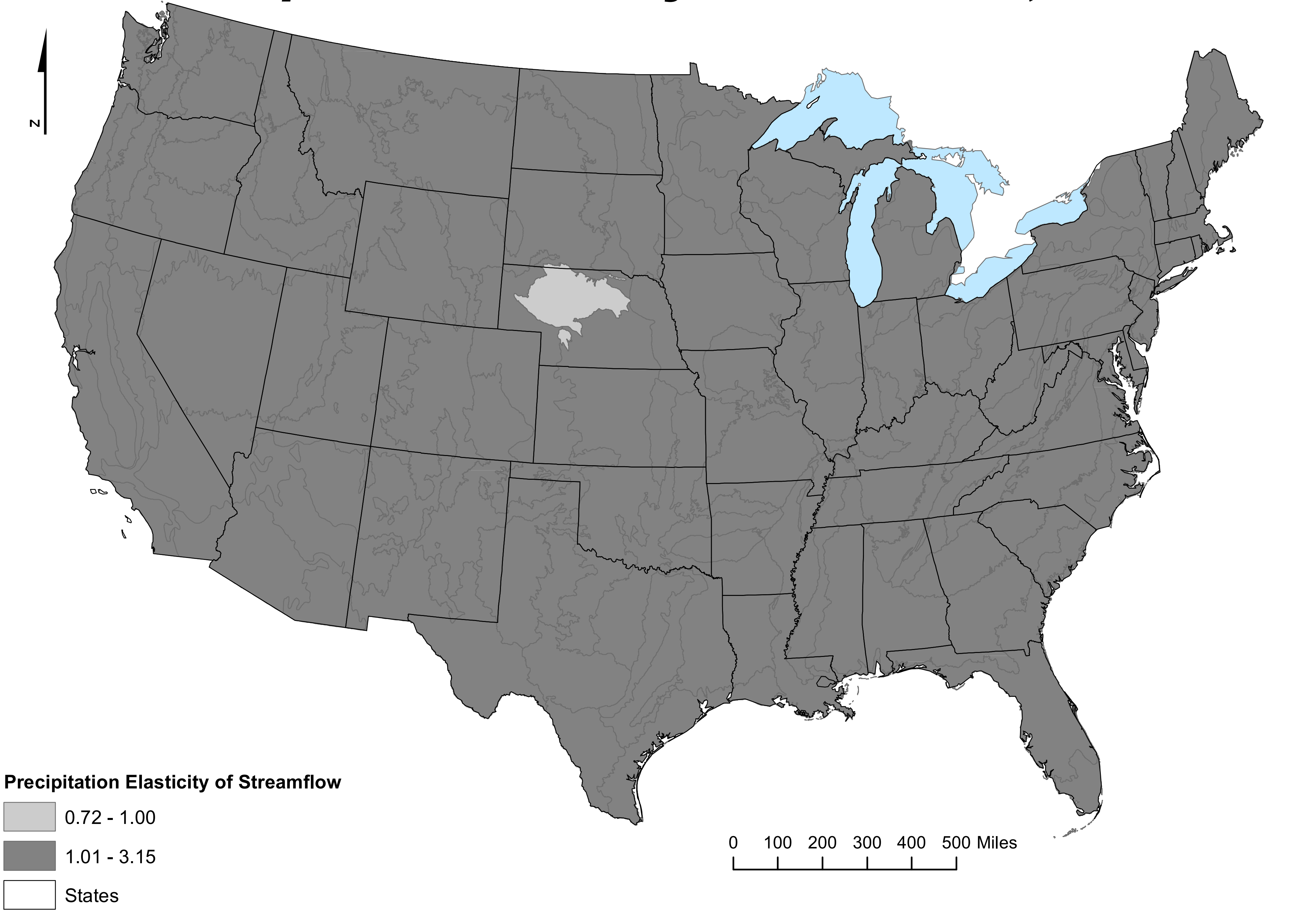

#369 Insecticide Concentrations in Streams, 1993-2001
N
Insecticide Concentration (ug/L)
0.000 - 0.006
0.007 - 0.020
0.021 - 0.044
0.045 - 0.107
0.108 - 0.751
No Data
States
0 100 200 300 400 500 Miles


#371 Organochlorines in Streambed Sediment, 1991-1997
N
Organochlorines in Streambed Sediment (ug/kg dry weight)
0.14 - 1.33
1.34 - 3.45
3.46 - 8.20
8.21 - 17.77
17.78 - 136.22
No Data
States
0 100 200 300 400 500 Miles

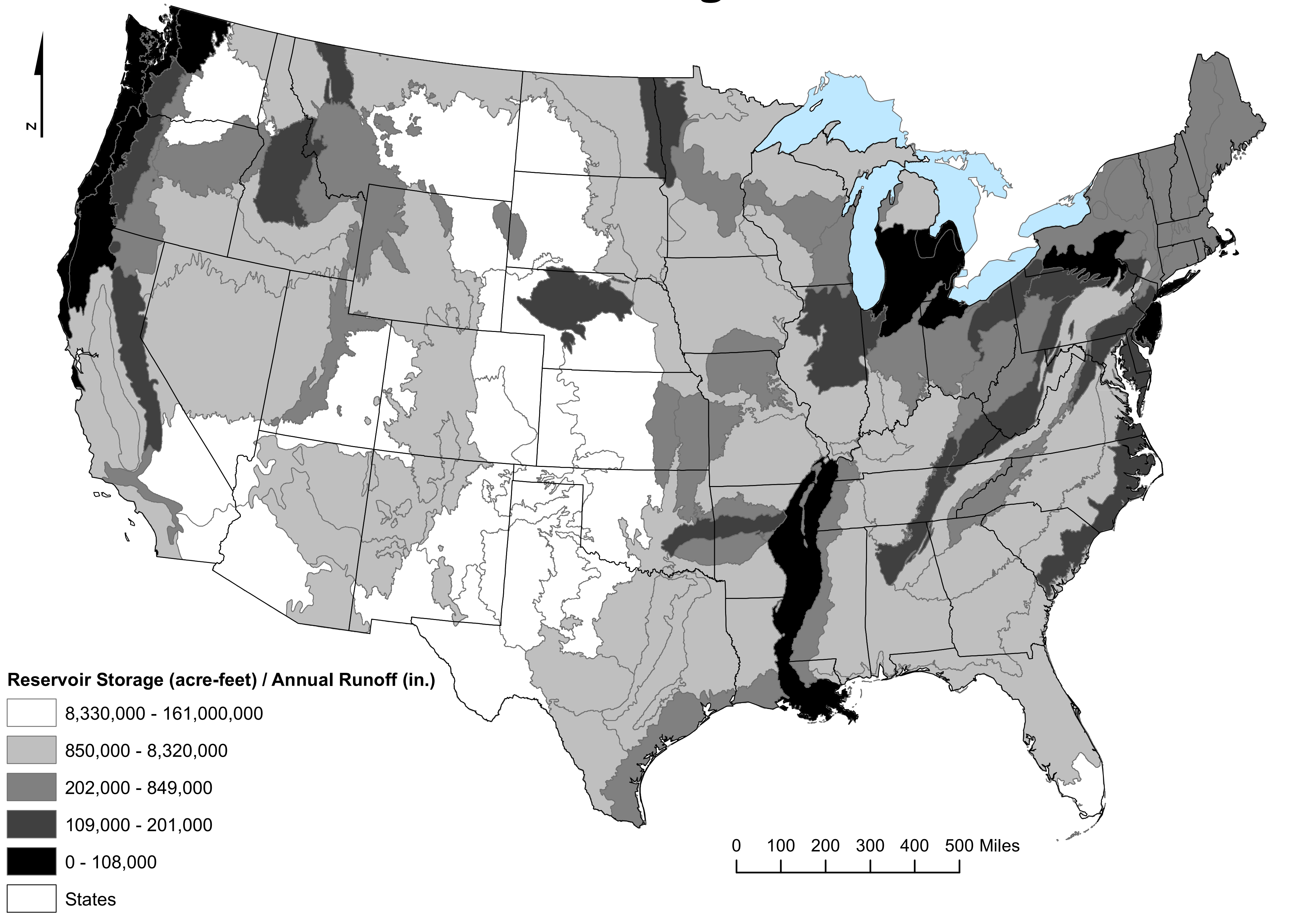

N
Herbicides in Groundwater (ug/L)
0.000 - 0.003
0.004 - 0.015
0.016 - 0.059
0.060 - 0.168
0.169 - 2.162
No Data
States
0 100 200 300 400 500 Miles


