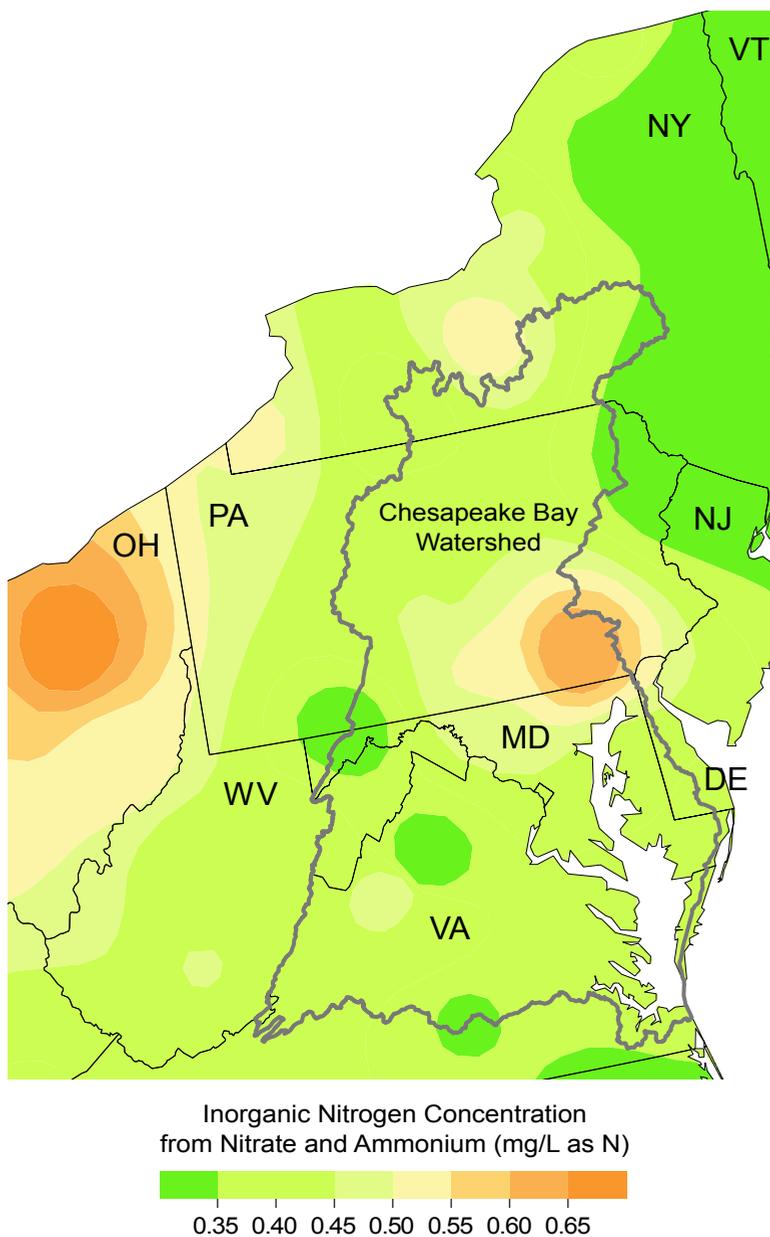


National Atmospheric Deposition Program 2005 Annual Summary



2005 Highlights

In 2005, scientists, students, educators, and others logged more than 310,000 sessions on the National Atmospheric Deposition Program (NADP) Web site (see back cover for address). This site had nearly 90,000 unique visitors, 19 percent more than in 2004. Users retrieved 18,564 data files, an increase of 35 percent, and they retrieved more than three times as many Mercury Deposition Network (MDN) data files as in 2004, reflecting the growing interest in these data. Records show that 61 percent of users study atmospheric deposition or its effects on aquatic and terrestrial ecosystems and cultural resources, and 39 percent use NADP data for educational purposes.

Educators included NADP maps and other information in textbooks, and the NADP Web site was used in public education and outreach materials. For example:

- *Chemistry in Context*, a textbook for liberal arts undergraduate students, has featured NADP National Trends Network (NTN) pH maps in all five editions, dating from 1994 to 2005. This textbook, a project of the American Chemical Society, was designed to teach chemical principles by introducing real-world issues.
- More than 1000 “Chemistry of Rain” packets, containing information about rain chemistry and the NADP, as well as pH measurement strips, a plastic rain gauge, and other materials, were distributed to elementary and middle school teachers for use in 4th and 8th grade science classes.

Government agencies continued to use NADP data to assess the nation’s air quality and evaluate policy decisions. For example:

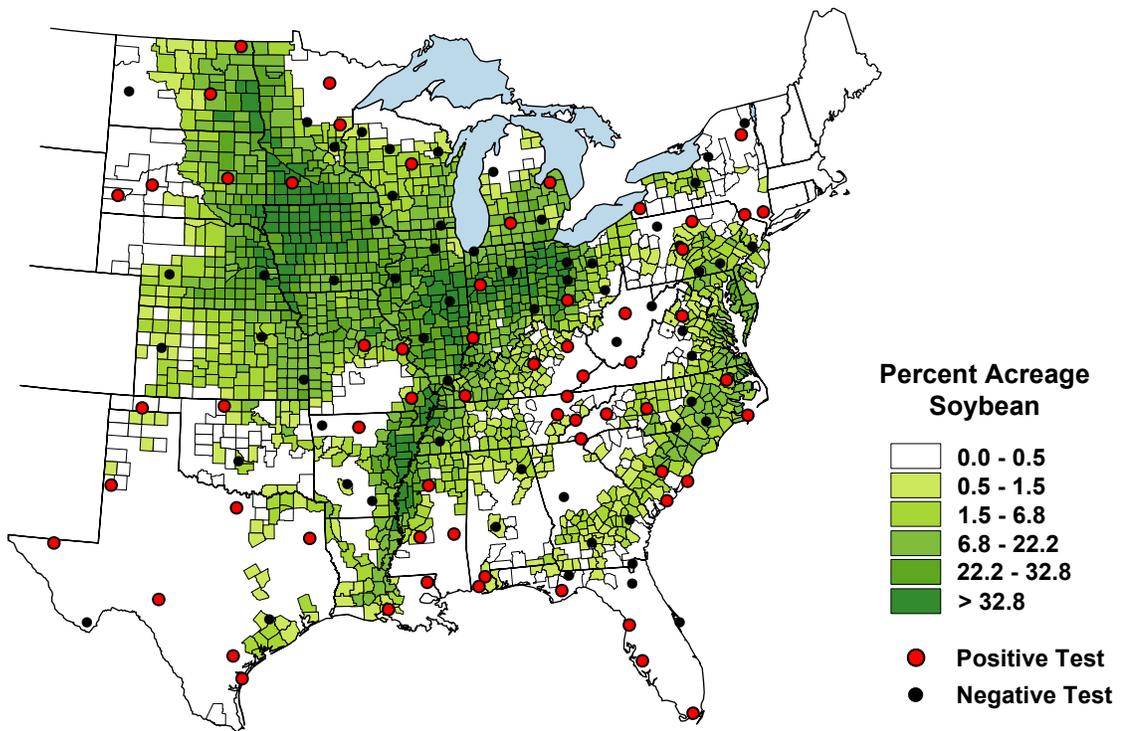
- In the 2005 *National Acid Precipitation Assessment Program Report to Congress - An Integrated Assessment*, NTN

concentration and deposition maps were presented to describe the current state of acid precipitation in the United States. Sulfate and nitrate trends from NTN data were especially effective in demonstrating the impact of sulfur and nitrogen oxide emissions reductions since 1990. The report emphasized the growing importance of nitrogen deposition in eastern U.S. estuaries and high-elevation Rocky Mountain ecosystems.

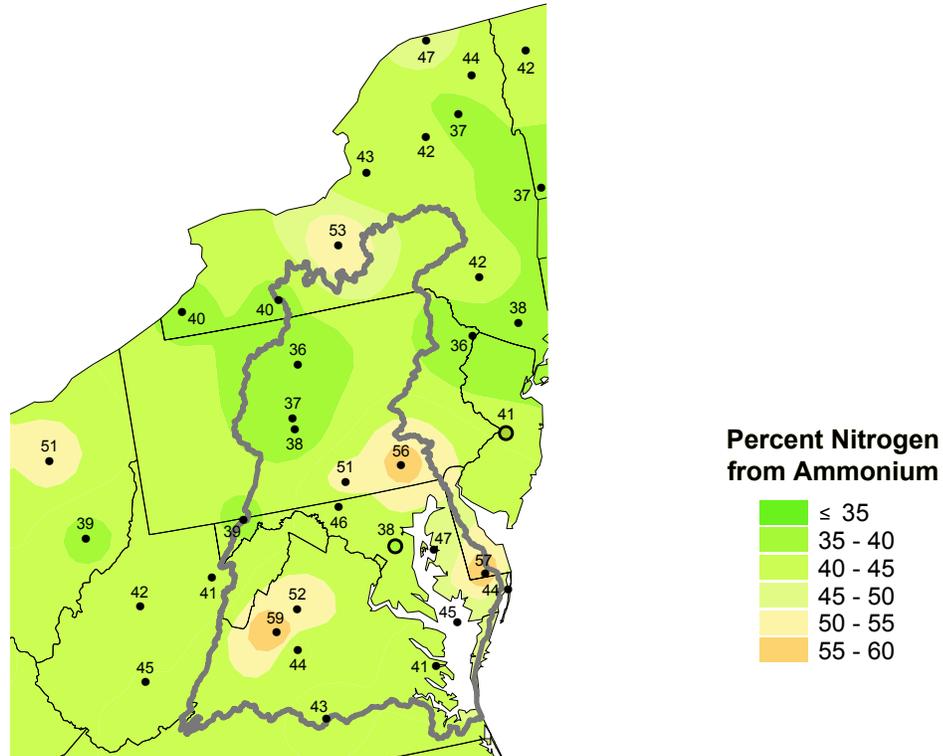
The NADP was involved in a field of emerging scientific interest.

