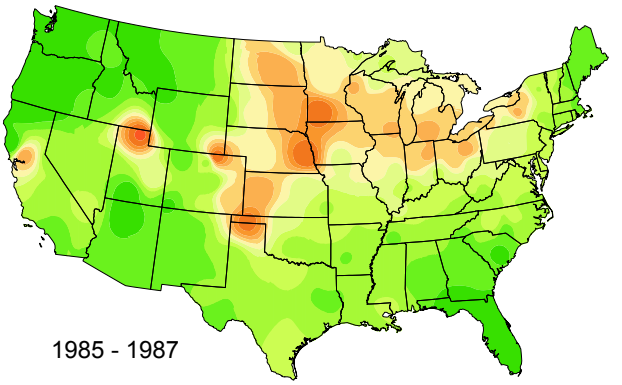
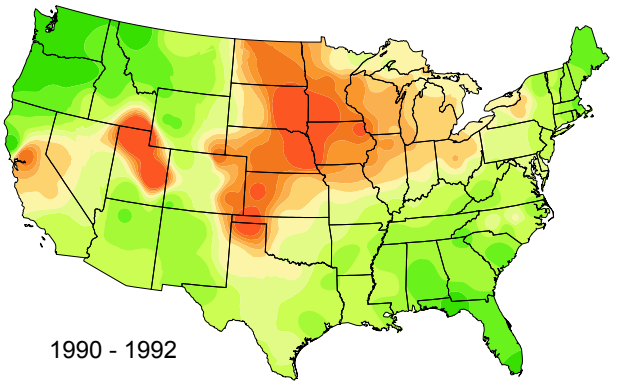
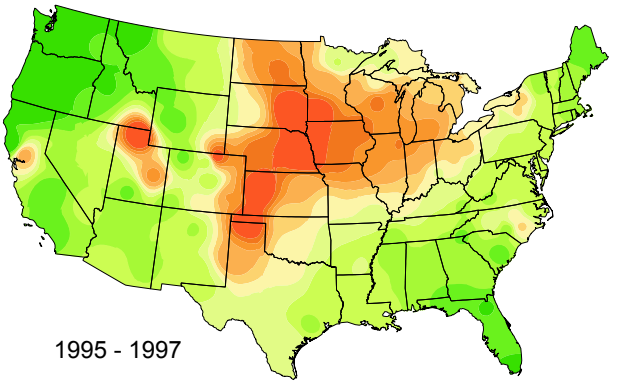
National Atmospheric Deposition Program
2002 Annual Summary



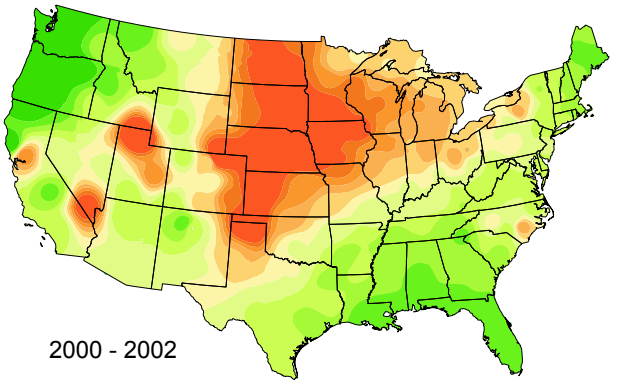
1985 - 1987



1990 - 1992

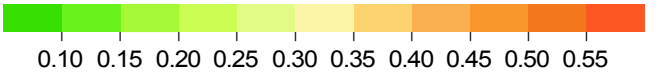


1995 - 1997



2000 - 2002

Average Ammonium Ion Concentration as NH_4^+ (mg/L)



NATIONAL ATMOSPHERIC DEPOSITION PROGRAM

A Cooperative Research Support Program of the
State Agricultural Experiment Stations (NRSP-3)
Federal and State Agencies
and Private Research Organizations

2002 Highlights

In 2002, scientists, students, educators, and others interested in the National Atmospheric Deposition Program (NADP) logged more than 150,000 sessions on the NADP Internet site (see the back cover for the address). This site had more than 52,000 unique visitors, a 23 percent increase since 2001, and now receives more than a million hits annually. Records show that about 60 percent of users study atmospheric deposition or its effects on aquatic and terrestrial ecosystems and cultural resources, and 40 percent use NADP data for educational purposes. Color-contour pH maps from the NADP National Trends Network (NTN) appeared in two new college textbooks: *Meteorology* and *Environmental Geology.*

Federal agencies continued to rely on NADP data to monitor the nation's air quality and evaluate policy decisions. For example:

- Recently, the U.S. Environmental Protection Agency used NTN maps to describe sulfate deposition decreases since sulfur dioxide emissions reductions began under the cap-and-trade program established in the 1990 Clean Air Act Amendments.
- In its report, *Air Quality in the National Parks* (second edition), the National Park Service used NTN sulfate, nitrate, and ammonium concentration and deposition data to characterize current air-quality conditions and trends.

Scientists published more than 80 journal articles using or citing NADP data. Two journal editions were of special note:

- In March, a special issue of *Ambio*, "Optimizing Nitrogen Management in Food and Energy Productions, and Environmental Change," featured papers from "N2001: The 2nd International Nitrogen Conference." More than a third of the papers addressed nitrogen deposition and used or cited NADP data.
- In April, *Atmospheric Environment* featured a special section "NADP 2000 - Ten Years After the Clean Air Act Amendments" of nine articles presented at the 2000 NADP Technical Committee meeting.

The NADP is in its third decade of recording high-quality precipitation chemistry data. A feature article on "Environmental Monitoring and National Security: Is There a Connection?" in a recent issue of *EM* suggested ways that monitoring networks, such as the NADP, could assist in a national surveillance system for biological, chemical, or radiological agents spread by terrorists. The NADP has a well-developed communications network and management infrastructure, and has previous experience with special efforts to monitor disasters, such as the Chernobyl nuclear accident in April 1986.

NADP Past

In 1977, U.S. State Agricultural Experiment Stations (SAES) organized a project, later titled NADP, to measure atmospheric deposition and study its effects on the environment. Sites in the NADP precipitation chemistry network began collecting samples in 1978. The goal was to provide data on the amounts, temporal trends, and geographic distributions of acids, nutrients, and base cations in precipitation. In the early 1980s, the network expanded its coverage to the entire country. The National Acid Precipitation Assessment Program, established in 1981 to improve understanding of the causes and effects of acidic precipitation, provided funding for much of this expansion. Today the NTN has about 250 sites.

[**About the cover:** Pictured are annual precipitation-weighted mean ammonium concentrations for four 3-year averaging periods: 1985-1987, 1990-1992, 1995-1997, and 2000-2002. Map animations of concentration changes for sulfate, nitrate, and ammonium from 1985 to the present are available at http://nadp.sws.uiuc.edu/amaps/.]

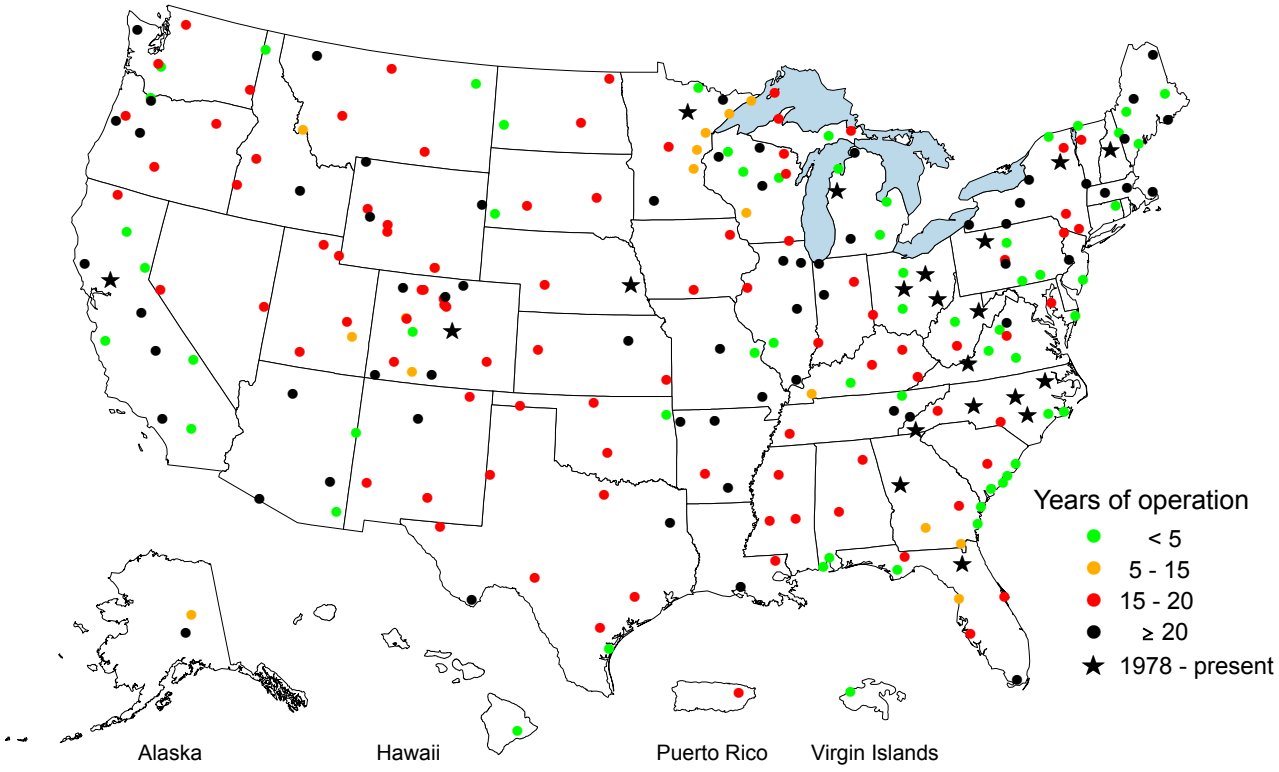
National Trends Network

The NTN is the only network providing a long-term record of precipitation chemistry across the United States. Sites predominantly are located away from urban areas and point sources of pollution. Each site has a precipitation chemistry collector and gage. The automated collector ensures that the sample is exposed only during precipitation (wet-only-sampling).