#374 Insecticides in Groundwater, 1992-2003
N
Insecticides in Groundwater (ug/L)
0.0000 - 0.0002
0.0003 - 0.0006
0.0007 - 0.0010
0.0011 - 0.0058
0.0059 - 0.1183
No Data
States
0 100 200 300 400 500 Miles

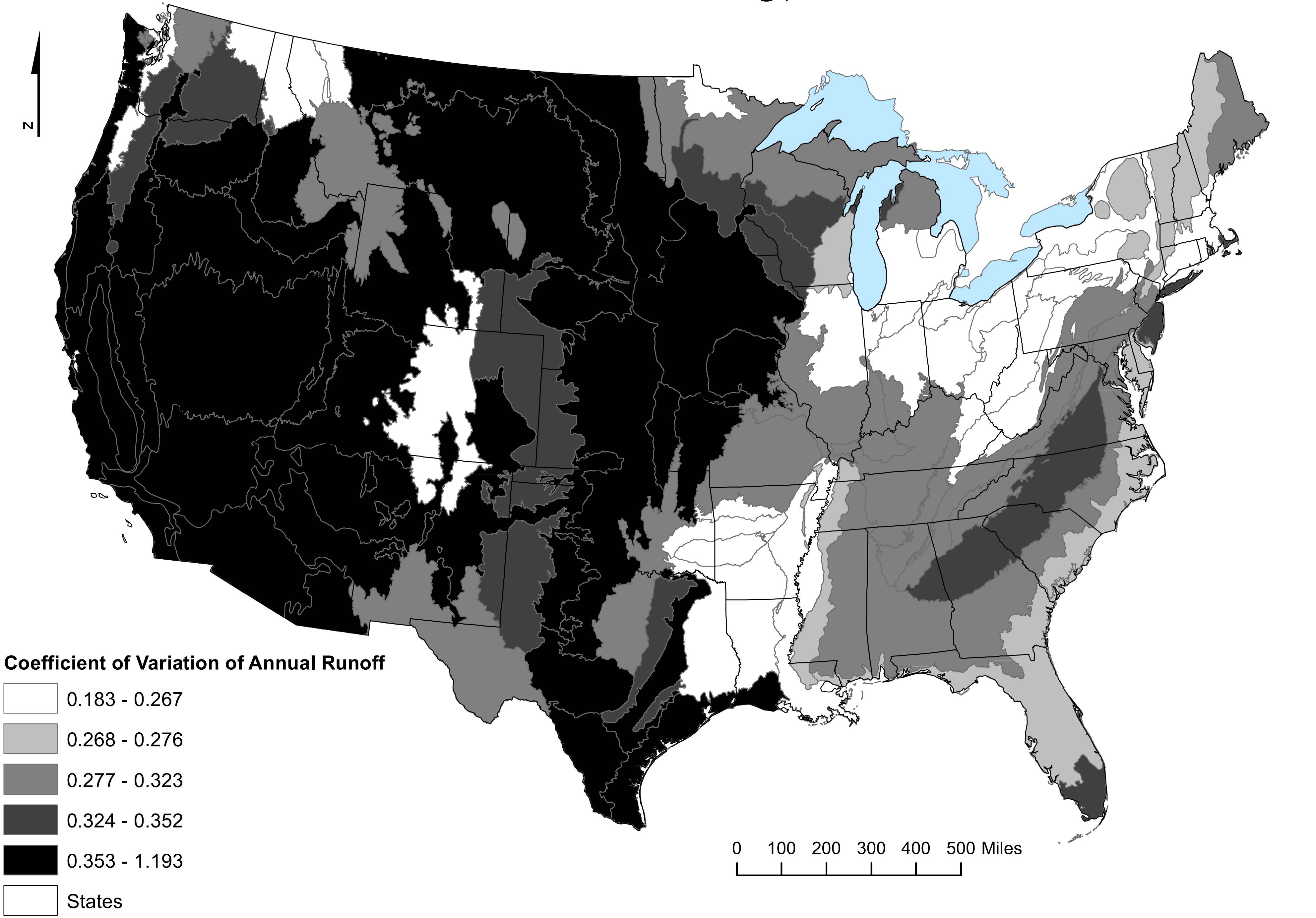
#437 Precipitation Elasticity of Streamflow, 1951-1988



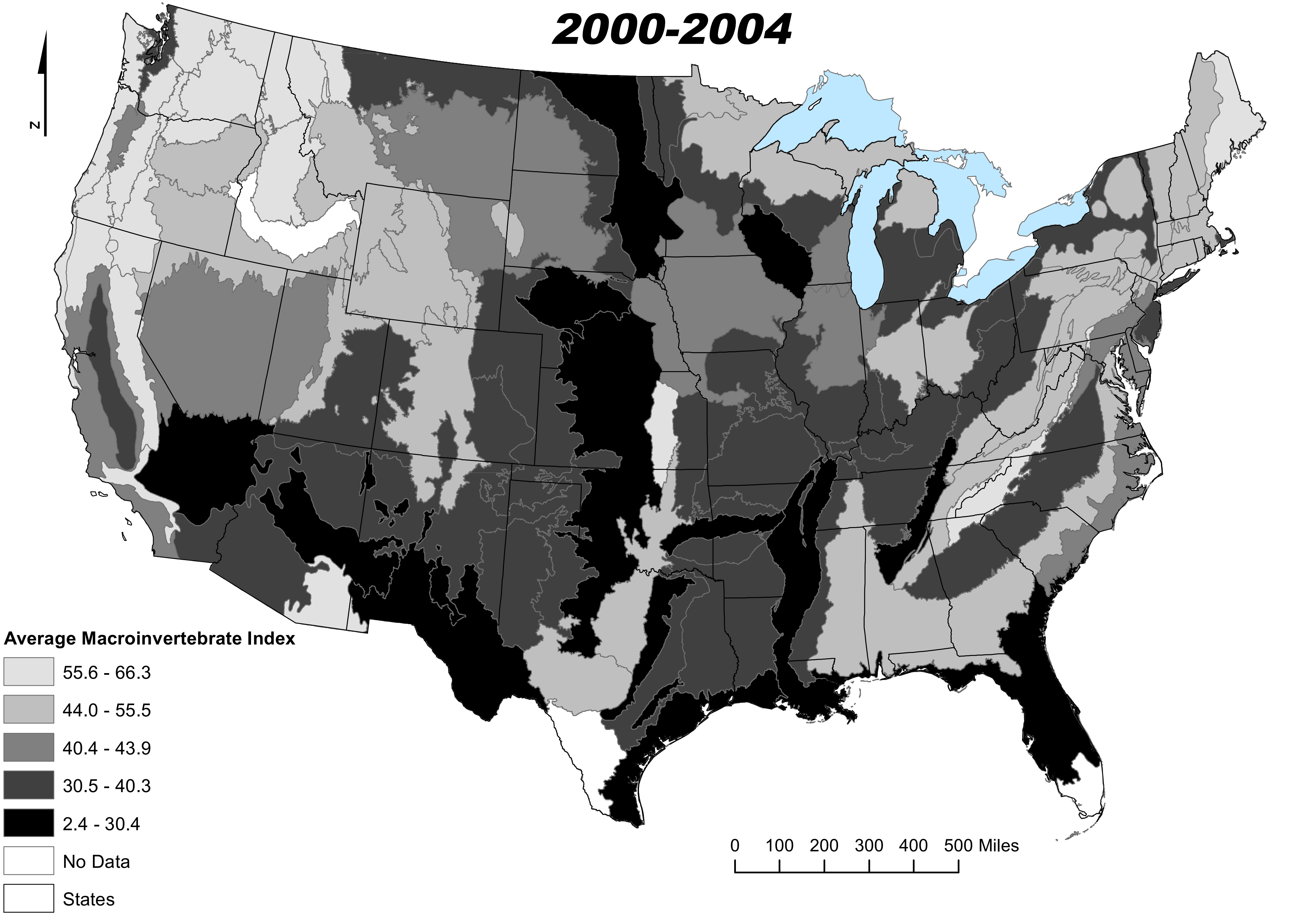
#449 Ratio of Reservoir Storage to Mean Annual Runoff