- In November 2004, the U.S. Department of Agriculture (USDA) issued the first report of Asian soybean rust (ASR) in the continental United States. *Phakopsora pachyrhizi* or ASR infects soybean and other legumes, and can reduce yields by more than 50 percent. It is spread by spores that can be airborne for hundreds of kilometers before their deposition by rain. The USDA developed a plan for studying ASR and it included the NADP. Filters from NTN rain samples were tested by a very sensitive method for identifying ASR-specific DNA. These tests were performed at the USDA Cereal Disease Laboratory. For this project, NTN sites in major soybean-growing areas were selected. Measurements were used to track ASR spore deposition and verify models designed to simulate spore transport and deposition. The top map on the next page summarizes project results.

[About the cover: Pictured is the map of 2005 precipitation-weighted average concentrations of dissolved inorganic nitrogen from nitrate and ammonium in the Chesapeake Bay watershed and surrounding area. The gray border marks the watershed boundaries. Data from 16 NTN sites inside and 20 sites outside the watershed were used in preparing this map. The green dot in the center of the bay is the Smith Island site, which had a concentration of 0.39 milligrams per liter. The bottom figure on the next page shows the relative amounts of dissolved inorganic nitrogen from ammonium at these sites.]



Measurements of Asian soybean rust on filters from rain samples collected at NTN sites, May - November 2005. (Soybean acreage data from USDA National Agricultural Statistics Service.)



Percent of dissolved inorganic nitrogen from ammonium in wet deposition at NTN sites in the Chesapeake Bay watershed and surrounding area in 2005.

NADP Background

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 operations in 1978 with the goal of providing data on the amounts, trends, and geographic distributions of acids, nutrients, and base cations in precipitation. The network grew rapidly in the early 1980s. Much of this expansion was funded by the National Acid Precipitation Assessment Program (NAPAP), established in 1981 to improve understanding of the causes and effects of acidic precipitation. Reflecting the federal NAPAP role in the NADP, the network name was changed to NADP/NTN. Today, the NADP is SAES National Research Support Project - 3. The network has more than 250 sites and is designated NTN.

A second network (AIRMoN) joined the NADP in 1992, and had eight sites at the end of 2005. Although measuring the same chemicals as NTN, AIRMoN sampling is daily rather than weekly. These higher resolution samples enhance researchers' ability to evaluate how emissions affect precipitation chemistry using computer simulations of atmospheric transport and pollutant removal. This network also evaluates alternative sample collection and preservation methods.

The MDN joined the NADP in 1996, and had 92 sites at the end of 2005. All MDN samples are analyzed for total mercury, and some for the more toxic methyl mercury. Forty-five states have advisories warning people to limit consumption of fish and wildlife from certain water bodies because of mercury contamination (see <http://www.epa.gov/ost/fish>). Researchers use MDN data to evaluate the role of precipitation as a source of mercury in these water bodies.

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 follow standard operational procedures to help ensure NTN data comparability and representativeness. They collect samples weekly on Tuesday morning, using only containers cleaned at the Central Analytical Laboratory (CAL) at the Illinois State Water Survey (ISWS). They weigh the collection bucket to determine sample volume and transfer the sample from the collection bucket to a shipping bottle. All samples are sent to the CAL for analysis, and data entry, verification, and screening.

The CAL measures free acidity (H^+ as pH), conductance, calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+), sulfate (SO_4^{2-}), nitrate (NO_3^-), chloride (Cl^-), and ammonium (NH_4^+). The CAL also measures orthophosphate, but only for quality assurance as an indicator of sample contamination.

The CAL reviews field and laboratory data for completeness and accuracy, and flags samples that were mishandled, compromised by precipitation collector failures, or grossly contaminated. 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 Web site.

NTN Maps

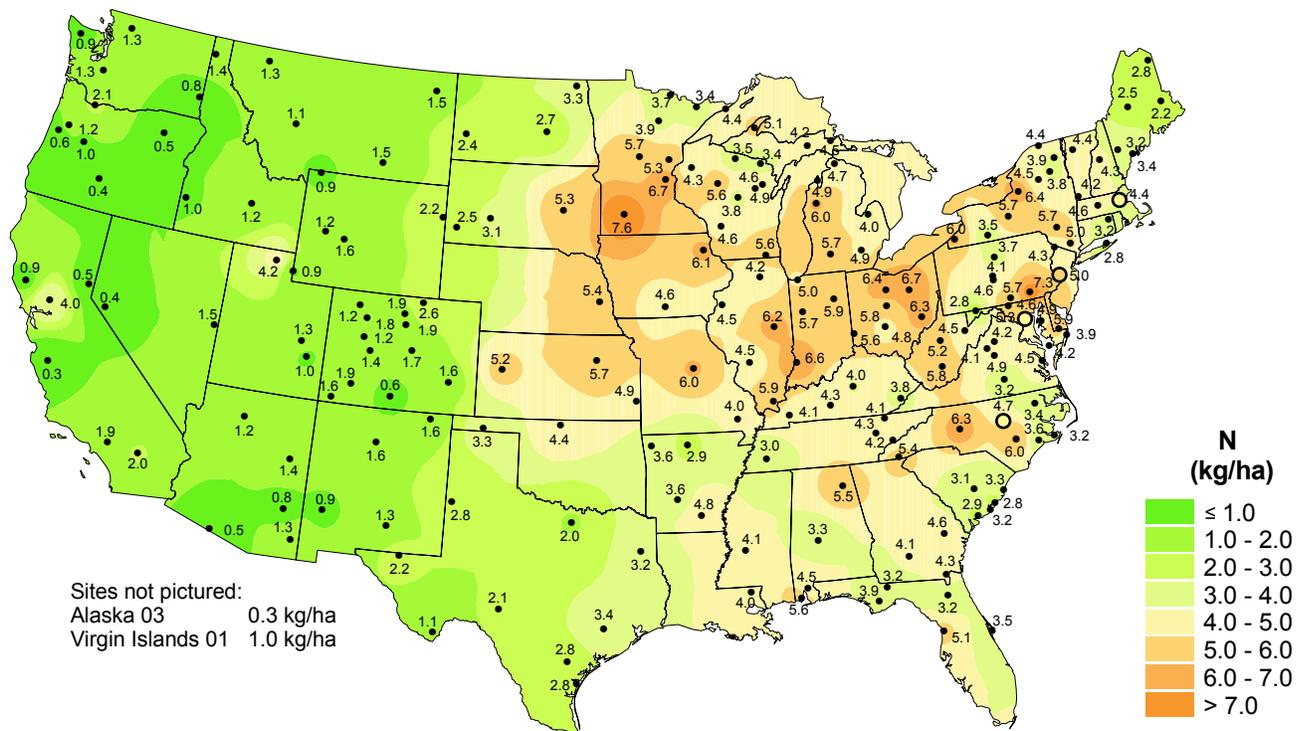
The NTN maps show spatial variability in the precipitation-weighted average concentration and wet deposition of selected acidic ions, nutrients, and base cations on regional and national scales. Only sites meeting NADP data completeness criteria are included. In 2005, 204 sites met these criteria. Black dots mark site locations. Open circles designate urban sites, defined as having at least 400 people per square kilometer (km²) within a 15-km radius of the site. Concentration or deposition values appear next to each site.

Color contours were created by using nonurban site values to compute an array of regularly spaced grid-point values across the nation. Sites within 500 km of each grid point were used in computations. Color contours and the color fill in the open circle of urban sites represent classes of concentrations or depositions in the

legend. (See the NADP Web site for information about the algorithm used to compute the grid values.)