Site operators collect samples weekly on Tuesday morning. They transfer each sample from the collection bucket to a shipping bottle, and send it to the Central Analytical Laboratory (CAL) at the Illinois State Water Survey for analysis, and data entry, verification, and screening. All sample containers are cleaned at the CAL, the sole analytical laboratory since the program began. The CAL measures sample volume, conductivity, and the following concentrations: calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), ammonium (NH_4^{+}), sulfate (SO_4^{2-}), nitrate (NO_3^{-}), chloride (Cl^{-}), and H^{+} as pH. The CAL also measures orthophosphate, but only for quality assurance purposes as an indicator of sample contamination.

The CAL reviews field and laboratory data for completeness and accuracy, and flags samples that have been mishandled, grossly contaminated, or compromised by precipitation collector failures. The CAL delivers all data and information to the NADP Program Office, which applies a final set of checks and resolves remaining discrepancies. Data then are made available on the NADP Internet site.

The map below shows NTN sites and their years of operation as of December 31, 2002. Twenty sites have operated continuously since 1978.



Years of operation at NTN sites as of December 31, 2002.

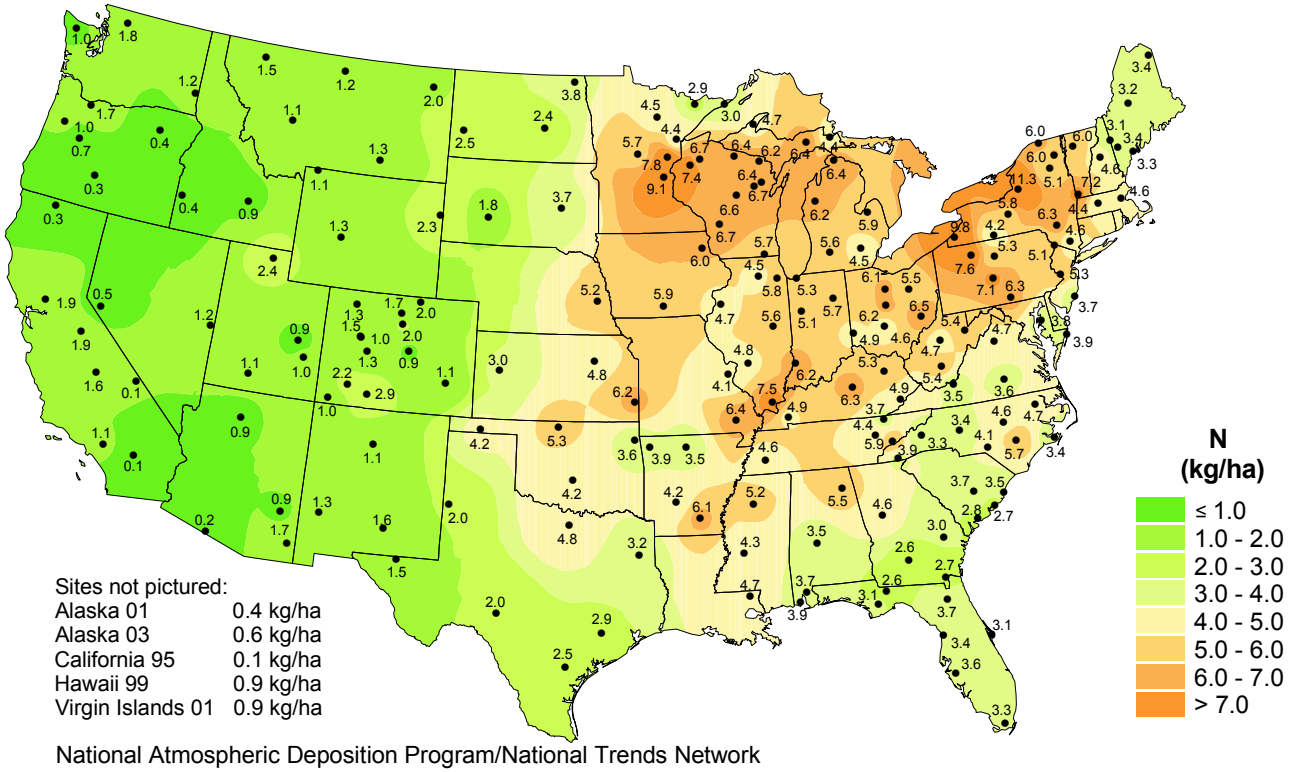
NTN Maps

The NTN maps show spatial variability in the annual concentration and wet deposition of selected acidic ions, nutrients, and base cations on regional and national scales. Only sites meeting prescribed data completeness criteria are included. In 2002, 195 sites met these criteria. Black dots mark site locations, and annual concentration or deposition values appear next to each site. Concentrations are precipitation-weighted averages. (For an explanation of the data completeness criteria or how the precipitation-weighted averages or deposition fluxes were calculated, see the NADP Internet site.)

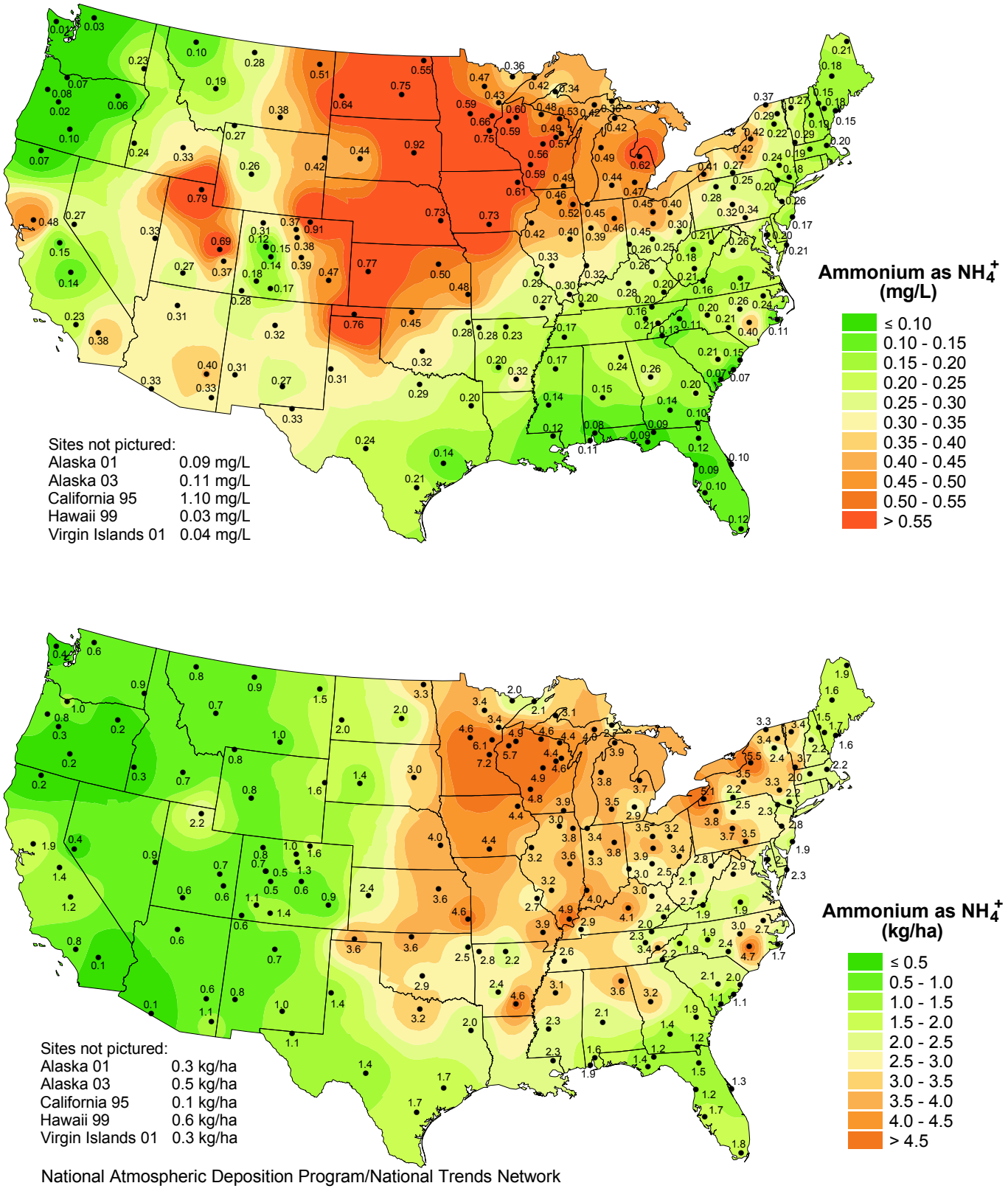
Color contours on the NTN maps were created by using site values to compute an array of regularly spaced grid-point values across the nation. Sites within 500 kilometers (km) of each grid point were used in computations. Color contours represent the classes of concentrations or depositions indicated in the legend. (For information about the algorithm used to compute grid-point values, see the NADP Internet site.)