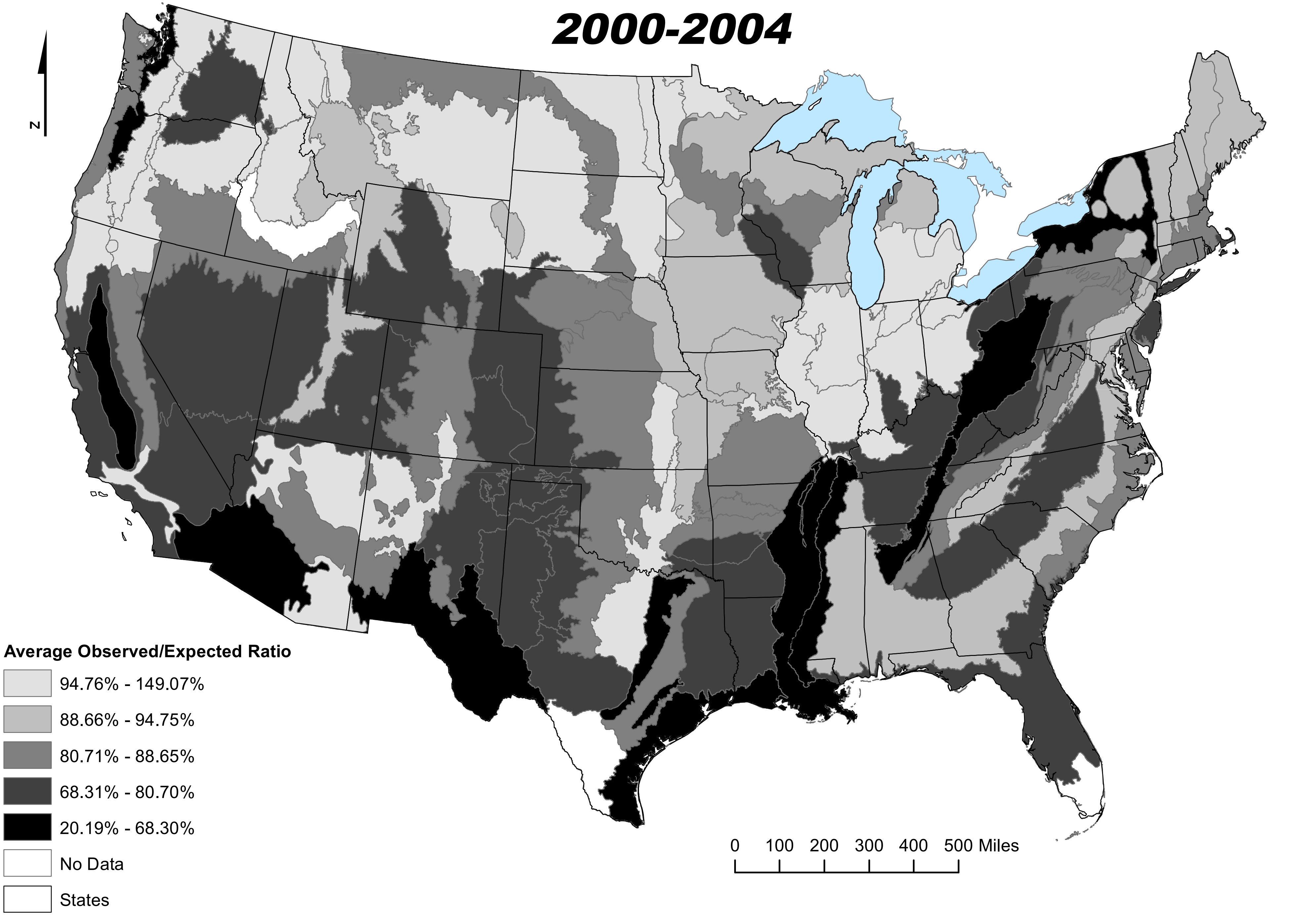
#453 Runoff Variability, 1984-1993



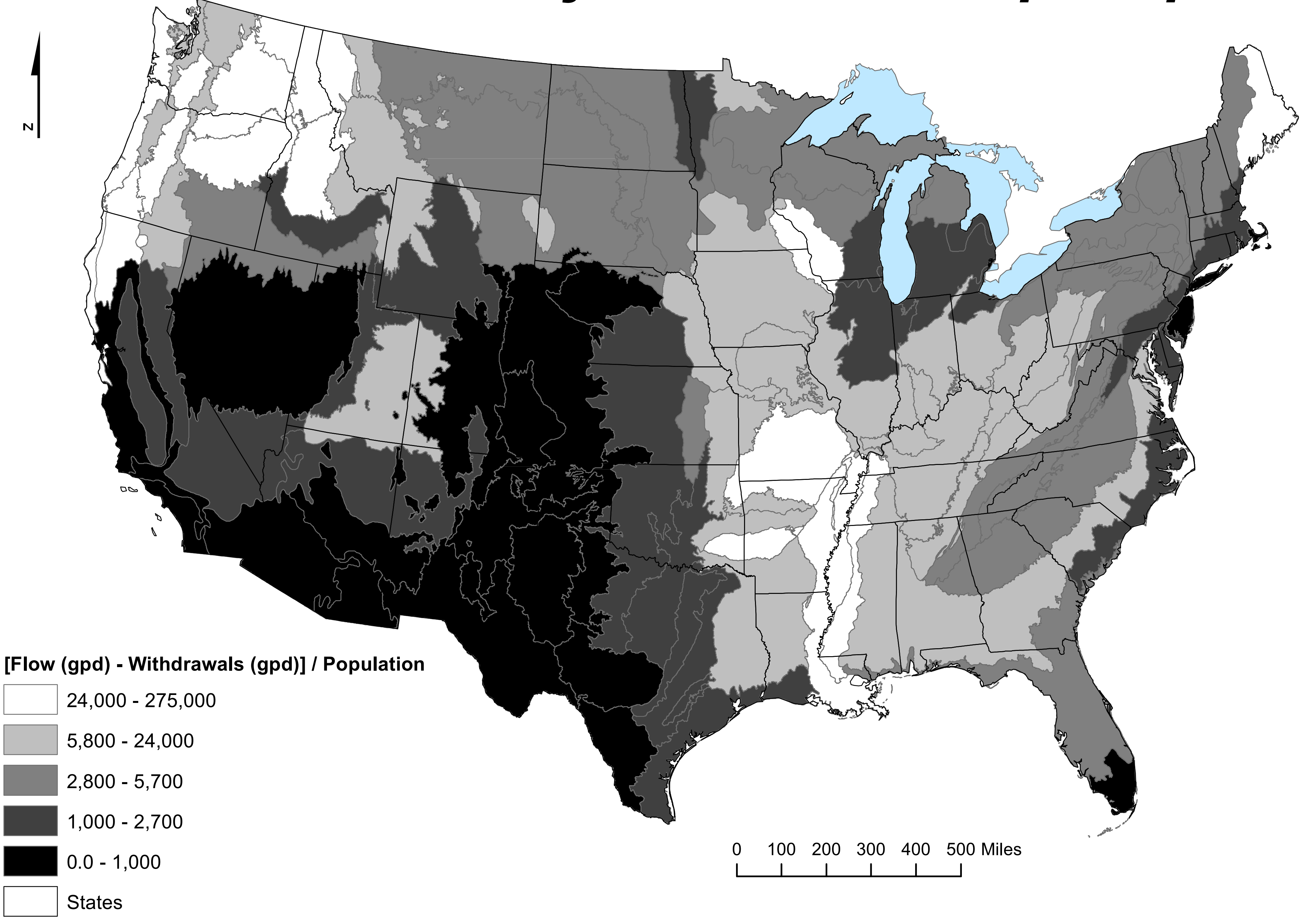
#460 Macroinvertebrate Index of Biotic Condition, 2000-2004