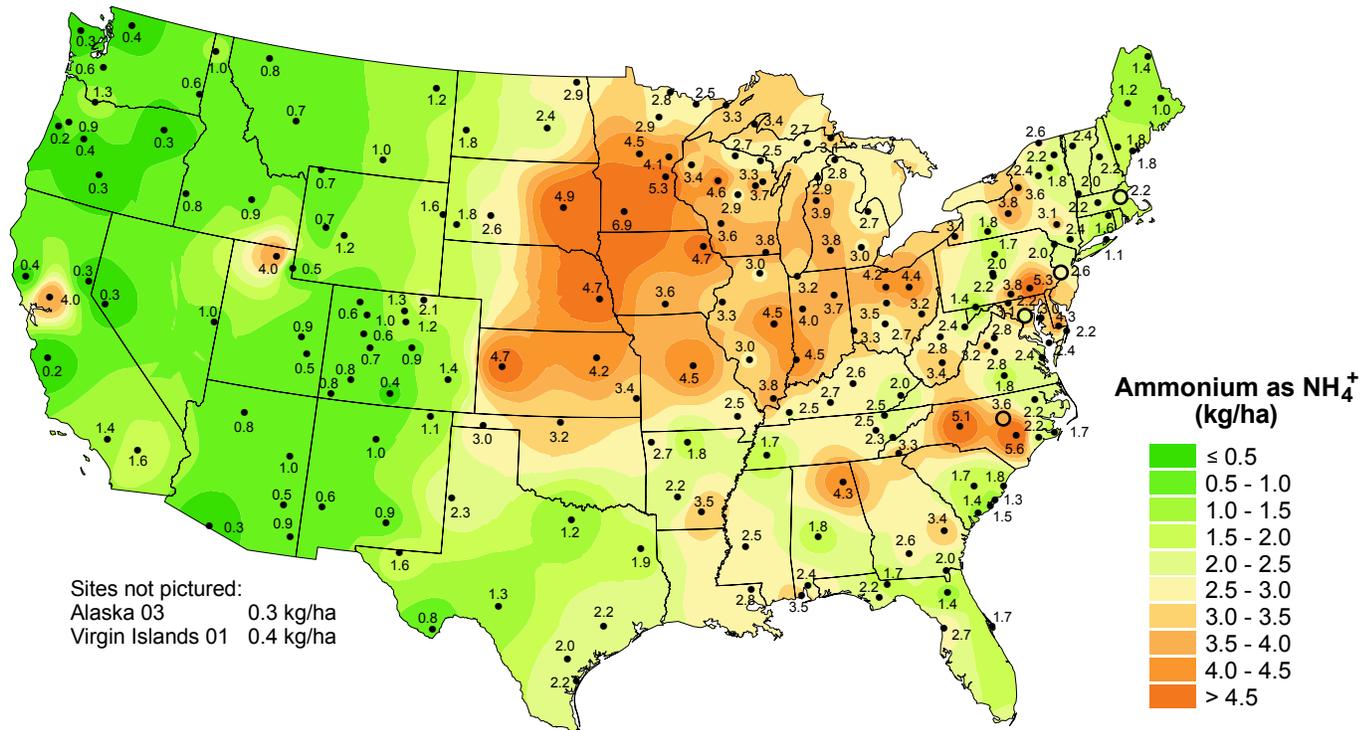
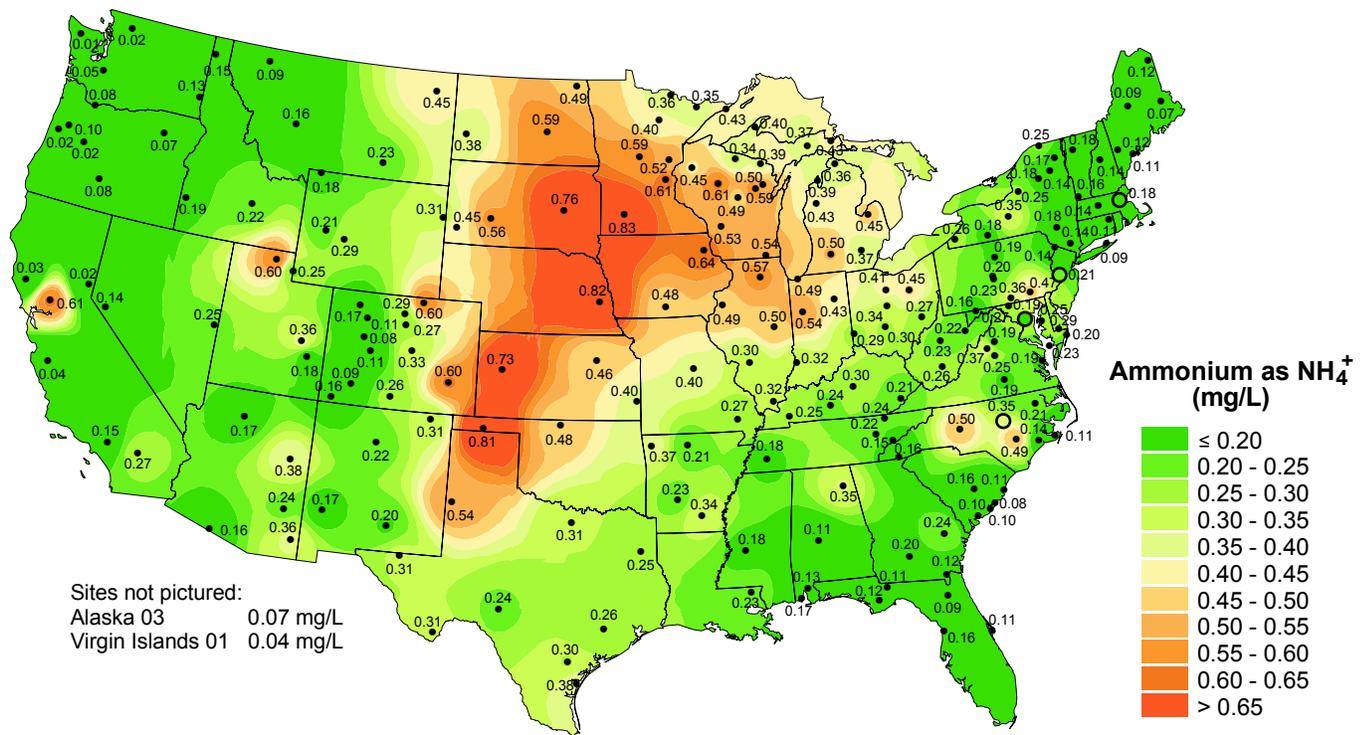
In addition to the map of inorganic nitrogen (N) wet deposition below, concentration and deposition maps show ammonium as NH₄⁺, nitrate as NO₃⁻, sulfate as SO₄²⁻, Ca²⁺, and laboratory pH. Also shown is a map of total precipitation. Maps of Mg²⁺, Na⁺, K⁺, and Cl⁻ are not included but are available from the NADP Web site.

Explanation of NTN Color Contours: Refer to the figure below, which has eight inorganic nitrogen wet deposition classes or contours. For example, the lightest green color in the legend represents 3.0 - 4.0 kilograms per hectare (kg/ha) of nitrate and ammonium as N. 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.



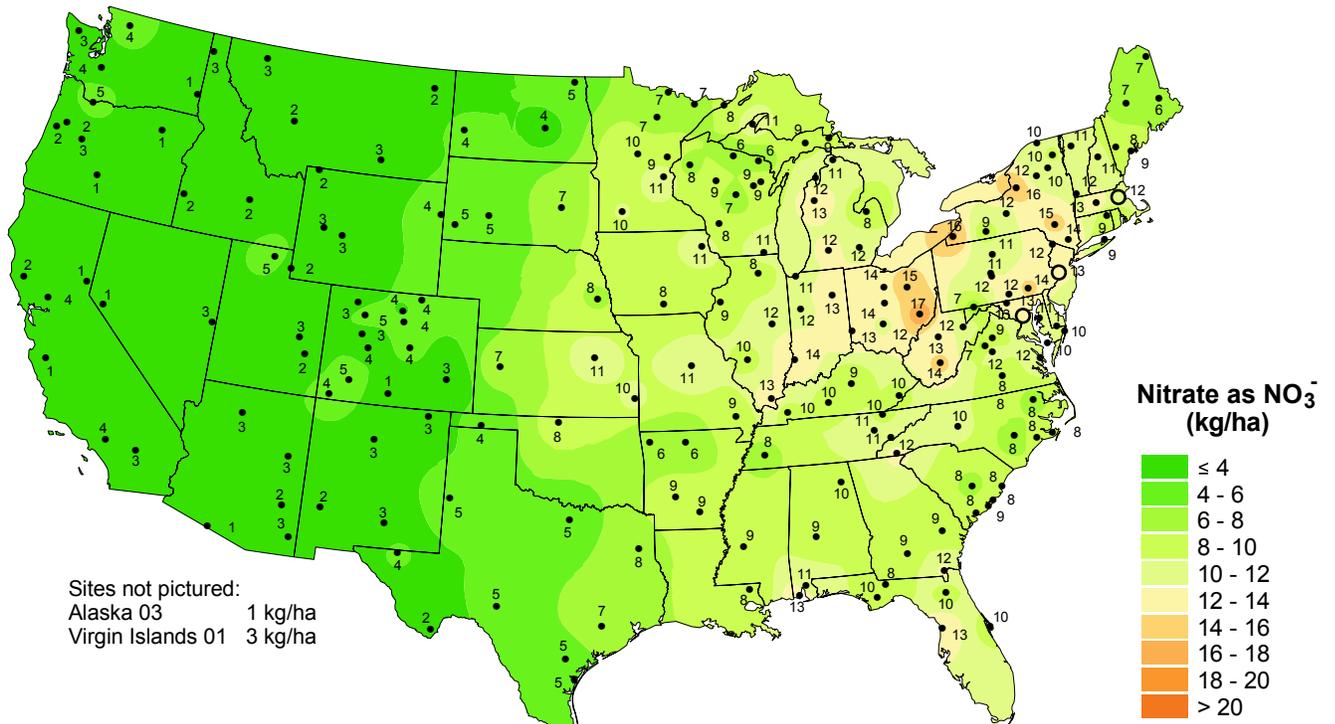
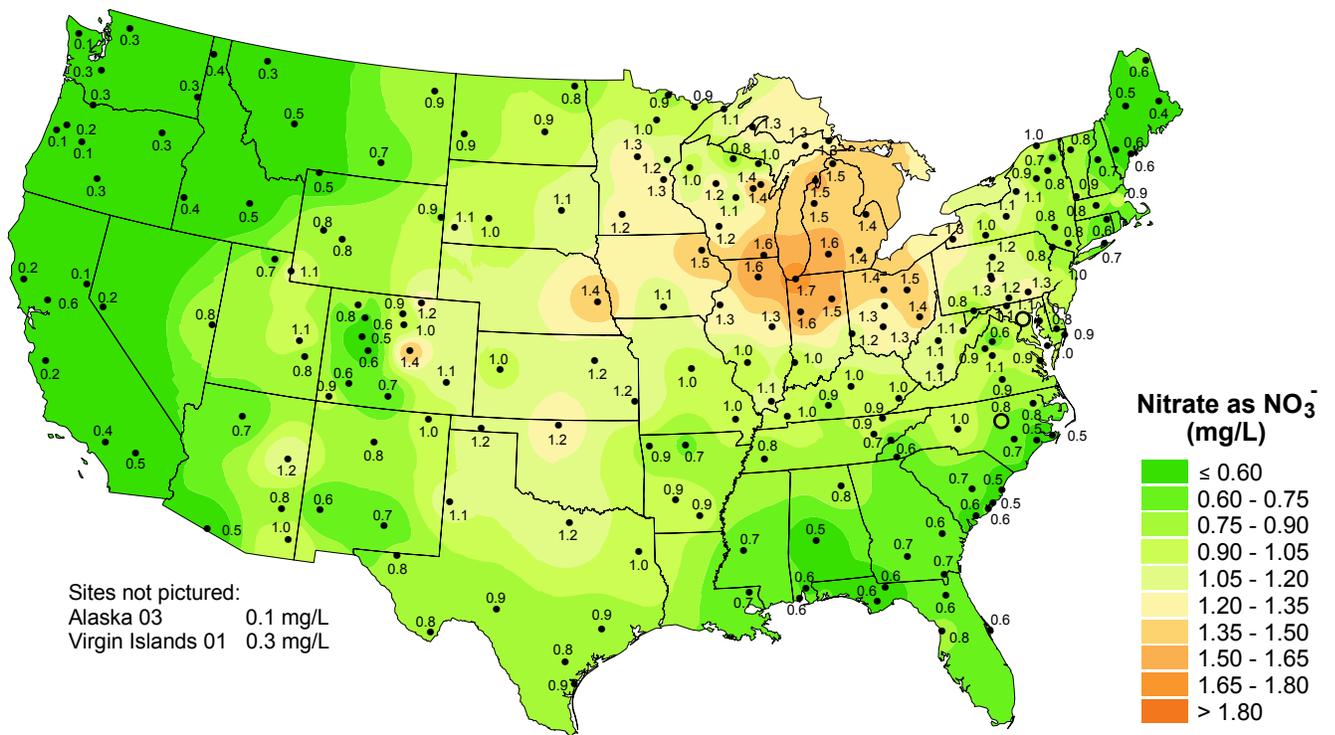
National Atmospheric Deposition Program/National Trends Network