In addition to the map of inorganic nitrogen wet deposition, below, concentration and deposition maps show NH_4^+, NO_3^-, SO_4^{2-}, Ca^{2+}, and laboratory pH. Also shown is a map of total precipitation. Maps of Mg^{2+}, Na^+, K^+, Cl^-, field pH, and field H^+ deposition are not included but are available from the NADP Internet site.

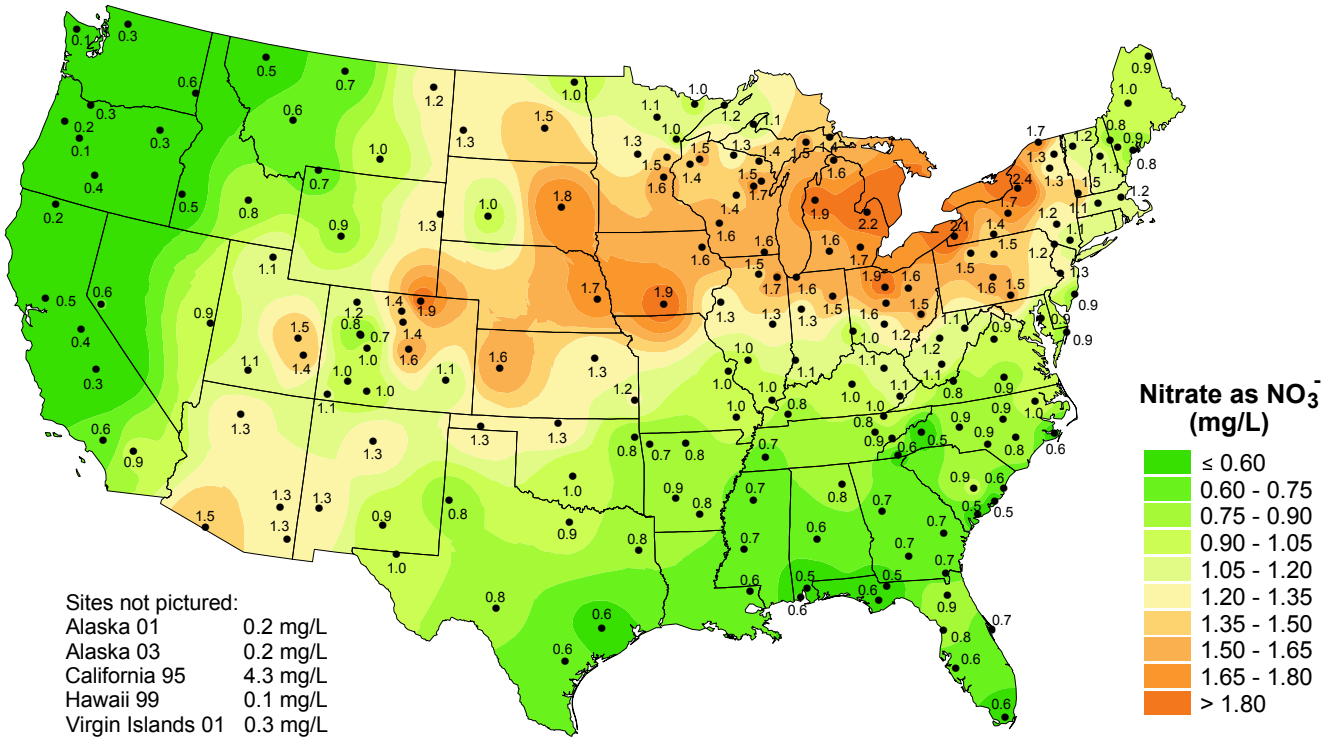
Explanation of NTN Color Contours: Refer to the figure below, which has eight inorganic nitrogen deposition classes or contours. The lightest green color in the legend represents 3.0 - 4.0 kilograms per hectare (kg/ha). Nitrogen deposition values in the area covered by this contour are greater than 3.0 kg/ha and less than or equal to 4.0 kg/ha.

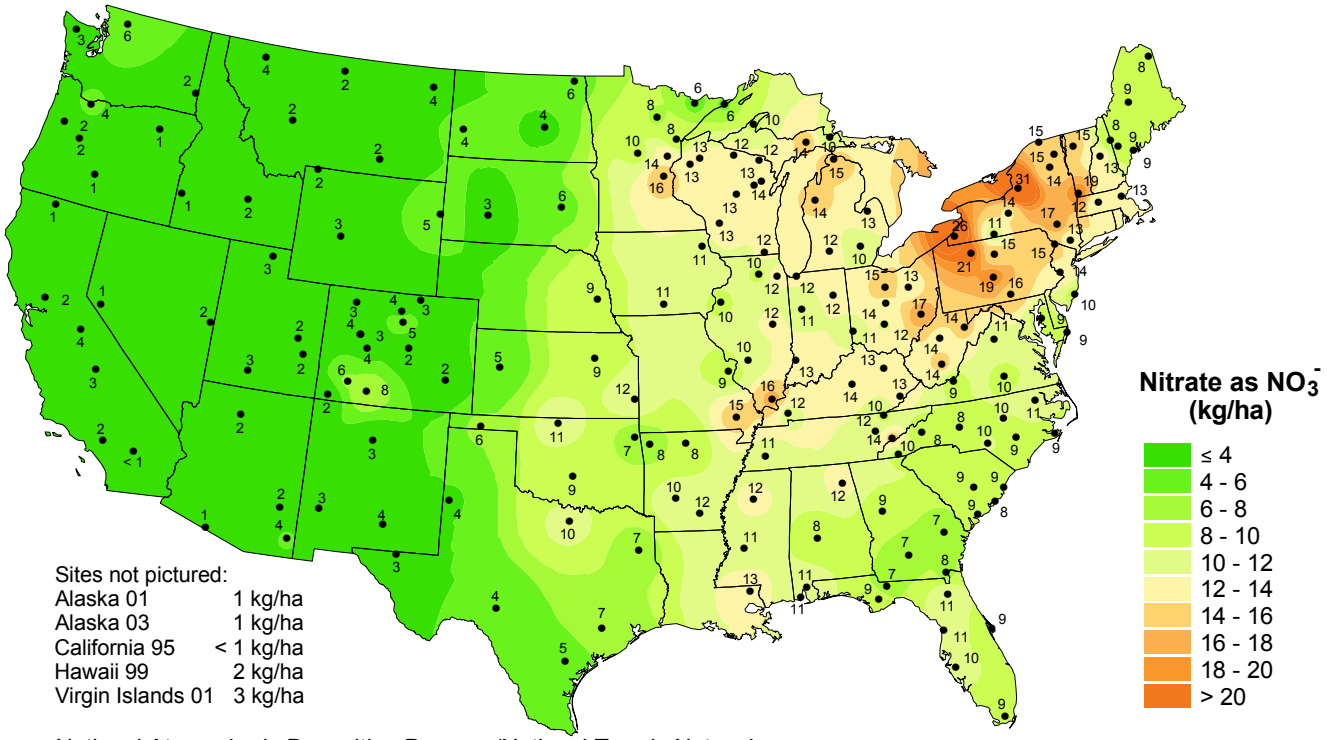


Inorganic nitrogen wet deposition from nitrate and ammonium, 2002.