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



#623 Water Availability: Net Stream Flow per capita



Appendix I. Descriptions of Example Indicator Maps by Ecoregion

This appendix describes the 25 example maps of vulnerability indicators by ecoregion presented in Appendix H. Descriptions of U.S. geographical regions and are based on the definitions provided by the U.S. Census Bureau. Subregions were based on U.S. Census definitions, but modified slightly for clarity.

1. **Northeast**
   a. New England
      i. Connecticut
      ii. Maine
      iii. Massachussetts
      iv. New Hampshire
      v. Rhode Island
      vi. Vermont
   b. Middle Atlantic
      i. New Jersey
      ii. New York
      iii. Pennsylvania
2. **Midwest**
   a. Great Lakes
      i. Indiana
      ii. Illinois
      iii. Michigan
      iv. Ohio
      v. Wisconsin
   b. Western Midwest
      i. Iowa
      ii. Kansas
      iii. Minnesota
      iv. Missouri
      v. Nebraska
      vi. North Dakota
      vii. South Dakota
3. **South**
   a. South Atlantic
      i. Delaware
      ii. Distric of Columbia
      iii. Maryland
      iv. North Carolina
      v. South Carlolina
      vi. Virgina
      vii. West Virginia
   b. Southeast
      i. Florida
      ii. Georgia
      iii. Kentucky
      iv. Alabama
      v. Mississippi
      vi. Tennessee
   c. Central South
      i. Texas
      ii. Oklahoma
      iii. Arkansas
      iv. Louisiana
4. **West**
   a. Mountain West
      i. Arizona
      ii. Colorado
      iii. Idaho
      iv. New Mexico
      v. Montana
      vi. Utah
      vii. Nevada
      viii. Wyoming
   b. Pacific West
      i. California
      ii. Oregon
      iii. Washington

#1 Acid Neutralizing Capacity

This continental U.S. indicator map shows the percentage of sites with Acid Neutralizing Capacity (ANC) less than 100 millieq/L in each ecoregion. Data were available for the vast majority of lower-48 ecoregions. The greater part of ecoregions in the West, Midwest, and Central South have 0% of sites with ANC less than 100 millieq/L. Several ecoregions in the South East and South Atlantic have a moderate (4.18 - 11.11%) or high (11.12 - 27.27%) percentage of sites with ANC less than 100 millieq/L. Ecoregions with the highest percentage of sites (27.28 - 66.67%) with ANC less than 100 millieq/L cover a majority of Florida, parts of the Northeast, and a smaller ecoregion spanning parts of Arkansas and Oklahoma.

#22 At-Risk Freshwater Plant Communities

This continental U.S. indicator map shows the percentage of freshwater plant communities that are considered at-risk in each ecoregion. Data were available for all lower-48 ecoregions. The ecoregions with the highest percentages of freshwater plant communities at risk (55.6 - 71.1%) for this indicator occur largely in the Southeast and the Pacific Northwest. Relatively high percentages of plant communities at risk (51.9 - 55.5%) occur in ecoregions extending northward from Texas to the Midwest, as well as in ecoregions scattered in the Mountain West.

Moderate percentages of plant communities at risk (45.8 - 51.8%) occur predominantly in the Southwest and Western Midwest regions. Relatively lower percentages of communities at risk (31.4 - 45.7%) occur in New Mexico, the Great Lakes region, and parts of the Middle-Atlantic. The northern Middle Atlantic and Northeast ecoregions have the lowest percentages (0 - 31.3%) of at-risk freshwater plant communities.

#24 At-Risk Native Freshwater Species

This continental U.S. indicator map shows the percentage of at-risk native freshwater species in each ecoregion. Data were available for all lower-48 ecoregions. Ecoregions with high percentages of freshwater species at risk (15.4 - 22.7%) are found in the Southwest and in the Southeast. These high risk areas are surrounded by bands of moderate (10.7 - 15.3%) percentages of freshwater species at risk. With very few exceptions, risk is a steady gradation from high risk areas in the southern U.S. to low risk areas (0.5 - 4.6%) in New England and the north-central U.S.

#125 Groundwater Reliance

This continental U.S. indicator map shows the percentage of groundwater reliance in each ecoregion. Data were available for all lower-48 ecoregions. A high level (42.3 - 78.7%) of groundwater reliance is mainly observed in the ecoregions that stretch from parts of North Dakota through parts of the western Midwest and Mountain West to western Texas. Other areas with high groundwater reliance are found in the ecoregions along the U.S.-Mexico border, in ecoregions along the lower Mississippi River, and in parts of California and Nevada. Moderate to low (4.9 - 42.2%) groundwater reliance is observed scattered across the nation. The main ecoregions with almost no groundwater reliance (1.7 - 4.8%) stretch from Montana to the Four Corners and also occur in parts of the Southeast, South, and Middle Atlantic regions.

#165 Meteorological Drought Indices

This continental U.S. indicator map shows the average Palmer Drought Severity Index (PDSI) in each ecoregion. Data were available for all lower-48 ecoregions. Negative values of the PDSI indicate drought, positive values indicate excess rainfall, while 0 represents normal conditions for a given region. A very distinctive pattern emerges on this map. Ecoregions having the lowest PDSI values (-2.79 to -0.42) occur predominantly in the West, but also in along the Great Lakes, and parts of the Central South. Low (-0.41 to -0.17) and moderate (-0.16 to 0.51)

PDSI values are observed in the central states. High (0.52 to 1.28) and very high (1.29 to 3.07) PDSI values observed mainly in parts of the Western Midwest, Great Lakes, South Atlantic, and Northeast.

#218 Ratio of Snow to Total Precipitation

This continental U.S. indicator map shows the ratio of total snowfall to total precipitation in each ecoregion. Data were available for all lower-48 ecoregions. Unsurprisingly, this map shows a strong north-south trend, with the ecoregions with the highest ratios (0.175 - 0.821) occurring in the northern and mountainous regions including the northern West, Great Lakes, and parts of the Northeast. These high ratios are surrounded by graded bands of moderate (0.113 - 0.174), low (0.032 - 0.112) and very low (0.004 - 0.031) snowfall to total precipitation ratios. Parts of California, Arizona, the Central South, and the Southeast have a ratio of zero, indicating no snowfall.