Inorganic nitrogen wet deposition from nitrate and ammonium, 2005.



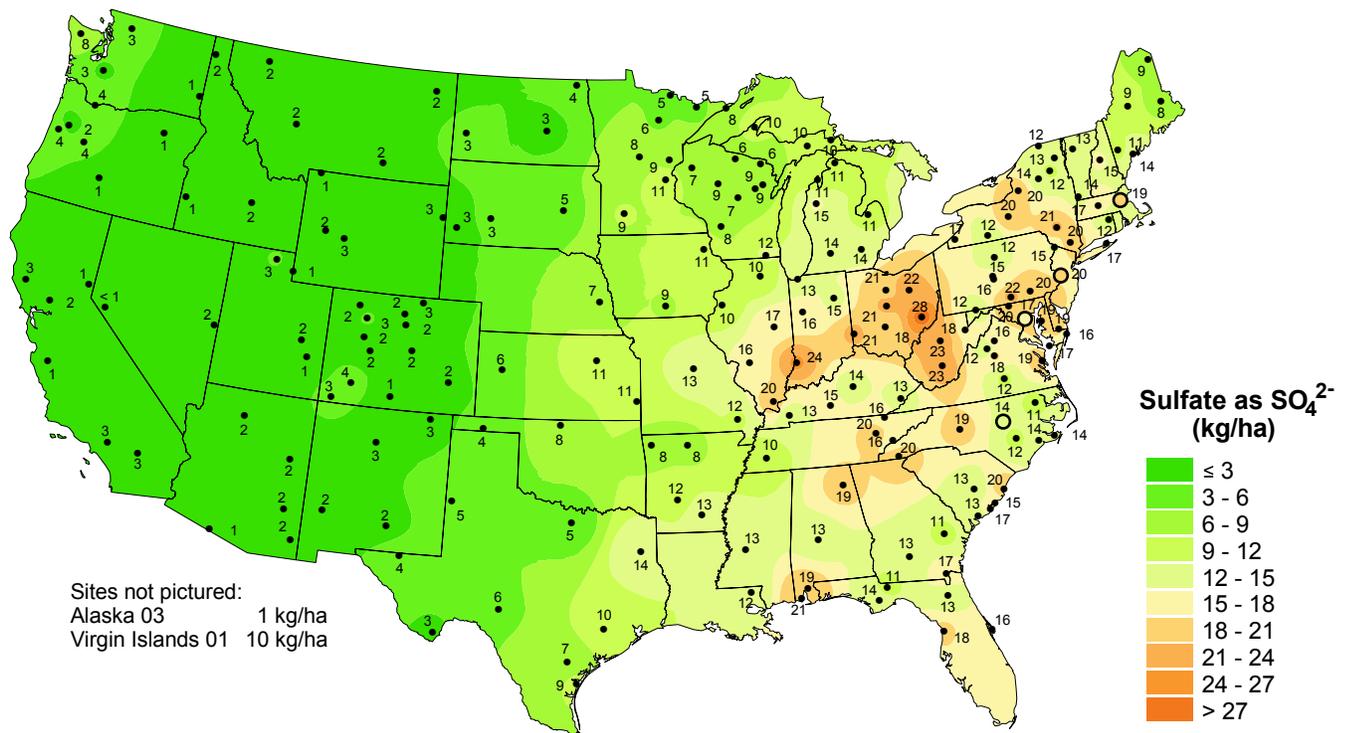
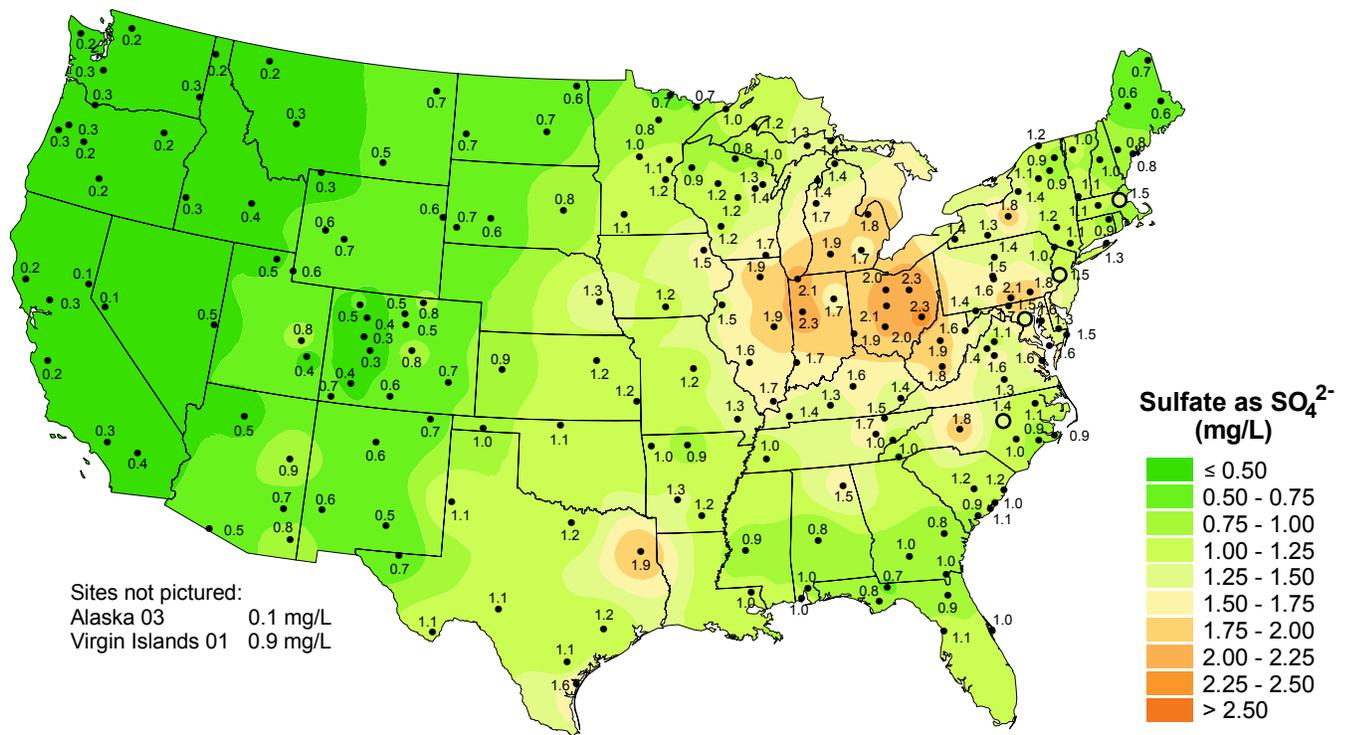
National Atmospheric Deposition Program/National Trends Network

Ammonium ion concentration (top) and wet deposition (bottom), 2005.