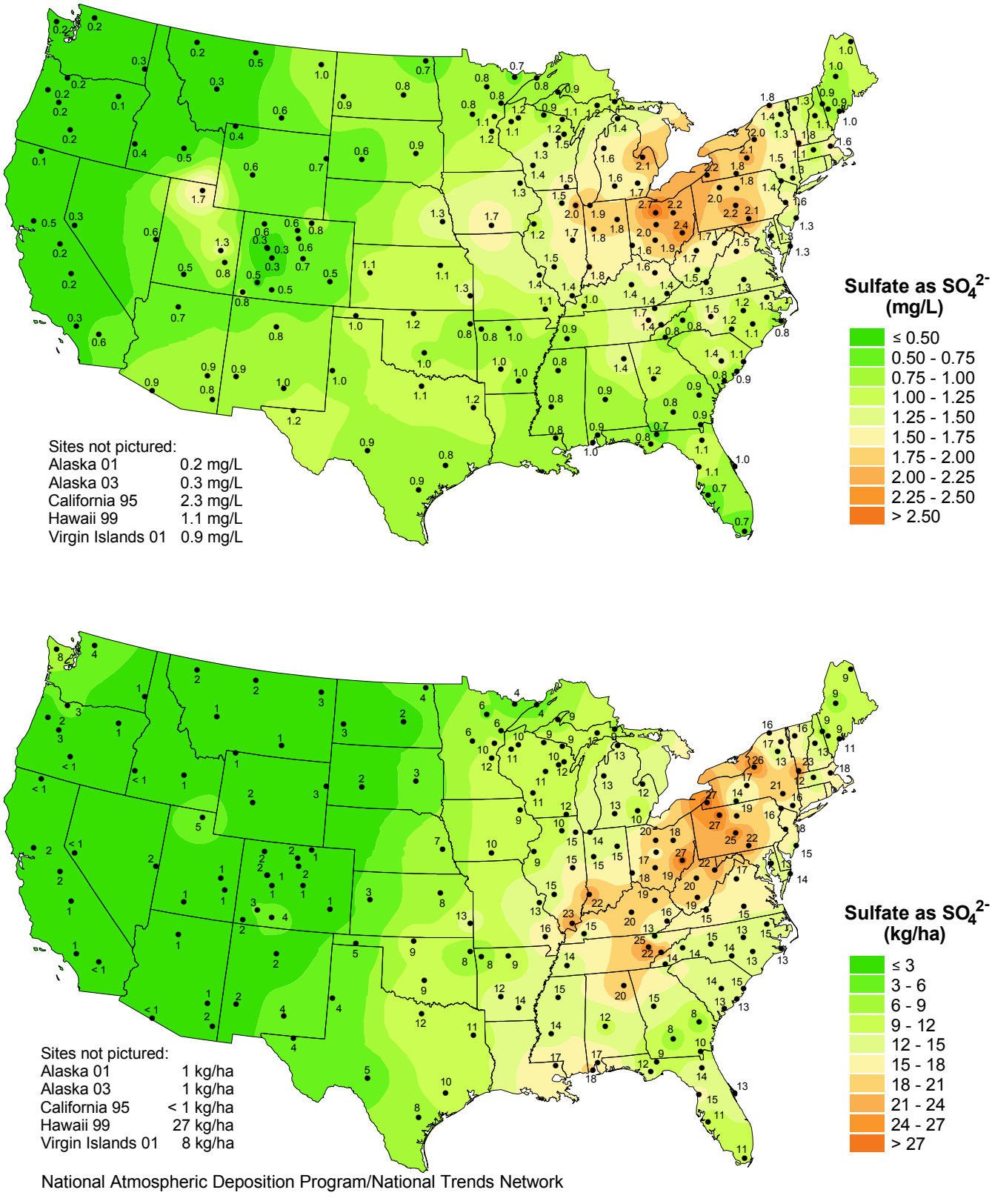


Ammonium ion concentration (top) and wet deposition (bottom), 2002.

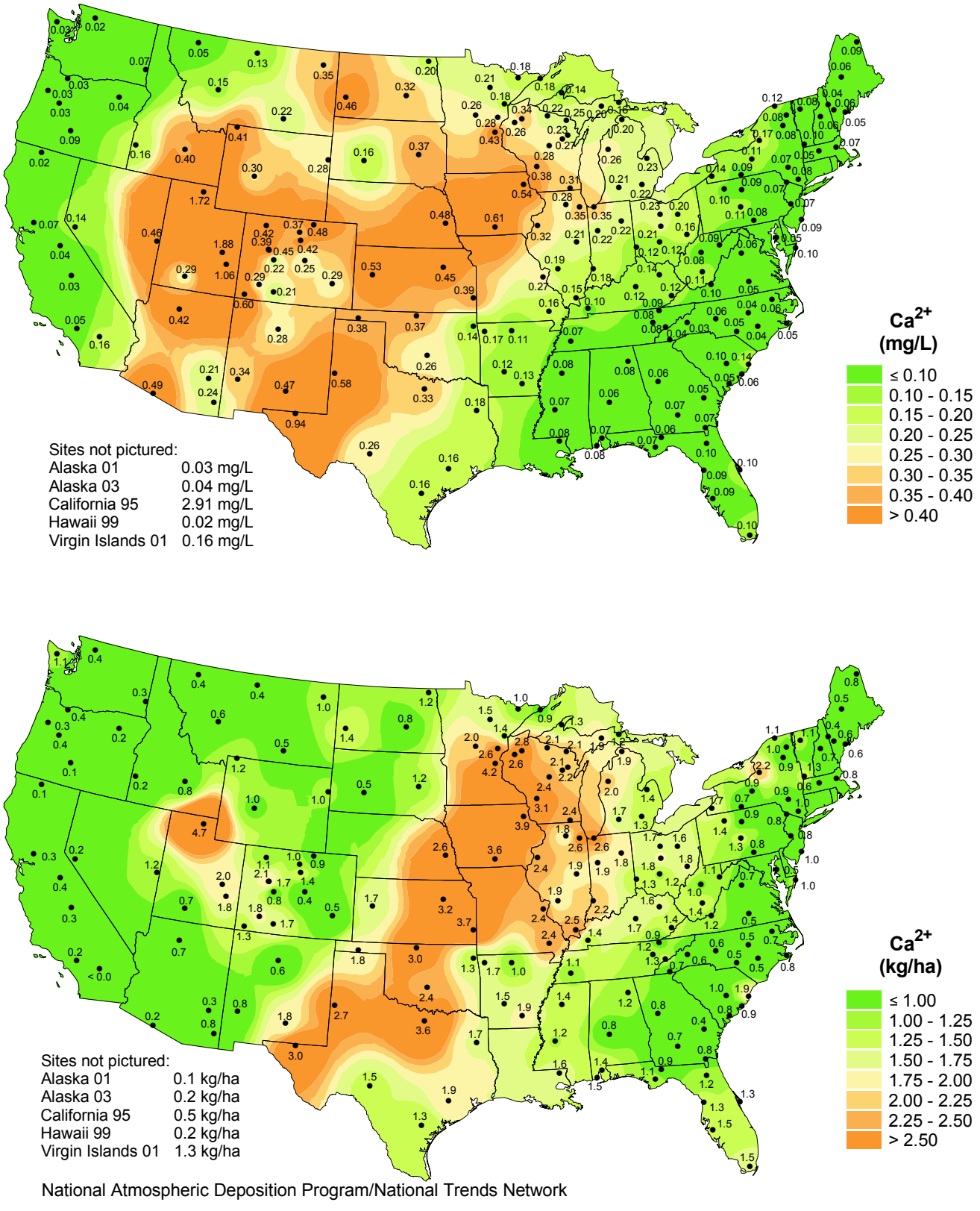




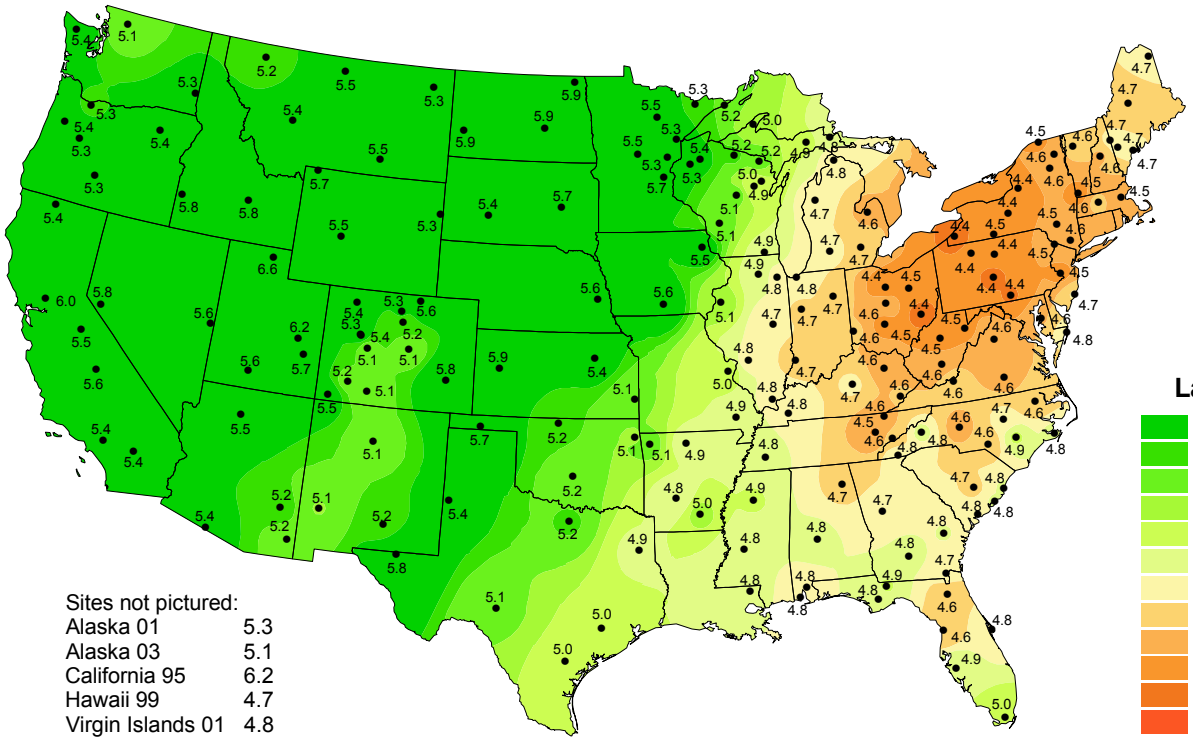
Nitrate ion concentration (top) and wet deposition (bottom), 2002.