#219 Ratio of Water Withdrawals to Annual Streamflow

This continental U.S. indicator map shows the ratio of water withdrawals to annual streamflow in each ecoregion. Data were available for all lower-48 ecoregions. High ratios (0.49 - 4.25) are almost exclusively found in the West. Ecoregions with moderate ratios (0.44 - 0.48) cover parts of Oregon, Nevada, Idaho, Montana, Wyoming, Nebraska, Kansas, Oklahoma, and Texas. Low (0.19 - 0.43) and very low (0.04 - 0.18) ratios are scattered throughout the country, but with higher prevalence in the Midwest and the East. Ratios near zero (0.00 - 0.03) are found largely near the Mississippi River or tributaries, in the Pacific Northwest, southern Wisconsin, and Maine.

#284 Stream Habitat Quality

This continental U.S. indicator map shows stream habitat quality based on the rapid bioassessment protocol score in each ecoregion. Data were available for the vast majority of lower-48 ecoregions. The ecoregions with the highest bioassessment protocol scores (146.1 - 182.8 and 135.9 - 146.0) include the northern Great Lakes region, an area which extends from parts of the Southeast to the Northeast and other areas scattered throughout the country. Moderate scores (126.9 - 135.8) are found primarily in the upper Midwest and Mountain West. The lowest scores (114.5 - 126.8 and 78.5 - 114.4) are found scattered in parts of the Southeast, Midwest, Mountain West, and Pacific Northwest.

#326 Wetland and Freshwater Species at Risk

This continental U.S. indicator map shows the number of wetland and freshwater species that are at risk in each ecoregion. Data were available for all lower-48 ecoregions. Ecoregions with the largest number (64 - 572) of species at risk are found primarily in the Southeast and South Atlantic regions. Ecoregions with a moderate (34 - 63) number of species at risk are largely found near ecoregions with a high number of species at risk in the Southeast, as well in ecoregions in the West and Midwest. Ecoregions with a low (20 - 33) and very low (13 - 19) number of species at risk are found everywhere but the Southeast. Ecoregions with almost no (0 - 12) species at risk are mostly found primarily in the northern Midwest and Mountain West.

#348 Erosion Rate

This continental U.S. indicator map shows the average erosion rate in each ecoregion. Data were available for all lower-48 ecoregions. Ecoregions with high (9.39 - 38.41 tons/ha/year) and moderate (5.45 - 9.38 tons/ha/year) soil loss are found principally in the West but also in the central Midwest and an area extending from parts of the Southeast to the Northeast. Lower (0.00 - 2.02 tons/ha/year) soil loss rates are found scattered throughout the country, including in a vertical band from North Dakota to Texas, the Great Lakes region, and the Eastern seaboard.

#351 Instream Use/Total Streamflow

This continental U.S. indicator map shows the ratio of instream use to total streamflow in each ecoregion. Data were available for all lower-48 ecoregions. All ecoregions have values within the range of 0.6 - 1.0.

#352 Total Use / Total Streamflow

This continental U.S. indicator map shows the ratio of total use to total streamflow in each ecoregion. Data were available for all lower-48 ecoregions. Most ecoregions have values within the 0.601 - 1.000 range. However, there are a few ecoregions in the West and in an area extending from Texas into the Central Midwest, that fall in the 1.001 to 4.187 category.

#364 Pesticide Toxicity Index

This continental U.S. indicator map shows the Pesticide Toxicity Index (PTI) for Daphnia species in each ecoregion. Data were not available for many of the lower-48 ecoregions. Available data is insufficient to infer geographic patterns, but does indicate the possibility of higher pesticide toxicity index values in the central states, Southwest, and Southeast.

#367 Herbicide Concentrations in Streams

This continental U.S. indicator map shows herbicide concentrations in streams in each ecoregion. Data were not available for many of the lower-48 ecoregions. Ecoregions with the highest (2.43 - 16.06 µg/L) herbicide concentrations in streams occur predominantly in the Midwest and the lower Mississippi Basin. Ecoregions with high (1.23 - 2.42 µg/L) and moderate (0.31 - 1.22 µg/L) herbicide concentrations in streams are scattered in the East, while ecoregions with low (0.09 - 0.30 µg/L) and very low (0.00 - 0.08 µg/L) herbicide concentrations in streams cover most of the Mountain West and parts of the Northeast.

#369 Insecticide Concentrations in Streams

This continental U.S. indicator map shows insecticide concentrations in streams in each ecoregion. Data were not available for many of the lower-48 ecoregions. Available data is insufficient to infer geographic patterns, but does indicate the possibility of higher concentrations of insecticides in streams in the central states, Southwest, and the lower Mississippi basin.

#371 Organochlorines in Bed Sediment

This continental U.S. indicator map shows organochlorine concentrations in streambed sediment in each ecoregion. Data were not available for many of the lower-48 ecoregions.

Available data is insufficient to infer geographic patterns, but does indicate the possibility of higher concentrations of organochlorines in streams in the East and the Southwest.

#373 Herbicides in Groundwater

This continental U.S. indicator map shows herbicide concentrations in groundwater in each ecoregion. Data were not available for many of the lower-48 ecoregions. Ecoregions with the highest (0.169 - 2.162 µg/L and 0.060 - 0.168 µg/L) concentrations of herbicides occur predominantly in the Southeast and in the central Midwestern states. Ecoregions with moderate (0.016 - 0.059 µg/L) and low (0.004 - 0.015 µg/L) concentrations of herbicides in groundwater are scattered throughout the country, while ecoregions with the lowest (0.000 - 0.003 µg/L) concentrations occur primarily in the Northwest.

#374 Insecticides in Groundwater

This continental U.S. indicator map shows insecticide concentrations in groundwater in each ecoregion. Data were available for only a fraction of lower-48 ecoregions. Ecoregions with the highest (0.0059 - 0.1183 µg/L and 0.0011 - 0.0058 µg/L) concentrations of insecticides in groundwater occur predominantly in the Southeast and South Atlantic regions. Ecoregions with moderate (0.0007 - 0.0010 µg/L) and low (0.0003 - 0.0006 µg/L) concentrations of insecticides in groundwater are scattered throughout the country, while ecoregions with the lowest (0.0000 - 0.0002 µg/L) concentrations occur mostly in the West.

#437 Precipitation Elasticity of Streamflow

This continental U.S. indicator map shows the precipitation elasticity of streamflow in each ecoregion. Data were available for all lower-48 ecoregions. Every ecoregion has elasticity in the higher range (1.01 - 3.15) except for one ecoregion in Nebraska, which has elasticity in the 0.72 - 1.00 range.

#449 Ratio of Reservoir Storage to Mean Annual Runoff

This continental U.S. indicator map shows the ratio of reservoir storage to mean annual runoff in each ecoregion. Data were available for all lower-48 ecoregions. Ecoregions with the lowest (0 – 108,000 acre-feet/inch) ratios occur in the Pacific Northwest, the lower Mississippi basin, and in Michigan. Ecoregions with low (109,000 - 201,000 acre-feet/inch) and moderate ratios (202,000 – 849,000 acre-feet/inch) are found primarily in the Northeast, but are also scattered throughout the country. Ecoregions with high (850,000 - 8,320,000 acre-feet/inch) and very high (8,330,000 - 161,000,000 acre-feet/inch) ratios cover most of the country with the highest ratios occurring in Western Midwest and Mountain West regions.