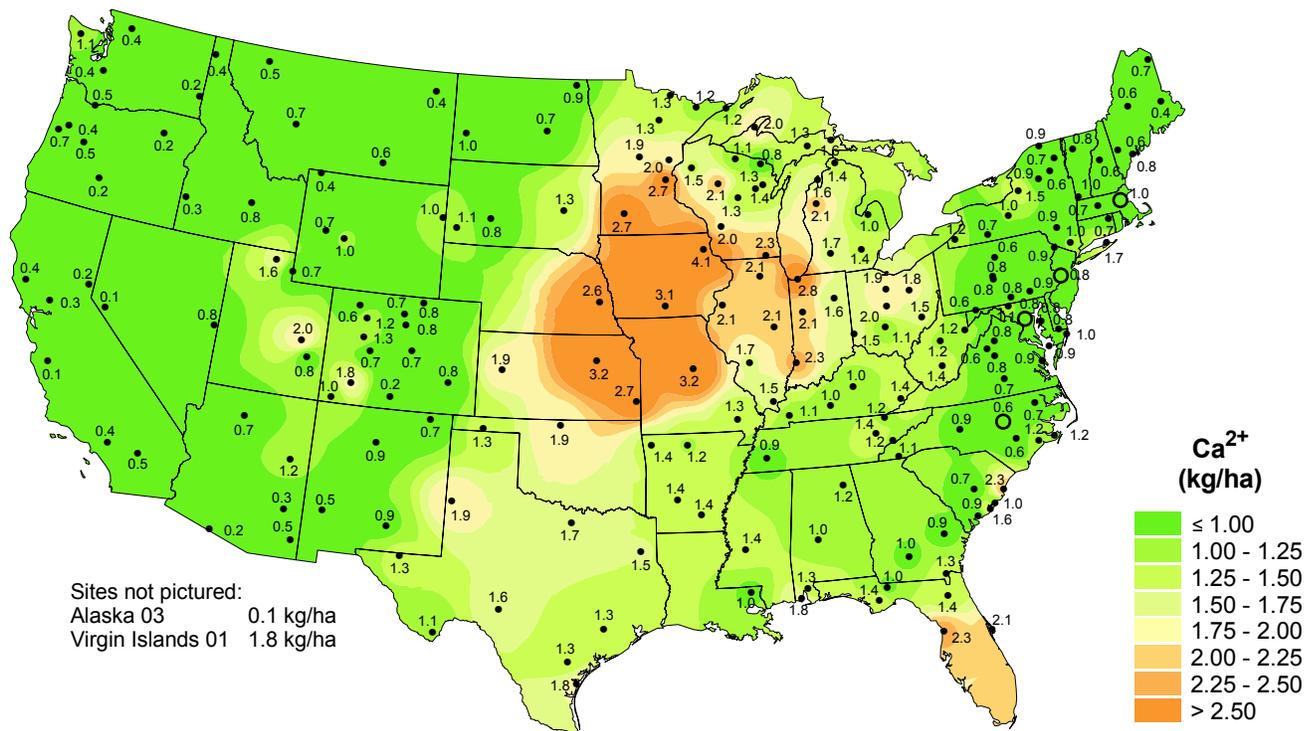
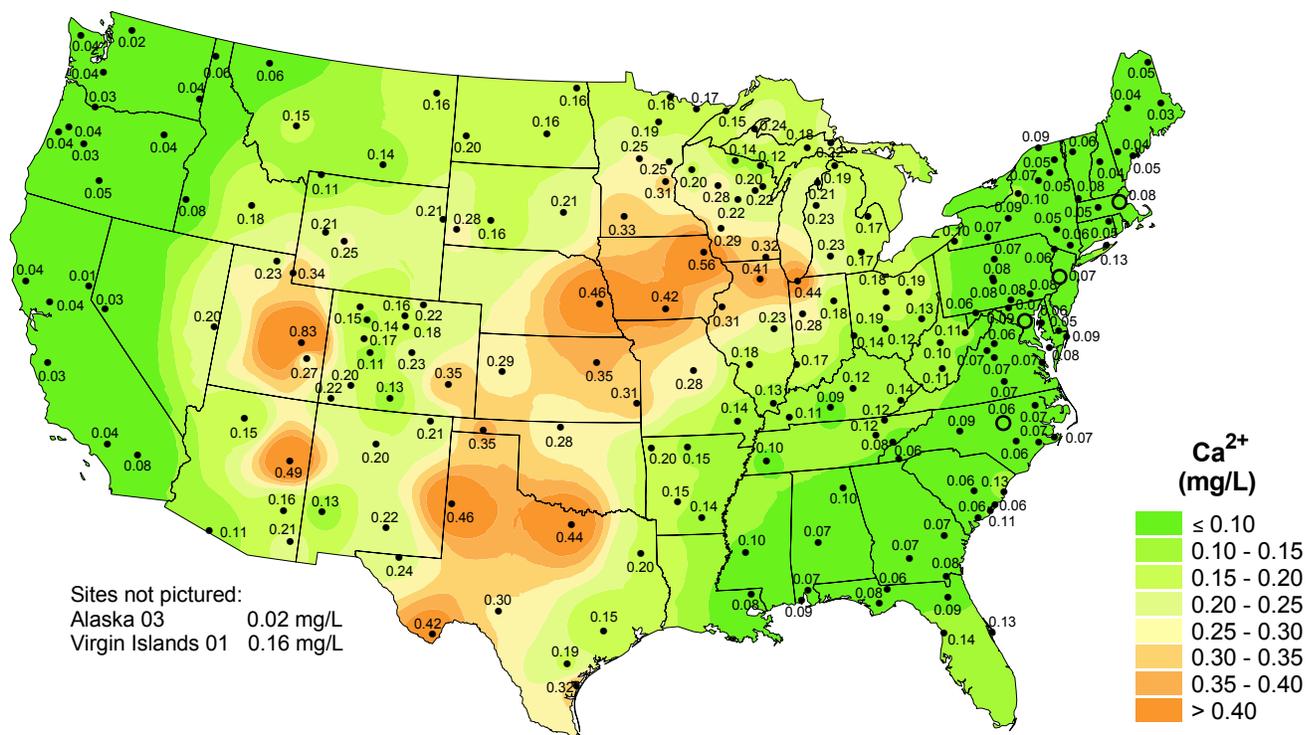
National Atmospheric Deposition Program/National Trends Network

Nitrate ion concentration (top) and wet deposition (bottom), 2005.



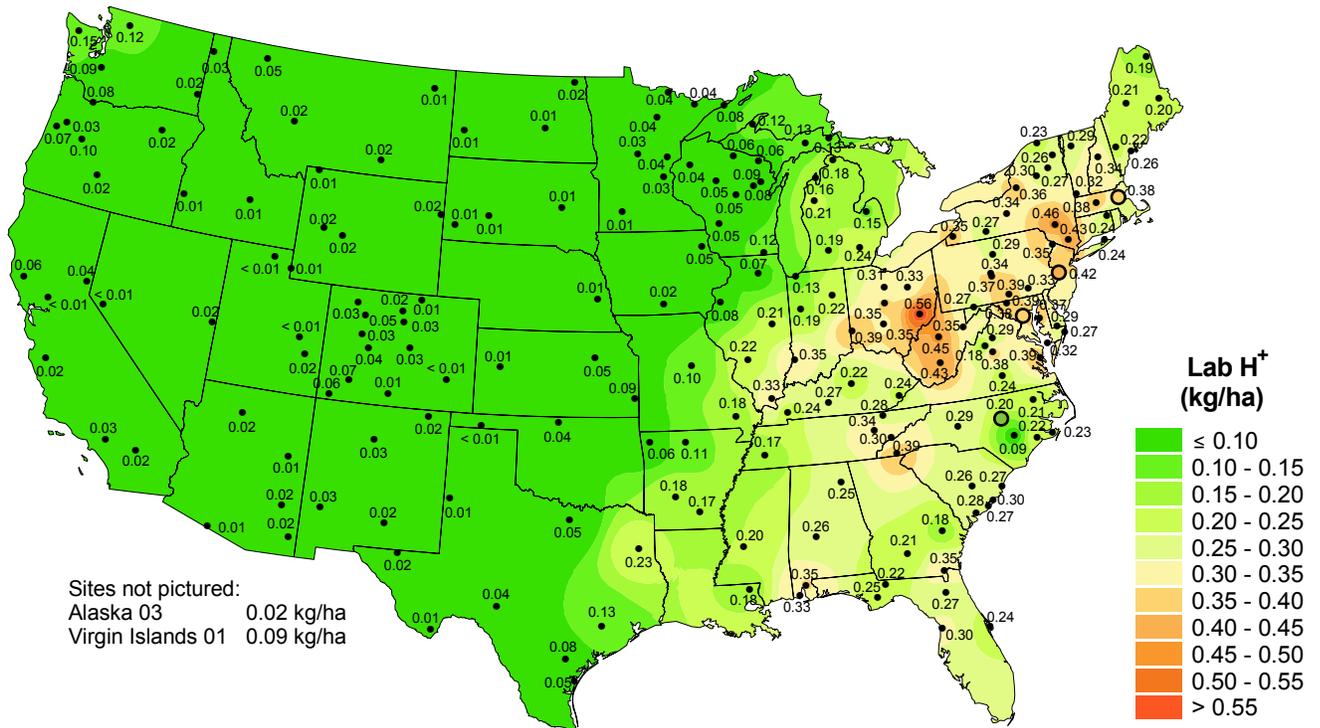
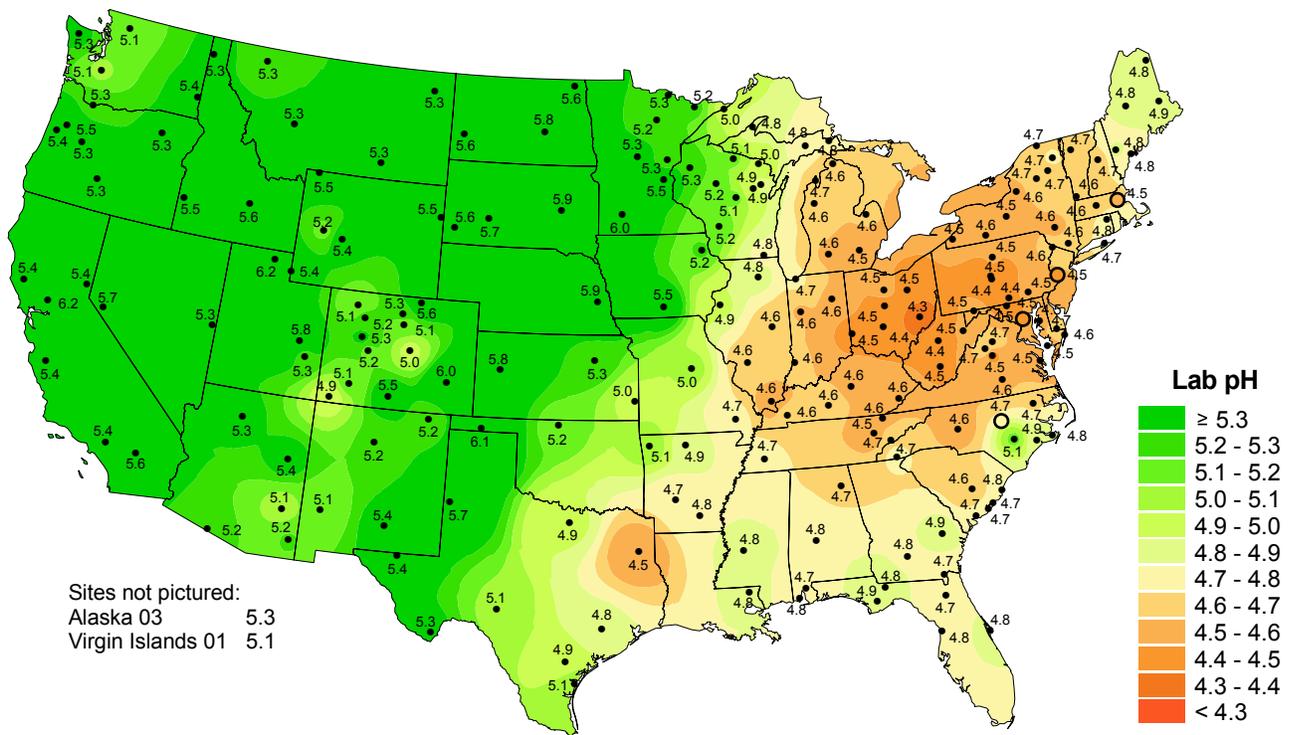
National Atmospheric Deposition Program/National Trends Network