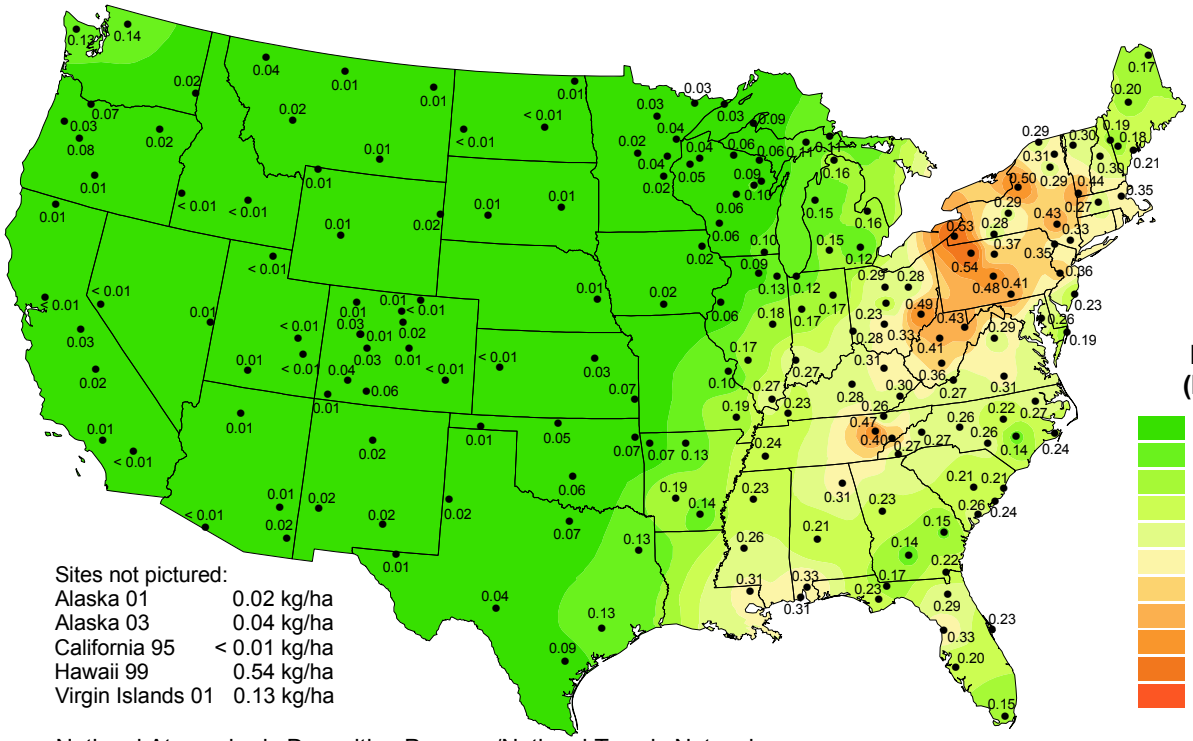


Sulfate ion concentration (top) and wet deposition (bottom), 2002.

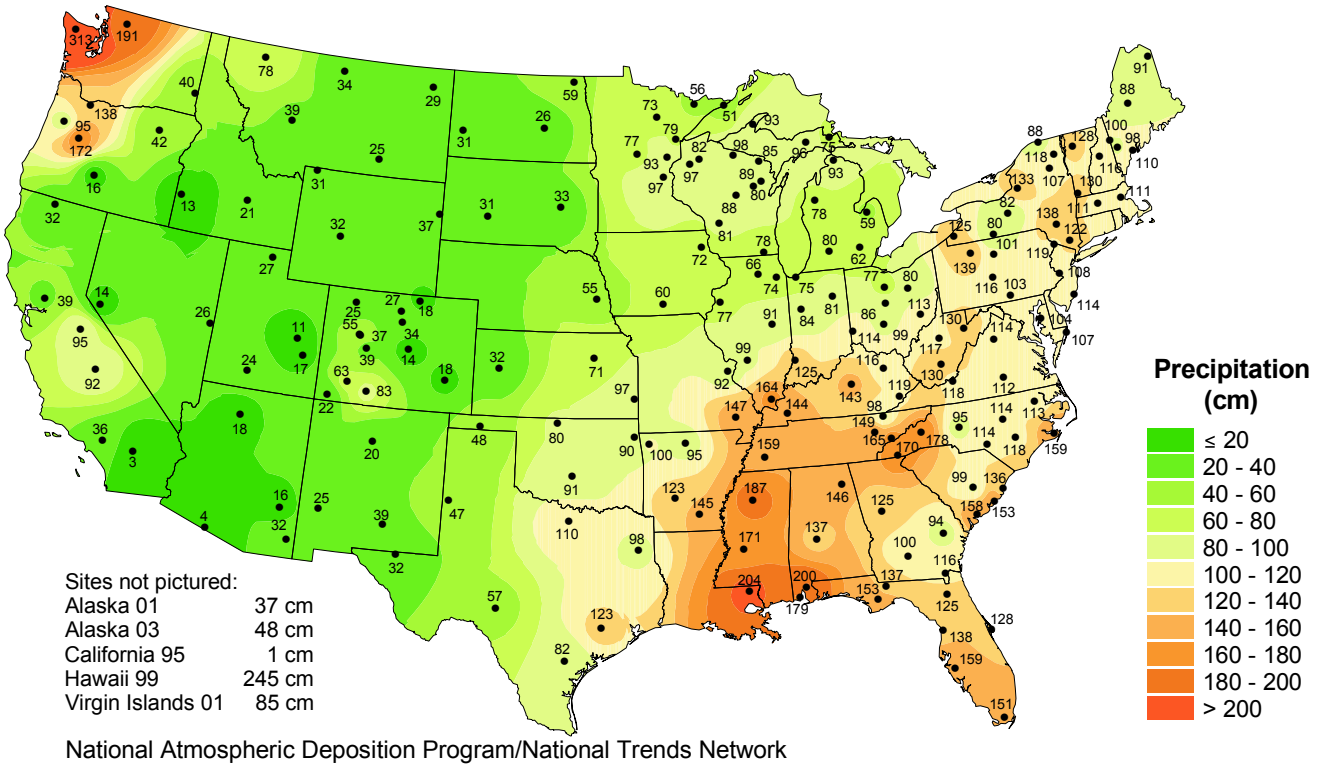


Calcium ion concentration (top) and wet deposition (bottom), 2002.





Hydrogen ion concentration as pH (top) and wet deposition (bottom) from pH measurements made at the Central Analytical Laboratory, 2002.

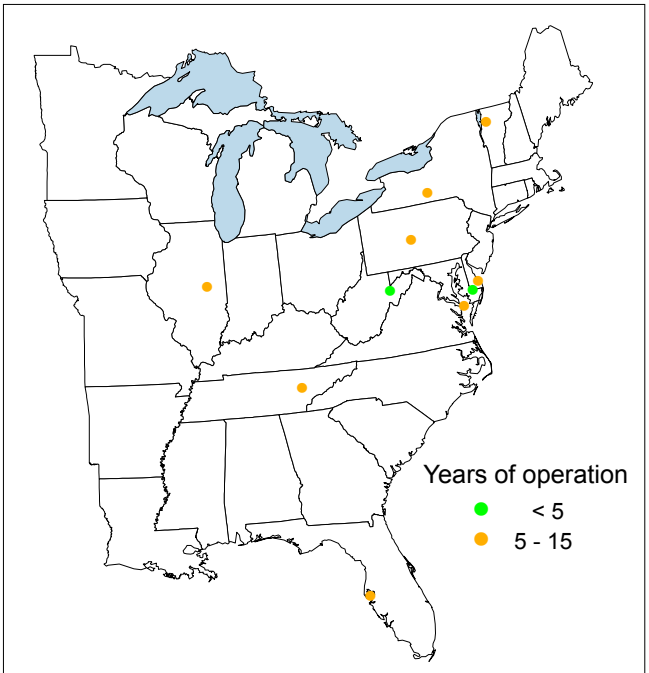


Total precipitation, 2002.