#453 Runoff Variability

This continental U.S. indicator map shows the coefficient of variation of annual runoff in each ecoregion. Data were available for all lower-48 ecoregions. A very distinctive pattern emerges on this map, with ecoregions with the highest (0.353 - 1.193 and 0.324 - 0.352) coefficients covering almost the entire western half of the country. Ecoregions with moderate (0.277 - 0.323) ratios are observed largely in the Southeast, while ecoregions with low (0.268 -

0.276) and very low (0.183 - 0.267) ratios are observed in the lower Mississippi basin, parts of the Great Lakes region, the Northeast, and Florida.

#460 Macroinvertebrate Index of Biotic Condition

This continental U.S. indicator map shows the macroinvertebrate index of biotic condition in each ecoregion. Data were available for the vast majority of lower-48 ecoregions. Ecoregions with the lowest (2.4 - 30.4) macroinvertebrate index values occur in the central Midwest and along the Gulf Coast, while ecoregions with the highest (44.0 - 55.5 and 55.6 - 66.3) index values occur primarily in the Northwest. The remaining ecoregions with macroinvertebrate index values in the moderate range (30.5 - 40.3 and 40.4 - 43.9) are scattered throughout the country.

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

This continental U.S. indicator map shows the observed taxa as a percentage of the expected macroinvertebrate taxa in each ecoregion. Data were available for the vast majority of lower-48 ecoregions. This map shows no discernable pattern, but does indicate the possibility of higher ratio of taxa loss in the lower Mississippi basin and parts of the Southwest.

#623 Water Availability: Net Streamflow per Capita

This continental U.S. indicator map shows the net streamflow per capita in each ecoregion. Data were available for all lower-48 ecoregions. Ecoregions with the lowest (0.0 – 1,000 gallons/day/capita and 1,000 – 2,700 gallons/day/capita) water availability occur predominantly in the Southwest and parts of the central Mountain West and Midwest. Ecoregions with moderate (2,800-5,700) water availability occur in the northern Mountain West, the Northeast, and in Florida. Ecoregions with the highest (5,800 – 24,000 gallons/day/capita and 24,000 – 275,000 gallons/day/capita) water availability occur in parts of the Midwest, Southeast, the Northwest, and Main

Appendix J. Vulnerability Category Matrix

The following matrix displays the data ranges for 24 mapped indicators for each of the 204 HUC-4 watersheds in the continental United States. (Note that one mapped indicator, the Coastal Vulnerability Index (#51), is not included here because a different spatial unit was used to map it). Values for each indicator are represented both by colors and numbers: No data (white, 0); Lowest (light gray, 1); Low (medium gray, 2); Medium (dark gray, 3); High (darker gray, 4), and Highest (black, 5). The shades of black, white, and gray in this matrix match those on the maps in Appendix F.

Appendix K. Evaluation and Potential Modification of Vulnerability Indicators

This appendix provides an evaluation of each of the 25 mappable indicators within the framework of the five questions presented in the flowchart in Figure 13 (Indicator Evaluation Process) of the report. Each indicator was evaluated to determine how well it represents vulnerability of water quality or aquatic ecosystems, and, when appropriate, how it might be modified to improve its representation of vulnerability (Table 1). In addition, the indicators were also evaluated to examine the extent to which objective functional thresholds may apply to them.

Table 1. Indicator Selection

Indicators are evaluated for the extent to which they represent vulnerability. The indicators can be further evaluated to determine how to modify them to improve their representation of vulnerability. An indicator that accounts for or could account for is then sifted through the Indicator Display (Table 2). An indicator that neither accounts for vulnerability nor can be modified to represent vulnerability is considered inappropriate for mapping with objective breakpoints.

Indicator ID#	Indicator	Does the indicator describe vulnerability?	Can the indicator be modified to describe vulnerability?
1	Acid Neutralizing Capacity (ANC)	Does not directly account for exposure to acidification.	If possible, develop model to predict changes in acidity of precipitation, and the resulting change in stream pH, given ANC.
22	At-Risk Freshwater Plant Communities	Does not directly account for exposure to additional stress from climate change.	Identify plant communities that would be most susceptible to changes in temperature or precipitation. Overlay with predicted climate changes.
24	At-Risk Native Freshwater Species	Does not directly account for exposure to additional stress from climate change.	Identify species that would be most susceptible to changes in temperature or precipitation. Overlay with predicted climate changes.
51	Coastal Vulnerability Index (CVI)	Yes	N/A
125	Groundwater Reliance	Does not put groundwater reliance into context of groundwater availability or availability of other water sources.	Changes in groundwater availability per capita could be simulated by coupling population projections with a groundwater model. However, these estimates would be more meaningful if they were integrated into a model of overall water availability that also included surface water.

Indicator ID#	Indicator	Does the indicator describe vulnerability?	Can the indicator be modified to describe vulnerability?
165	Meteorological Drought Indices	Does not directly account for exposure to additional stress from climate change.	A stochastic climate model could be used to predict change in drought frequency.
218	Ratio of Snow to Total Precipitation (S/P)	Does not directly account for exposure to additional stress from climate change.	This indicator could be improved by identifying areas where the ratio of snow to precipitation is most sensitive to a unit change in temperature. It could also be improved by accounting for the reliance of streamflow and human water use on snowmelt.
219	Ratio of Withdrawals to Stream Flow	Does not account for water shortage risk associated with temporal variability in streamflow and does not directly account for exposure to additional stress from climate change or growth in water demand.	This indicator could be considered one factor in an integrated climatic-hydrologic model (e.g., Wilby, R. L., P. G. Whitehead, A. J. Wade, D. Butterfield, R. J. Davis, and G. Watts. 2006. Integrated modelling of climate change impacts on water resources and quality in a lowland catchment: River Kennet, UK. Journal of Hydrology 330:204-220.)
284	Stream Habitat Quality	Does not directly account for exposure to additional stress from climate change.	Predictions from a climate model could be used to forecast changes in streamflow, which could be linked to stream channel stability (one component of habitat quality) with a hydraulic model.
326	Wetland and Freshwater Species At Risk	Does not directly account for exposure to additional stress from climate change.	Identify species that would be most susceptible to changes in temperature or precipitation. Overlay with predicted climate changes.
348	Erosion Rate	Does not account for exposure to precipitation changes.	Yang et al. (2003) provide projections of the change in erosion rate that would result from climate change. These projections would account for both sensitivity and exposure. However, the model for this indicator does not account for deposition of eroded sediment and therefore cannot be solely relied upon to estimate sediment delivery to aquatic ecosystems.
351	Instream Use/Total Streamflow	Does not directly account for exposure to additional stress from climate change.	The USGS used the information in this indicator and other information to calculate the ratio of consumptive use to renewable water supply. This indicator is a more holistic view of water sustainability. Forecasts of the effects of climate change and population growth on this indicator would integrate sensitivity and exposure.