Sulfate ion concentration (top) and wet deposition (bottom), 2005.



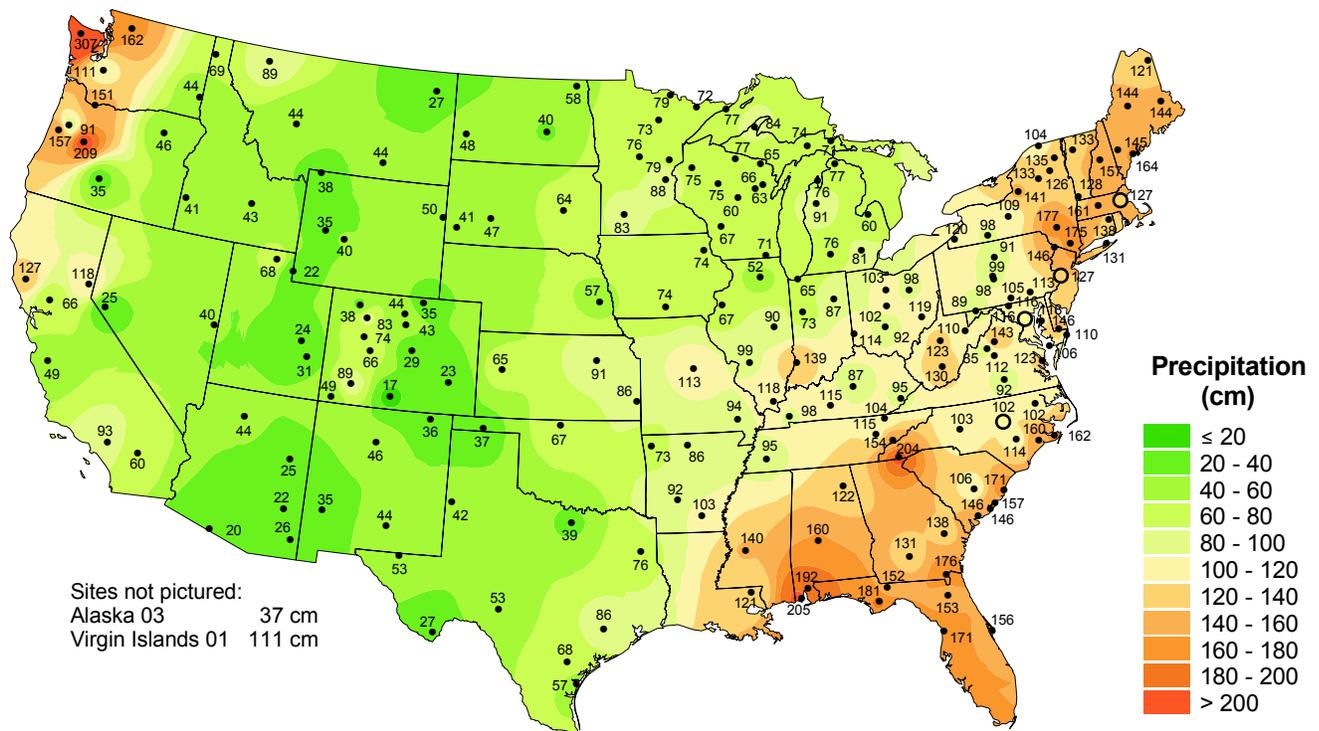
National Atmospheric Deposition Program/National Trends Network

Calcium ion concentration (top) and wet deposition (bottom), 2005.



National Atmospheric Deposition Program/National Trends Network

Hydrogen ion concentration as pH (top) and wet deposition (bottom) from pH measurements made at the Central Analytical Laboratory, 2005.



National Atmospheric Deposition Program/National Trends Network

Total precipitation, 2005.

Atmospheric Integrated Research Monitoring Network

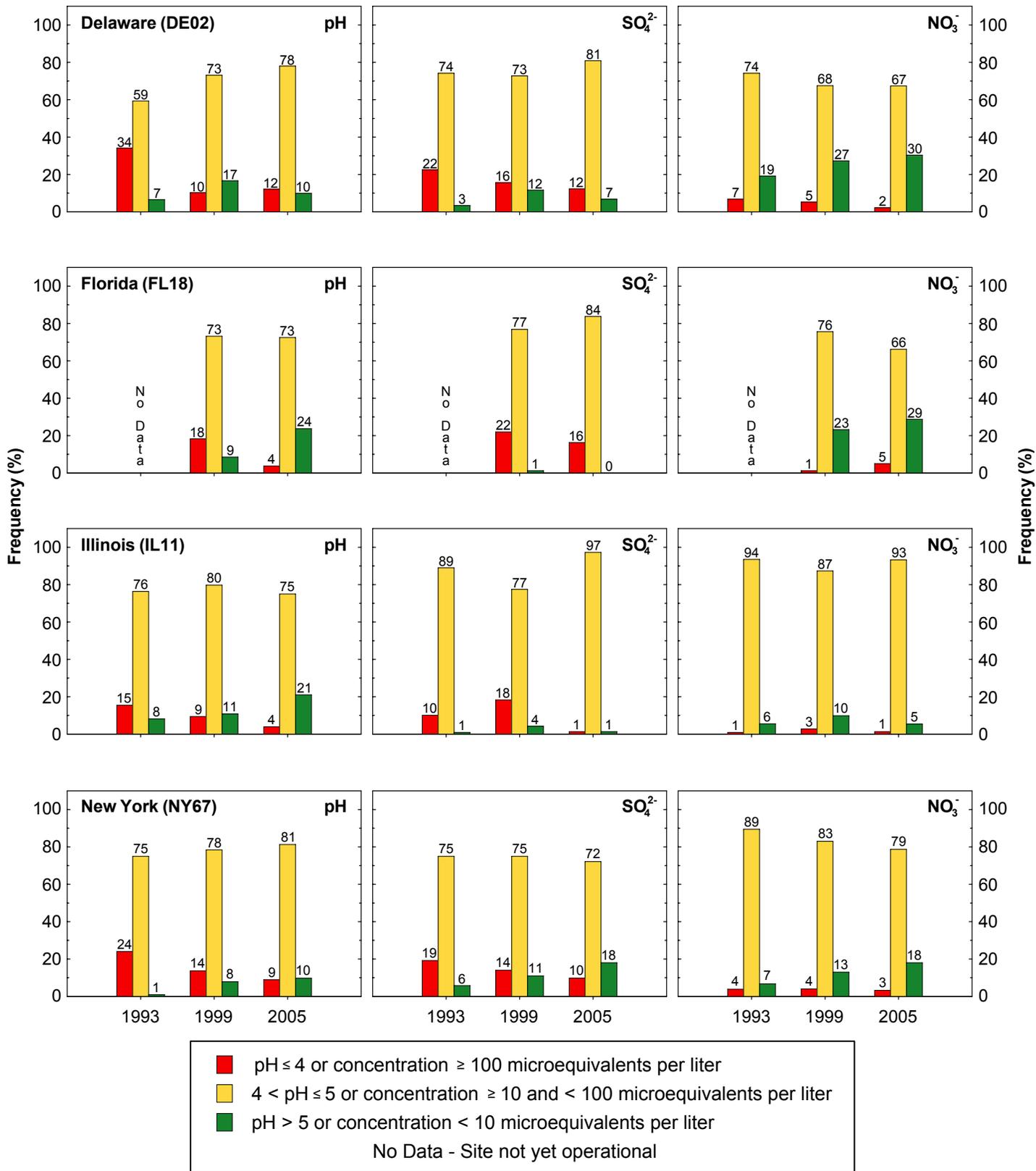
At AIRMoN sites, samples are collected daily within 24 hours of the start of precipitation, often providing data for all or part of a single storm. Single-storm data facilitate studies of atmospheric processes and the development and testing of computer simulations of these processes. Making data available for these studies is a principal AIRMoN goal.