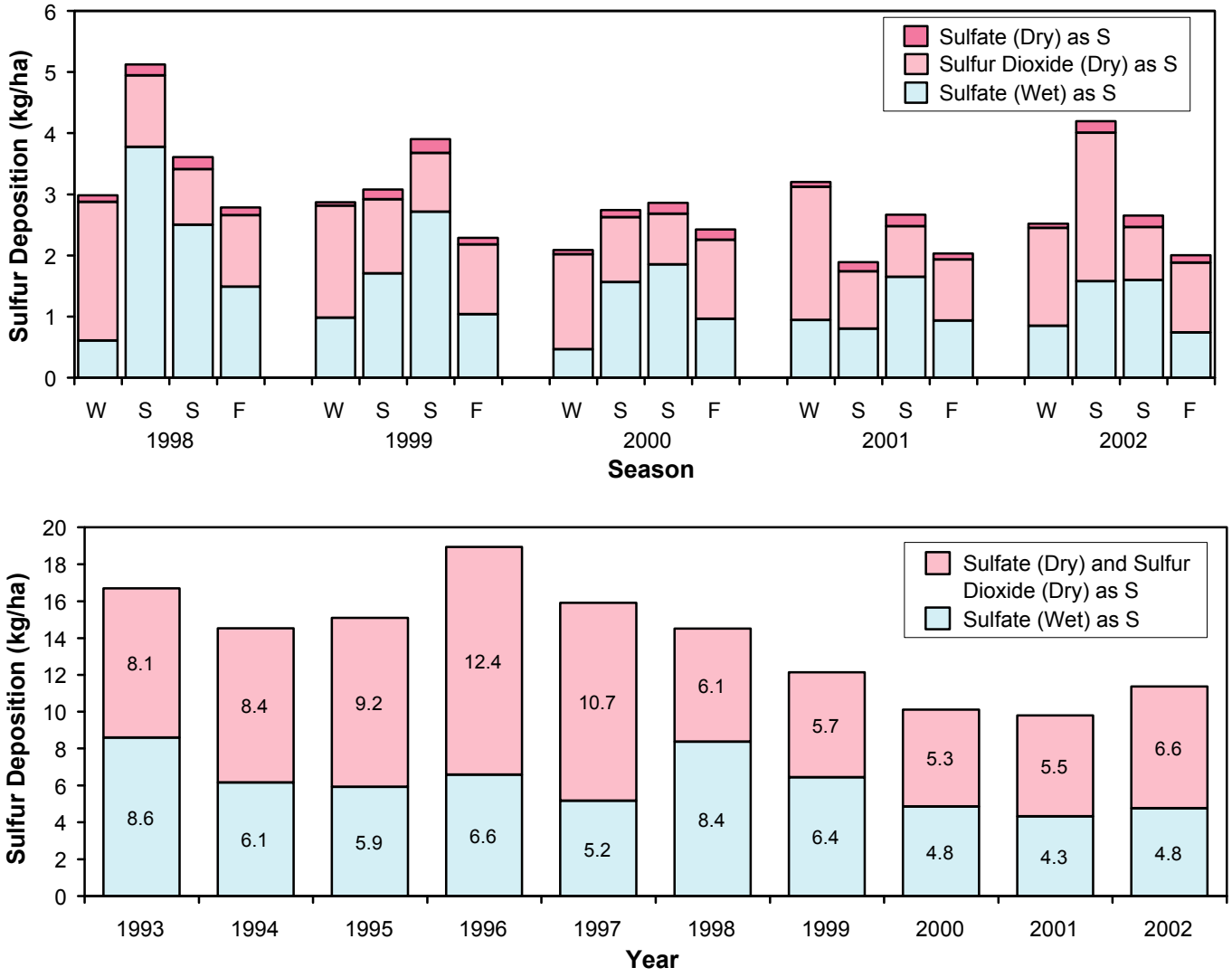
Atmospheric Integrated Research Monitoring Network

The Atmospheric Integrated Research Monitoring Network (AIRMoN) joined NADP in 1992. As of December 31, 2002, there were ten AIRMoN sites collecting samples within 24 hours of the start of precipitation (see map at right). While AIRMoN measures the same chemicals as NTN, sampling is daily rather than weekly. These higher resolution samples enhance researchers' ability to evaluate how emissions affect precipitation chemistry using computer models that simulate atmospheric transport and removal of pollutants on a storm-by-storm basis.

The AIRMoN samples are refrigerated after collection and until analysis at the CAL to retard chemical changes. Analyses and data screening procedures for AIRMoN and NTN are similar. The NADP Program Office makes the data available on the NADP Internet site.



Years of operation at AIRMoN sites as of December 31, 2002.



Winter, spring, summer, and fall (top) and annual (bottom) wet and dry deposition of sulfur at the Bondville AIRMoN-wet and AIRMoN-dry site.

AIRMoN Data

The bar charts above show wet and dry deposition of sulfur (S) at the Bondville AIRMoN-wet and AIRMoN-dry site in central Illinois. Each bar in the top chart depicts S deposition in kilograms per hectare (kg/ha) for a meteorological season. The 1998 meteorological winter is December 1997 through February 1998. Spring is March through May, etc. The AIRMoN-wet deposition (blue) is the product of the seasonal precipitation amount and precipitation-weighted-mean S from sulfate. The AIRMoN-dry deposition is the S deposition from aerosol sulfate (dark red) and the S deposition from gaseous sulfur dioxide (red). Each bar in the bottom chart depicts the annual (December - November) S deposition. Numbers on the bars indicate wet or dry S deposition with no distinction for aerosol or gaseous dry deposition.

Dry depositions of S from aerosol sulfate and gaseous sulfur dioxide were calculated using atmospheric concentrations, meteorological data, and information on land use, vegetation, and surface conditions. Individual measurement programs use different methodologies, which can result in large differences in S deposition estimates. The National Oceanic and Atmospheric Administration, Air Resources Laboratory, sponsors the AIRMoN-dry program. For more information, see http://www.arl.noaa.gov/research/projects/airmon_dry.html.

Mercury Deposition Network

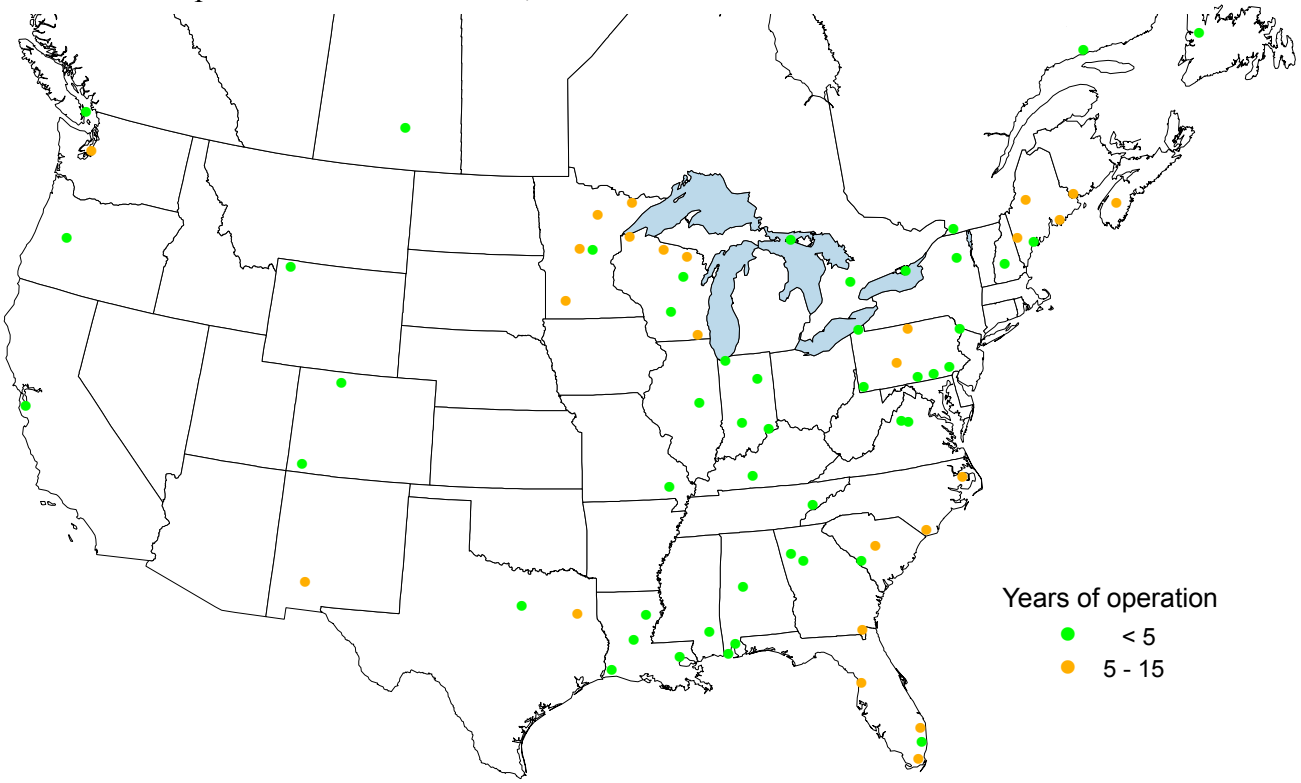
The Mercury Deposition Network (MDN), joined NADP in 1996. As of December 31, 2002, there were 73 active MDN sites, including ten sites in Canada (see map, below). All MDN sites collect samples using a precipitation chemistry collector especially modified to preserve mercury and equipped with ultra-clean glassware. The automated collector ensures that a sample is exposed only during precipitation (wet-only sampling). Precipitation is measured with a recording gage. All samples are analyzed for total mercury and a subset of samples for the more toxic methyl mercury at Frontier Geosciences, Inc., Seattle, Washington. Data are reviewed and validated by the NADP Program Office before they are made available on the NADP Internet site.