Indicator ID#	Indicator	Does the indicator describe vulnerability?	Can the indicator be modified to describe vulnerability?
352	Total Use/Total Streamflow	Does not directly account for exposure to additional stress from climate change.	The USGS used the information in this indicator and other information to calculate the ratio of consumptive use to renewable water supply. This indicator is a more holistic view of water sustainability. Forecasts of the effects of climate change and population growth on this indicator would integrate sensitivity and exposure.
364	Pesticide Toxicity Index (PTI)	Does not directly account for exposure to additional stress from climate change.	USGS is developing predictive models for individual pesticides (e.g., atrazine; http://infotrek.er.usgs.gov/warp/). Some of these models contain precipitation variables whose values could be adjusted to simulate the effect of climate change on pesticide concentrations. These individual predictions could be combined to calculate the change in PTI that would be caused by climate change.
367	Herbicide Concentrations in Streams	Does not directly account for exposure to additional stress from climate change.	The pesticide indicators could be improved by: 1. comparing the concentration of an individual pesticide to its health-based regulatory threshold (e.g., atrazine), or 2. calculating the pesticide toxicity index.
369	Insecticide Concentrations in Streams	Does not directly account for exposure to additional stress from climate change.	The pesticide indicators could be improved by: 1. comparing the concentration of an individual pesticide to its health-based regulatory threshold (e.g., atrazine), or 2. calculating the pesticide toxicity index.
371	Organochlorines in Bed Sediment	Does not directly account for exposure to additional stress from climate change.	EPA's National Sediment Quality Survey reports and maps human health and aquatic life risk due to contaminated sediment (http://www.epa.gov/waterscience/cs/report/1997/). Risk is based on all sediment contaminants, so this would be a different indicator.
373	Herbicides in Groundwater	Does not directly account for exposure to additional stress from climate change.	The pesticide indicators could be improved by: 1. comparing the concentration of an individual pesticide to its health-based regulatory threshold (e.g., atrazine), or 2. calculating the pesticide toxicity index.

Indicator ID#	Indicator	Does the indicator describe vulnerability?	Can the indicator be modified to describe vulnerability?
374	Insecticides in Groundwater	Does not directly account for exposure to additional stress from climate change.	The pesticide indicators could be improved by: 1. comparing the concentration of an individual pesticide to its health-based regulatory threshold (e.g., atrazine), or 2. calculating the pesticide toxicity index.
437	Precipitation Elasticity of Streamflow	Does not account for exposure to precipitation changes.	This indicator could be combined with predicted changes in precipitation to predict changes in streamflow.
449	Ratio of Reservoir Storage to Mean Annual Runoff	Does not directly account for exposure to additional stress from climate change.	This indicator could be considered one factor in an integrated climatic-hydrologic model (e.g., Wilby, R. L., P. G. Whitehead, A. J. Wade, D. Butterfield, R. J. Davis, and G. Watts. 2006. Integrated modelling of climate change impacts on water resources and quality in a lowland catchment: River Kennet, UK. Journal of Hydrology 330:204-220.)
453	Runoff Variability	Does not directly account for exposure to additional stress from climate change.	This indicator could be considered one factor in an integrated climatic-hydrologic model (e.g., Wilby, R. L., P. G. Whitehead, A. J. Wade, D. Butterfield, R. J. Davis, and G. Watts. 2006. Integrated modelling of climate change impacts on water resources and quality in a lowland catchment: River Kennet, UK. Journal of Hydrology 330:204-220.)
460	Macroinvertebrate Index of Biotic Condition	The stress-response curve may be improperly characterized, and spatial variation in exposure to future stress is not accounted for.	Indexes of biotic condition respond linearly to stress, so vulnerability to further degradation should be relatively constant.
461	Macroinvertebrate Observed/Expected (O/E) Ratio of Taxa Loss	The stress-response curve may be improperly characterized, and spatial variation in exposure to future stress is not accounted for.	The scale of vulnerability for this indicator should be reversed. The first taxa that are lost are sensitive to small amounts of stress.

Indicator ID#	Indicator	Does the indicator describe vulnerability?	Can the indicator be modified to describe vulnerability?
623	Water Availability: Net Streamflow per Capita	Does not account for water shortage risk associated with temporal variability in streamflow and does not directly account for exposure to additional stress from climate change or growth in water demand.	It may be more appropriate to consider net streamflow in the context of instream flow requirements. This indicator could be considered one factor in an integrated climatic-hydrologic model (e.g., Wilby, R. L., P. G. Whitehead, A. J. Wade, D. Butterfield, R. J. Davis, and G. Watts. 2006. Integrated modelling of climate change impacts on water resources and quality in a lowland catchment: River Kennet, UK. Journal of Hydrology 330:204-220.)

Table 2. Indicator Display

The numerical thresholds used for indicator example maps were determined based on the information available in the literature or by using a continuous grayscale color ramp. Indicators that already reflect vulnerability or could be modified to do so (based on Table 1) can be further evaluated to determine whether objective, functional breakpoints can be used in displaying their values. If so, attributes necessary for determining such functional breakpoints can be identified through a review of relevant literature or through new data collection and analysis efforts. Finally, the validity of the breakpoints when data are aggregated to the appropriate spatial unit can be analyzed to assess the accuracy of the resultant map.

An indicator for which objective breakpoints exist, or for which objective breakpoints can be identified, and for which breakpoints remain valid even when data are aggregated, is considered mappable with objective thresholds. An indicator for which objective breakpoints cannot be identified or for which breakpoints are not valid after data are aggregated is considered mappable along a continuous gradient.

Indicator ID#	Indicator	Are objective breakpoints in the range of vulnerability documented?	Can objective breakpoints be identified?	Are the breakpoints valid when the data are aggregated?
1	Acid Neutralizing Capacity (ANC)	Yes; when ANC values fall below zero, the water is considered acidic and can be either directly or indirectly toxic to biota (i.e., by mobilizing toxic metals, such as aluminum). When ANC is between 0 and 25 milliequilivents, the water is considered sensitive to episodic acidification during rainfall events. These threshold values were determined based on values derived from the National Acid Precipitation Assessment Program (USEPA 2006).	N/A	No; indicator mapped as percentage of sites.
22	At-Risk Freshwater Plant Communities	Yes; risk levels for individual communities are semi-quantitatively defined.	N/A	No; indicator mapped as percentage of sites.
24	At-Risk Native Freshwater Species	Yes; risk levels for individual species are semi-quantitatively defined.	N/A	No; indicator mapped as percentage of sites.

Indicator ID#	Indicator	Are objective breakpoints in the range of vulnerability documented?	Can objective breakpoints be identified?	Are the breakpoints valid when the data are aggregated?
51	Coastal Vulnerability Index (CVI)	No; it indicates relative risk.	Ideally, the CVI would be calibrated to the occurrence of actual physical effects. This stress response relationship could then be divided into vulnerability categories with natural breaks, or with subjective evaluations of acceptable risk.	Yes
125	Groundwater Reliance	No, because this indicator is not a good measure of vulnerability.	The ratio of per capita water availability to water use has a natural threshold: 1. Other thresholds would be somewhat arbitrary.	Yes, but only with suggested modifications.
165	Meteorological Drought Indices	The thresholds that were used are somewhat objective because a PDSI of 0 indicates neutral conditions, and negative numbers indicate drought. Because the medium category is centered around zero, it appropriately separates areas that have experienced recent drought from those that have not.	While there is an objective breakpoint for separating drought from non-drought, an objective measure of what constitutes a critical drought frequency was not identified.	Yes
218	Ratio of Snow to Total Precipitation (S/P)	No	A general model of water availability that included snowmelt could be used to simulate changes in water availability relative to water demand. A ratio of 1 would be an objective threshold.	Yes, but only with suggested modifications.
219	Ratio of Withdrawals to Annual StreamFlow	Yes, a value of 1 indicates that there is no room for further water withdrawals.	N/A	Yes
284	Stream Habitat Quality	No, breakpoints are arbitrary.	No	N/A

Indicator ID#	Indicator	Are objective breakpoints in the range of vulnerability documented?	Can objective breakpoints be identified?	Are the breakpoints valid when the data are aggregated?
326	Wetland and Freshwater Species At Risk	Yes; risk levels for individual species are semi-quantitatively defined.	N/A	No; indicator mapped as percentage of sites.
348	Erosion Rate	No, tolerable erosion rates vary among ecosystems and are not documented at the national scale.	With the suggested modification, three objective categories of vulnerability would be less erosion, no change, and more erosion with predicted climate change.	Yes, but only with suggested modifications.
351	Instream Use/Total Streamflow	Yes, a value of 1 indicates that there is no room for further water withdrawals, assuming that there is no consumptive use.	The same breakpoint also applies to the suggested modification of the indicator.	Yes, because the HUC is the original scale of measurement.
352	Total Use/Total Streamflow	Yes, a value of 1 indicates that there is no room for further water withdrawals.	The same breakpoint also applies to the suggested modification of the indicator.	Yes, because the HUC is the original scale of measurement.
364	Pesticide Toxicity Index (PTI)	Pesticide toxicity index values have a built-in threshold (1) that indicates probable cumulative effects equivalent to an LC50 or EC50 assuming that the additive toxicity model is appropriate. However, even these standard measures of toxicity are based on a somewhat arbitrary standard of what constitutes a serious health effect (affects 50% of test organisms).	What constitutes a critical level of risk is a subjective choice.	There is no basis for identifying a critical value for the average PTI in a HUC. Averages also obscure variance among the values at individual sites.