The AIRMoN sites are equipped with the same wet-only deposition collector and precipitation gage used at NTN sites. Each site also has a National Weather Service standard gage for reporting storm total precipitation. Samples are refrigerated after collection and are sent in chilled insulated shipping containers to the CAL, where they are kept refrigerated until analysis. Refrigeration retards chemical changes. Chemical analyses and data screening procedures for AIRMoN and NTN are similar, although low-volume AIRMoN samples are not diluted to

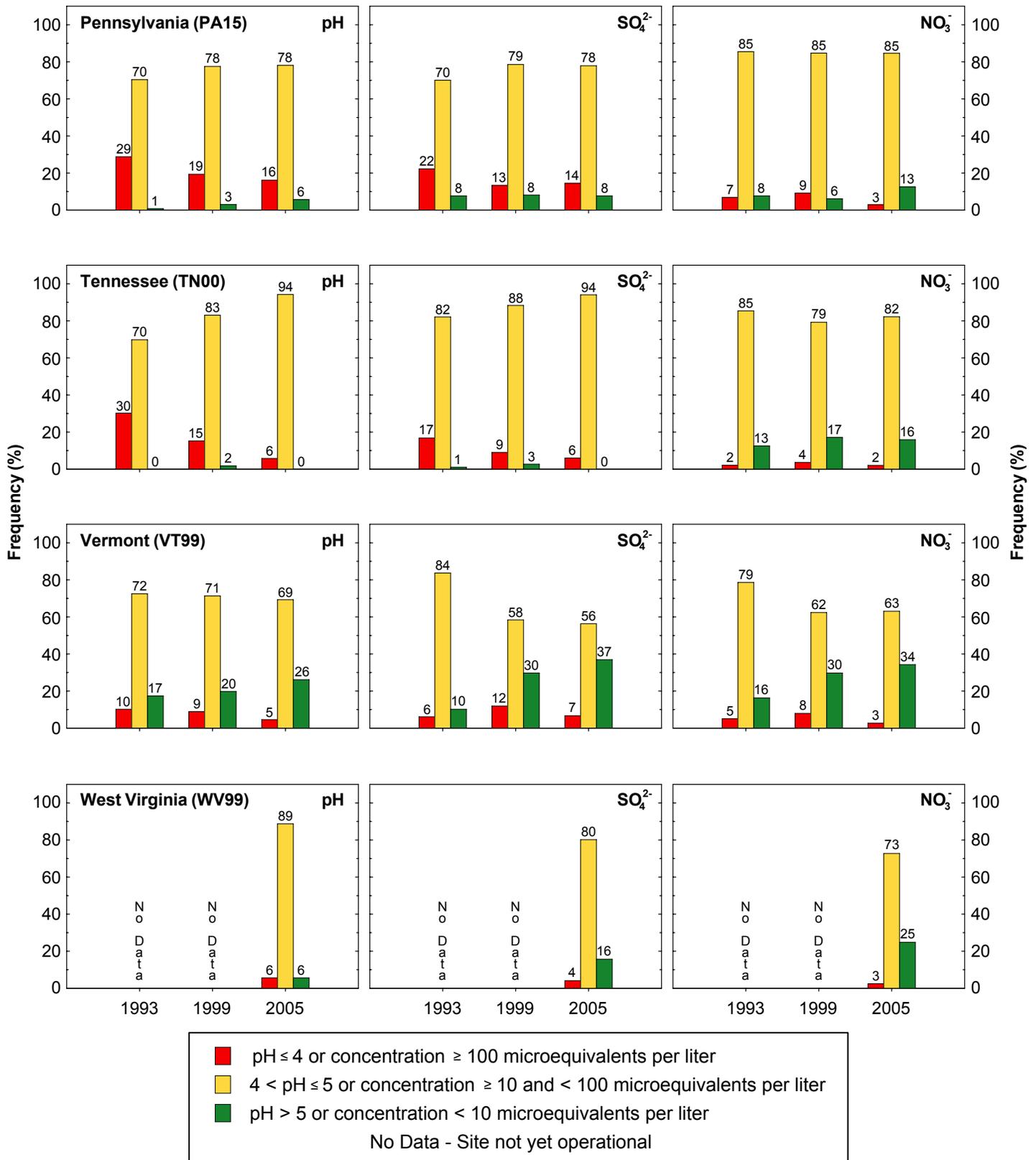
accommodate a complete analysis, as is standard NTN procedure. Another difference is that during the data review, the CAL assigns a quality rating code before sending AIRMoN data to the NADP Program Office for final checks and posting on the Web site.

AIRMoN Data

Bar charts on pages 12-13 show the frequency of occurrence of H^+ (as pH), SO_4^{2-} , and NO_3^- in three concentration classes for 1993, 1999, and 2005. Using a pH of 5 or below to define acid rain, the height of the green bars can be used to gauge whether acid rain events have generally decreased (e.g., VT99), remained the same, or increased over these three time periods. The height of the red bars can be used to gauge how the frequency of extreme acid rain events ($pH \leq 4$) has changed with time. Similar comparisons can be made for SO_4^{2-} and NO_3^- . Collecting samples daily facilitates the examination of changes in the chemical characteristics of individual storms, which can provide important insights into the effects of emission changes, storm tracks, storm type, etc.



Frequency of occurrence of free acidity (H⁺ as pH), sulfate (SO₄²⁻), and nitrate (NO₃⁻) concentrations in samples from AIRMoN sites active at the end of 2005.



Frequency of occurrence of free acidity (H^+ as pH), sulfate (SO_4^{2-}), and nitrate (NO_3^-) concentrations in samples from AIRMoN sites active at the end of 2005.

Mercury Deposition Network

The MDN is the only network providing a long-term record of total mercury (Hg) concentration and deposition in precipitation in the United States, Canada, and Mexico. All MDN sites follow standard procedures and have uniform precipitation chemistry collectors and gages. The automated collector has the same basic design as the NTN collector but is modified to preserve mercury. Modifications include a glass funnel, connecting tube, bottle for collecting samples, and an insulated enclosure to house this sampling train. The funnel and connecting tube reduce sample exposure to the open atmosphere and limit loss of dissolved mercury. As an additional sample preservation measure, the collection bottle is charged with 20 mL of a one percent hydrochloric acid solution.

Site operators collect samples Tuesday morning or daily within 24 hours of the start of precipitation. In 2005, the Devil's Lake site in south-central Wisconsin and the Underhill site in northern Vermont opted to collect samples daily. With each MDN sample, the entire sampling train is replaced with one that is cleaned by the Mercury Analytical Laboratory (HAL) at Frontier Geosciences, Inc., Seattle, Washington. Rigorous cleaning ensures that each sampling train component is essentially mercury-free. The HAL supplies the collection bottles already charged with the hydrochloric-acid preservative. By following those procedures and stringent sampling protocols, the MDN is able to report mercury concentrations below 1 part per trillion (<1 nanogram/liter).

All MDN samples are sent to the HAL, which analyzes all forms of mercury in a single measurement and reports this as total mercury concentrations. At the end of 2005, 23 MDN sites also opted for methyl mercury analysis. The HAL reviews field and laboratory data for completeness and accuracy, and flags samples that were mishandled, compromised by precipitation collector failures, or grossly contaminated. The

HAL delivers all data and information to the NADP Program Office for final checks and resolution of remaining discrepancies. Data then are made available on the NADP Web site.