MDN Data

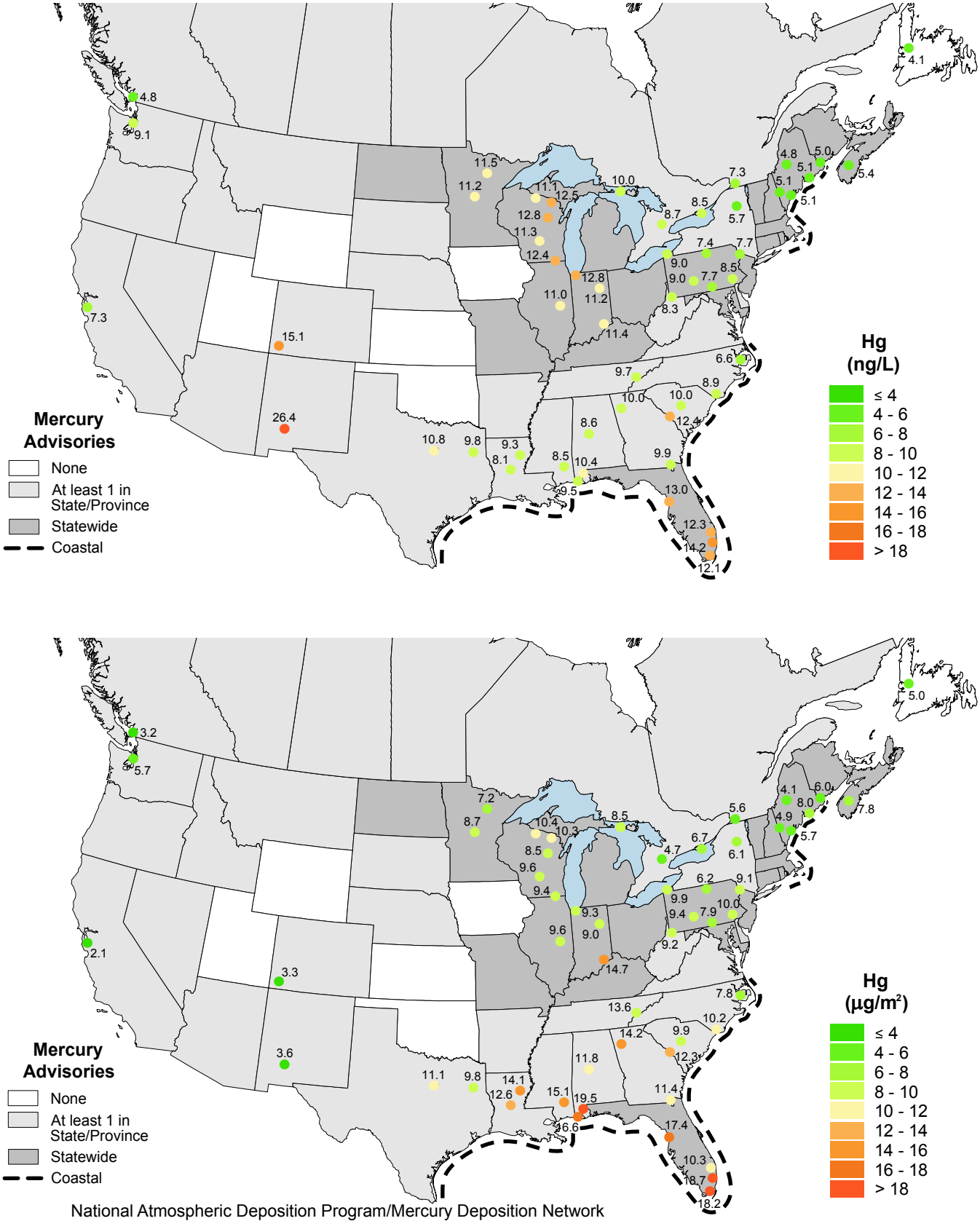
The MDN maps on page 13 show the 2002 precipitation-weighted average concentrations and wet depositions of total mercury (Hg) in precipitation. Colored dots mark MDN sites meeting prescribed data completeness criteria. In 2002, 54 sites met these criteria. The colors represent concentration or deposition classes indicated in the legend. Concentration and deposition values are printed next to the colored dots. (For an explanation of the data completeness criteria and how precipitation-weighted averages or depositions were calculated, see the NADP Internet site.)

The maps also show where the U.S. Environmental Protection Agency has posted fish or wildlife consumption advisories. These advisories warn that high concentrations of mercury have been found or are suspected in fish or wildlife from certain water bodies in these areas, and that consumption of these fish or wildlife may pose health risks. Forty-three states and 8 Canadian Provinces have advisories (see www.epa.gov/ost/fish).

Mercury in fish and wildlife can come from many natural processes, including precipitation. The connection between mercury deposition and mercury in fish or wildlife is under study. Researchers can use MDN data to evaluate the role of mercury deposition as a source of mercury in aquatic and terrestrial ecosystems.



Years of operation at MDN sites as of December 31, 2002.



Total mercury concentration (top) and wet deposition (bottom), 2002.
Mercury advisories are for fish and wildlife consumption, not deposition.

Recent Developments

Most NTN sites were installed predominantly away from pollution sources, such as urban areas, industrial operations, power plants, and animal feeding operations. The NADP siting criteria specify minimum separation distances from these and other potential sources. More than a third of the NTN sites have operated for 20 years or more, and land-use changes have occurred at some sites, such that urban or industrial development has encroached on these minimum separation distances. In addition, important new environmental issues, requiring long-term wet deposition data in coastal, urban, and suburban areas, have emerged. The NADP is addressing these issues by locating new sites in these areas, even though not all siting criteria could be met.

Recognizing that these changes can affect wet deposition, the NADP developed a site classification and characterization scheme that provides data users with information about potential influences of human activities. This scheme complements information that the NADP already compiles: site latitude, longitude, elevation, watershed, and ecoregion. (For a complete description of this scheme, see the NADP Internet site.)

Site Classification

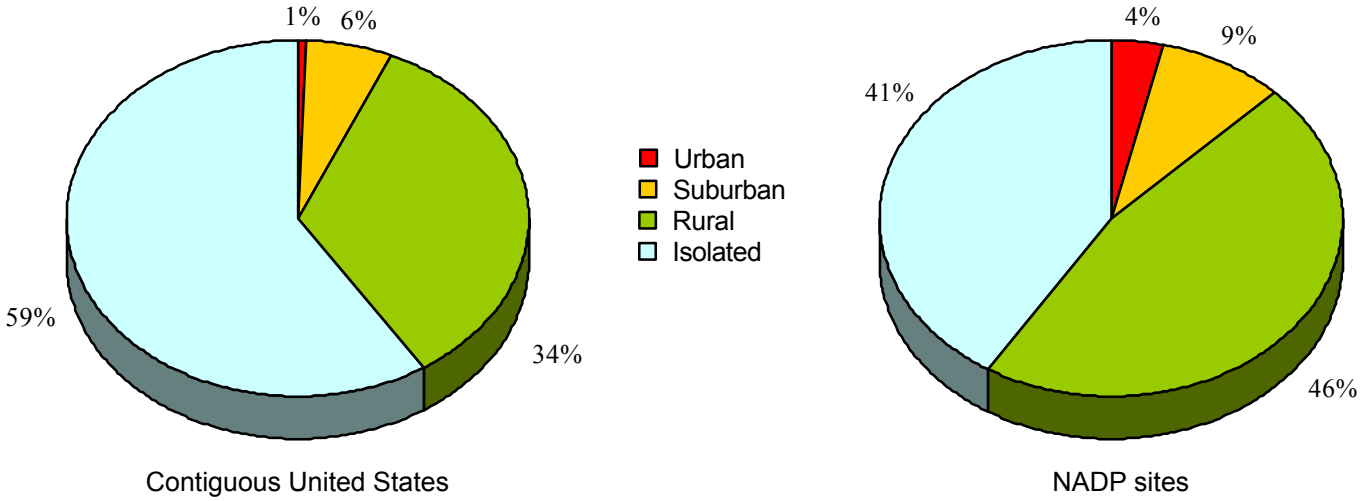
Sites are assigned to one of four classes, based on population density within a 15-km radius:

Urban	400 or more people/km^2
Suburban	100 - 399 people/km^2
Rural	10 - 99 people/km^2
Isolated	fewer than 10 people/km^2