Indicator ID#	Indicator	Are objective breakpoints in the range of vulnerability documented?	Can objective breakpoints be identified?	Are the breakpoints valid when the data are aggregated?
367	Herbicide Concentrations in Streams	No, not for mixtures of pesticides.	What constitutes a critical level of risk is a subjective choice. Pesticide toxicity index values have a built-in threshold that indicates probable cumulative effects equivalent to an LC50 or EC50 assuming that the additive toxicity model is appropriate. However, even these standard measures of toxicity are based on a somewhat arbitrary standard of what constitutes a serious health effect (affects 50% of test organisms).	There is no basis for identifying a critical value for the average probability of exceeding a health-based threshold or the average PTI in a HUC. Averages also obscure variance among the values at individual sites.
369	Insecticide Concentrations in Streams	No, not for mixtures of pesticides.	What constitutes a critical level of risk is a subjective choice. Pesticide toxicity index values have a built-in threshold that indicates probable cumulative effects equivalent to an LC50 or EC50 assuming that the additive toxicity model is appropriate. However, even these standard measures of toxicity are based on a somewhat arbitrary standard of what constitutes a serious health effect (affects 50% of test organisms).	There is no basis for identifying a critical value for the average probability of exceeding a health-based threshold or the average PTI in a HUC. Averages also obscure variance among the values at individual sites.
371	Organochlorines in Bed Sediment	Yes, but only with the suggested modification.	N/A	No, data would have to be mapped as percentages for which thresholds are arbitrary, or averages, which obscure variance.

Indicator ID#	Indicator	Are objective breakpoints in the range of vulnerability documented?	Can objective breakpoints be identified?	Are the breakpoints valid when the data are aggregated?
373	Herbicides in Groundwater	No, not for mixtures of pesticides.	What constitutes a critical level of risk is a subjective choice. Pesticide toxicity index values have a built-in threshold that indicates probable cumulative effects equivalent to an LC50 or EC50 assuming that the additive toxicity model is appropriate. However, even these standard measures of toxicity are based on a somewhat arbitrary standard of what constitutes a serious health effect (affects 50% of test organisms).	There is no basis for identifying a critical value for the average probability of exceeding a health-based threshold or the average PTI in a HUC. Averages also obscure variance among the values at individual sites.
374	Insecticides in Groundwater	No, not for mixtures of pesticides.	What constitutes a critical level of risk is a subjective choice. Pesticide toxicity index values have a built-in threshold that indicates probable cumulative effects equivalent to an LC50 or EC50 assuming that the additive toxicity model is appropriate. However, even these standard measures of toxicity are based on a somewhat arbitrary standard of what constitutes a serious health effect (affects 50% of test organisms).	There is no basis for identifying a critical value for the average probability of exceeding a health-based threshold or the average PTI in a HUC. Averages also obscure variance among the values at individual sites.
437	Precipitation Elasticity of Streamflow	The thresholds that were used are somewhat objective because a value of 1 separates areas where a given percentage change in precipitation results in a lower percentage change in streamflow from areas where a that same percentage change in precipitation results in a higher percentage change in streamflow.	Changes in streamflow could be evaluated against in-stream flow requirements for aquatic life.	In-stream flow requirements tend to stream-specific, and therefore, cannot be generalized to all streams in a HUC.

Indicator ID#	Indicator	Are objective breakpoints in the range of vulnerability documented?	Can objective breakpoints be identified?	Are the breakpoints valid when the data are aggregated?
449	Ratio of Reservoir Storage to Mean Annual Runoff	No	Stochastic model output from an integrated climatic-hydrologic model could be evaluated to identify areas where reservoir storage is expected to drop to zero more often than a specified frequency.	Yes, but only with suggested modifications.
453	Runoff Variability	No	Stochastic model output from an integrated climatic-hydrologic model could be evaluated to identify areas where reservoir storage is expected to drop to zero more often than a specified frequency.	Yes, but only with suggested modifications.
460	Macroinvertebrate Index of Biotic Condition	No, breakpoints are arbitrary.	No	N/A
461	Macroinvertebrate Observed/Expected (O/E) Ratio of Taxa Loss	No, breakpoints are arbitrary.	No	N/A
623	Water Availability: Net Streamflow per Capita	Regional differences in water-using activities mean that the sufficiency of available water supplies varies geographically. No documented thresholds were found.	Possibly, although Indicator #351 (Instream Use/Total Streamflow) describes the same concept and has an objective threshold (1).	Yes

Appendix L. Contact Information

The Cadmus Group, Inc.

Julie Blue, Ph.D.
The Cadmus Group, Inc.
57 Water St,
Watertown, MA 02472
E-mail: julie.blue@cadmusgroup.com
Phone: 617-673-7154

EPA

Chris Weaver, Ph.D.
Global Change Research Program (GCRP),
U.S. Environmental Protection Agency
Office of Research and Development,
National Center for Environmental Assessment
8601-P, 1200 Pennsylvania Ave.,
Washington, DC 20460
E-mail: weaver.chris@epa.gov
Phone: 703-347-8621

Technical Advisors

Thomas Meixner, Ph.D.
Associate Professor
University of Arizona,
Room 202 Harshbarger Building,
Tucson, AZ 85721
E-mail: tmeixner@hwr.arizona.edu
Phone: 520-626-1532

David Allan, Ph.D.
Professor and Acting Dean
University of Michigan,
School of Natural Resources and Environment,
2064 Dana Building, 440 Church Street,
Ann Arbor, MI 48109-1041
E-mail: dallan@umich.edu
Phone: 734-764-6553

John Day, Ph.D.
Distinguished Professor
Louisiana State University,
2237 Energy Coast and Environment Building,
LSU-Coastal Ecology Institute,
Baton Rouge, LA 70803
E-mail: johnday@lsu.edu
Phone: 225-578-6508

Kathleen Miller, Ph.D.
Scientist III
Institute for the Study of Society and Environment (ISSE),
National Center for Atmospheric Research (NCAR),
P.O. Box 3000, Boulder, CO 80307
E-mail: kathleen@ucar.edu
Phone: 303-497-8115

Technical Advisors (continued)

David Yates, Ph.D.
Project Scientist
Institute for the Study of Society and Environment (ISSE) & Research Applications Laboratory (RAL),
National Center for Atmospheric Research (NCAR),
62 Pennsylvania St.,
Denver, CO 80203
E-mail: yates@ucar.edu
Phone: 303-497-8394

David Gochis, Ph.D.
Scientist I
Research Applications Laboratory (RAL) & The Institute for Integrative and Multidisciplinary Earth Studies (TIIMES),
National Center for Atmospheric Research (NCAR),
3450 Mitchell Lane, Boulder, CO 80307
E-mail: gochis@rap.ucar.edu
Phone: 303-497-2809