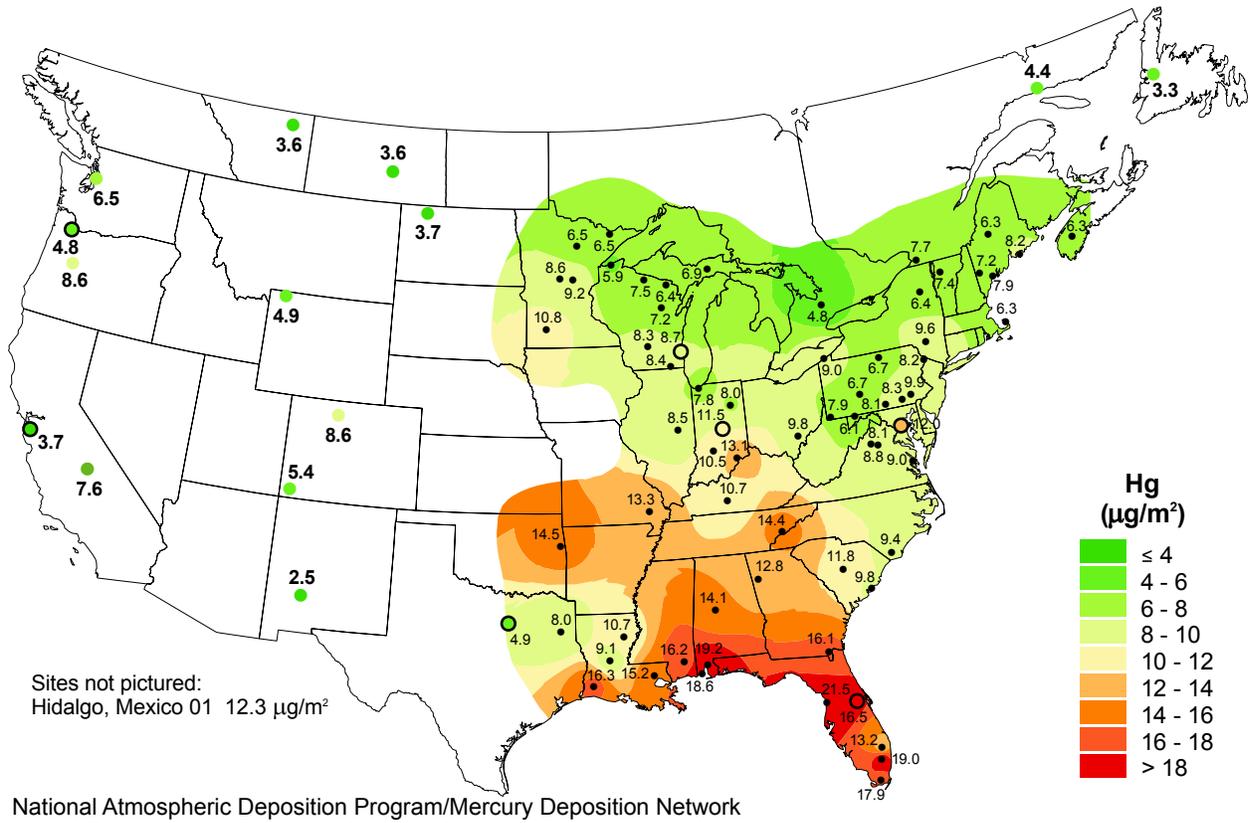
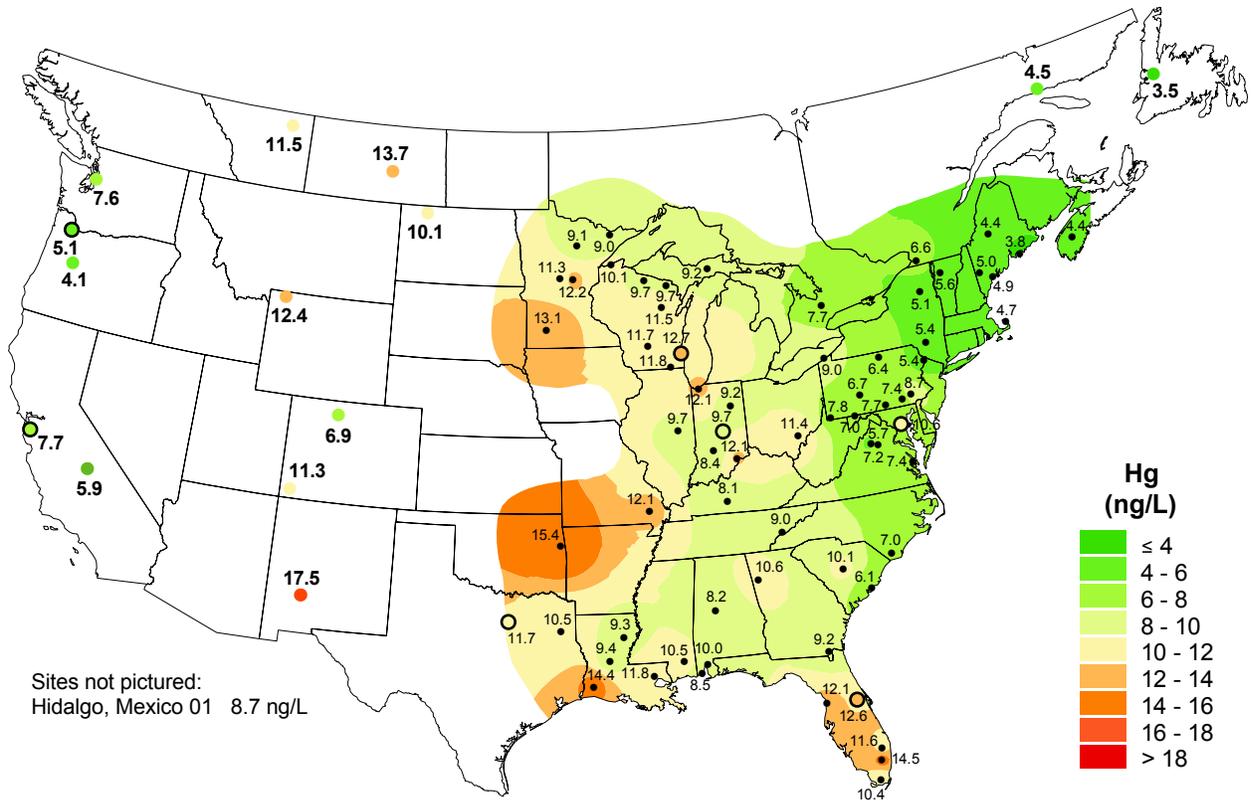
MDN Maps

The MDN maps on page 15 show spatial variability in the precipitation-weighted average concentration and wet deposition of total mercury. Only sites meeting NADP data completeness criteria are included. In 2005, 83 sites met these criteria.

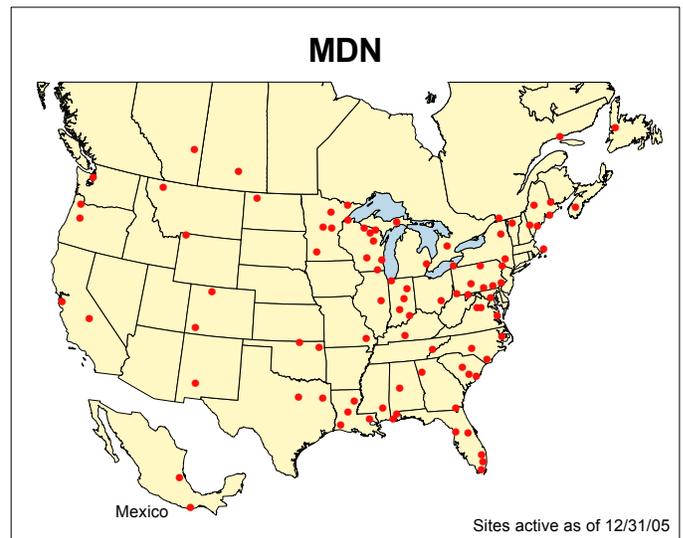
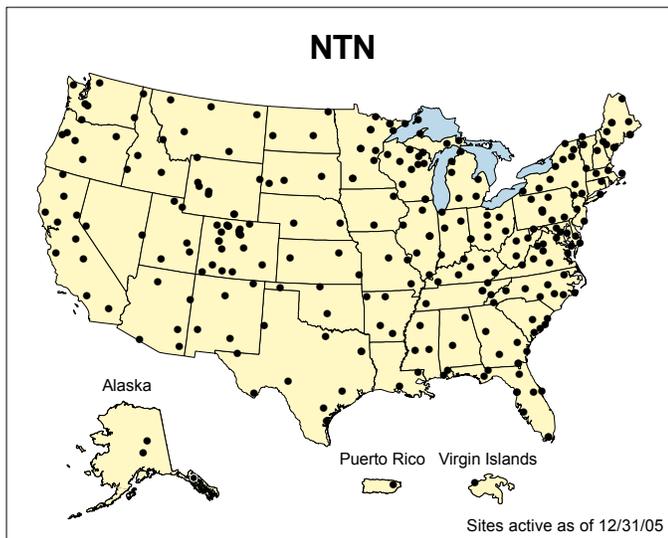
In the eastern United States and southern Canada, color contours display the concentration and deposition distributions. Black dots mark site locations, and open circles designate urban sites. Concentration or deposition values appear next to each site.

Color contours were created by using nonurban site values to compute an array of regularly spaced grid-point values. Sites within 500 km of each grid point were used in computations. In the area covered by color contours, it was necessary to have two or more data points occurring within 500 km of each grid point. The boundary of the color-contoured area was trimmed at the coastline and over land 250 km from outermost data points. The landward boundary was smoothed. Color contours and the color fill in the open circle of urban sites represent classes of concentrations or depositions in the legend. Outside of the color-contoured area where data are too sparse to draw contours, colored dots mark site locations. Dot colors represent concentration or deposition classes in the legend.

Methyl Mercury. Methyl mercury is highly toxic and builds up in fish tissue, resulting in advisories warning people to limit fish consumption. All states except Alaska, Iowa, Kansas, Utah, and Wyoming have some form of advisory (see <http://www.epa.gov/ost/fish>).



Total mercury concentration (top) and wet deposition (bottom), 2005.



Note:

When referencing maps or information in this report, please use the citation: National Atmospheric Deposition Program. 2006. *National Atmospheric Deposition Program 2005 Annual Summary*. NADP Data Report 2006-01. 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 Web site:

<http://nadp.sws.uiuc.edu>

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