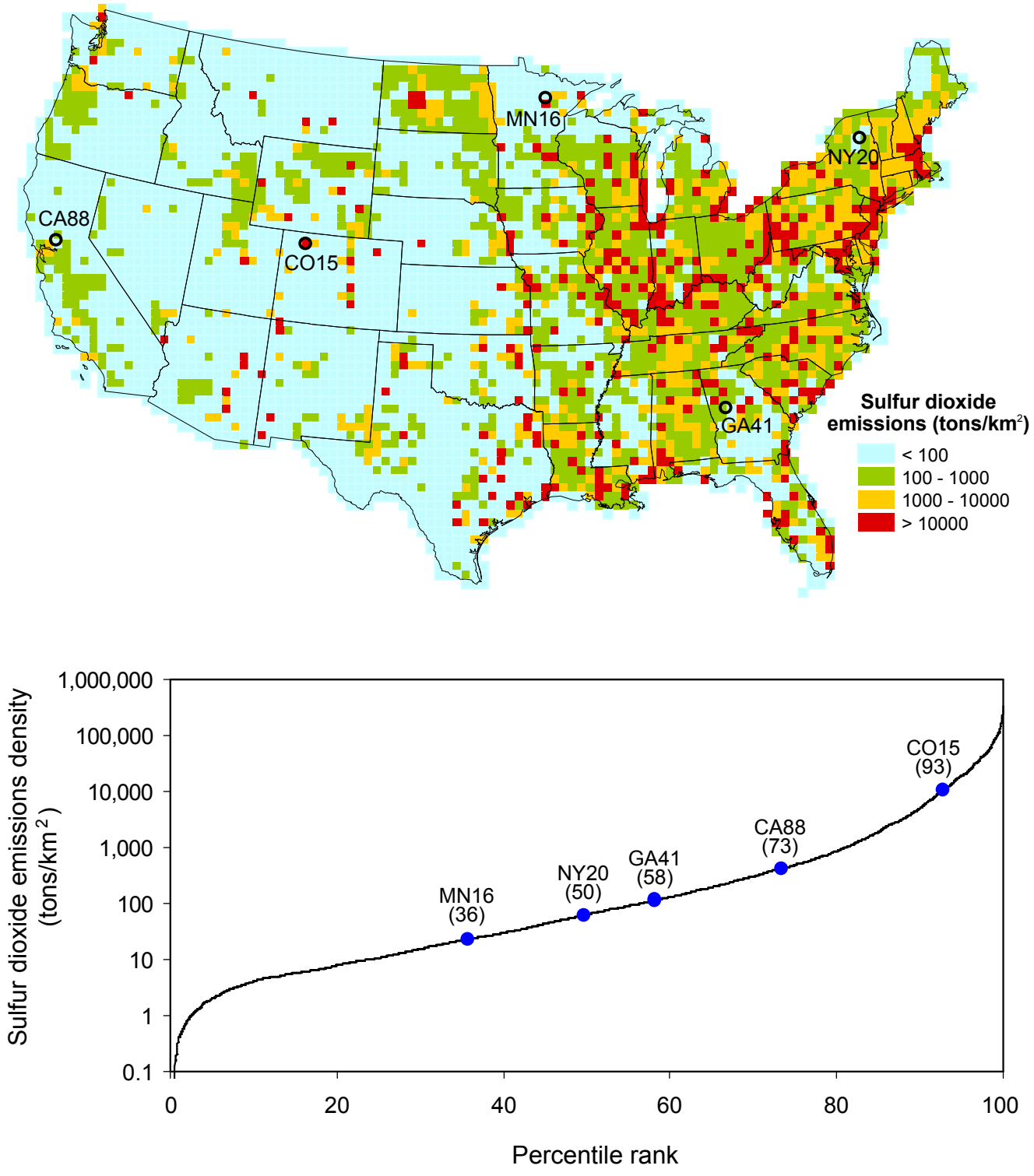
Population density was based on year 2000 U.S. census data. The pie charts, below, display the frequency of occurrence of population density classes in the contiguous United States and at NADP sites. The map on the back cover shows the classifications for all NADP sites in the United States, Puerto Rico, and the Virgin Islands.

Site Characterization

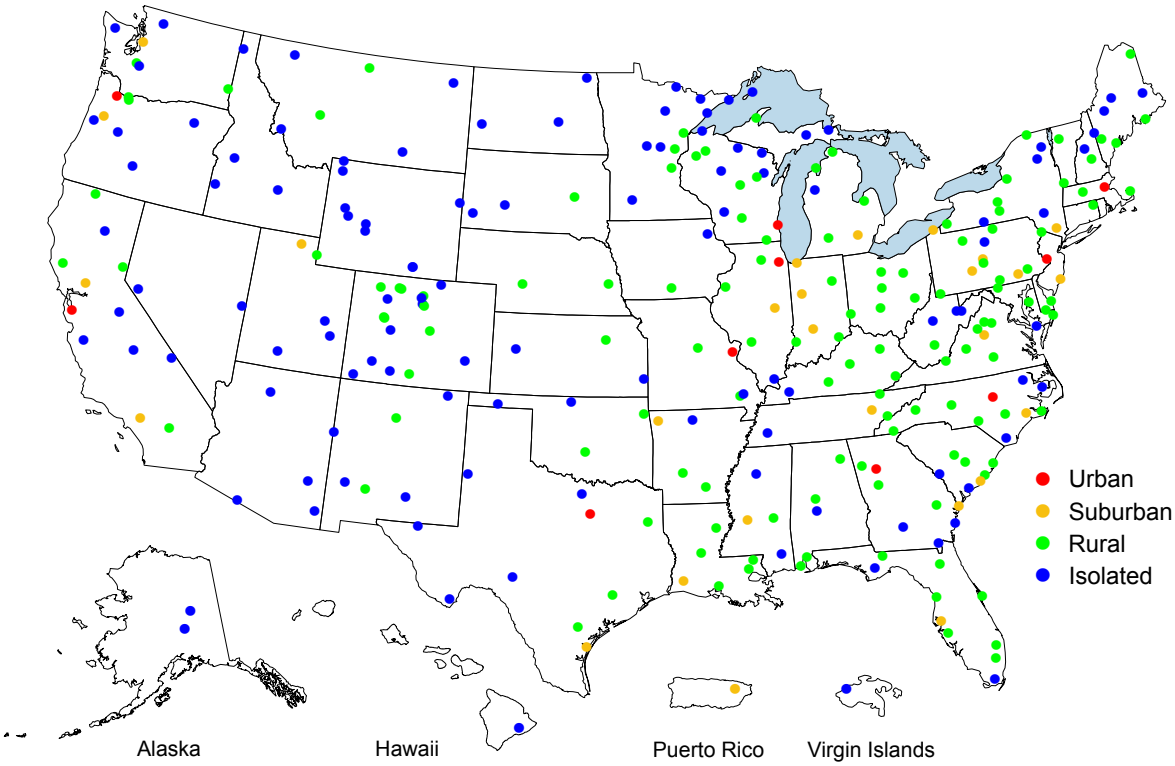
Sites are characterized by four factors related to: (1) population density within 15 km, (2) road density within 5 km, (3) sulfur dioxide emissions density within 25 km, and (4) nitrogen oxide emissions density within 25 km. Each factor ranges from 0 to 99, the percentile rank of the density at the site compared with the distribution of densities for the contiguous United States. The map on page 15 shows U.S. sulfur dioxide emissions densities; the plot shows percentile ranks for five sites with nearly 25 years of continuous operations.



Frequency of population density classes.



Sulfur dioxide emissions densities in the contiguous United States (top) and percentile ranks (bottom) of five NTN sites illustrate how site characterization factors are assigned (see page 14 for explanation.)



NADP site classifications (see page 14 for explanation.)

Note: When referencing maps or information in this report, please use the citation: National Atmospheric Deposition Program. 2003. *National Atmospheric Deposition Program 2002 Annual Summary.* NADP Data Report 2003-01. Illinois State Water Survey, Champaign, IL.

The NADP is National Research Support Project - 3: A Long-Term Monitoring Program in Support of Research on the Effects of Atmospheric Chemical Deposition. More than 250 sponsors support the NADP, including private companies and other nongovernmental organizations, universities, local and state government agencies, State Agricultural Experiment Stations, national laboratories, Native American organizations, Canadian government agencies, the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, the Tennessee Valley Authority, the U.S. Geological Survey, the National Park Service, the U.S. Fish & Wildlife Service, the Bureau of Land Management, the U.S. Department of Agriculture - Forest Service, and the U.S. Department of Agriculture - Cooperative State Research, Education, and Extension Service (under agreement no. 2002-39138-11964). Any findings or conclusions in this publication do not necessarily reflect the views of the U.S. Department of Agriculture or other sponsors.

The NADP Program Office is located at the Illinois State Water Survey, an affiliated agency of the University of Illinois and a Division of the Illinois Department of Natural Resources.
All NADP data and information, including color contour maps in this publication, are available from the NADP Internet site:

http://nadp.sws.uiuc.edu

For further information, special data requests, or to obtain copies of this publication, contact the NADP Program Office, Illinois State Water Survey, 2204 Griffith Drive, Champaign, IL 61820.
Telephone: (217) 333-2213 *Fax: (217) 244-0220* *e-mail:* nadp@sws.uiuc.edu