



## 2008 Highlights

The National Atmospheric Deposition Program (NADP) provides data that support informed decisions on air quality issues related to precipitation chemistry. Scientists, educators, policy-makers, and the public obtain NADP data via the NADP Web site (<http://nadp.isws.illinois.edu>). This site allows online retrieval of individual data points, seasonal and annual averages, trend plots, concentration and deposition maps, reports, and other information. In 2008, the number of registered users rose to nearly 40,000, representing over 150 countries. NADP data and data products were downloaded more than 25,000 times, an increase of about 5 percent from 2007.

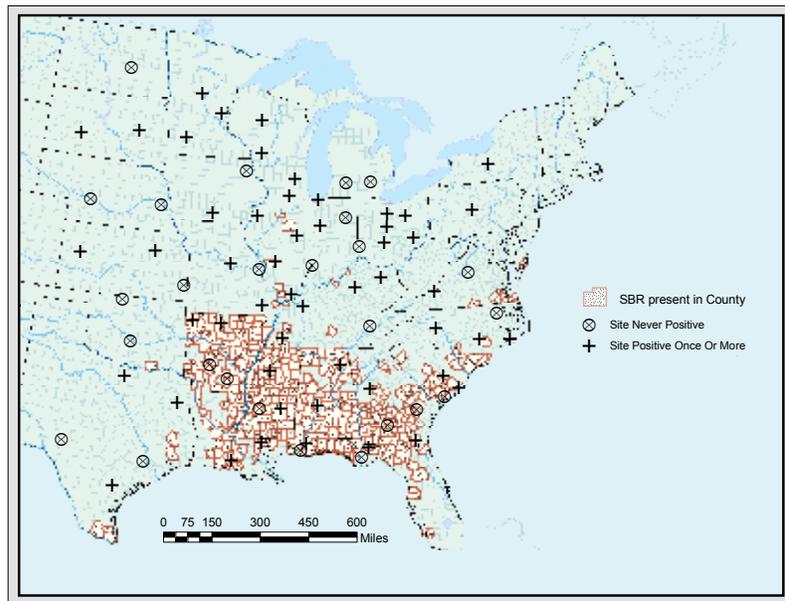
The NADP processed approximately 13,000 samples from the 250-site National Trends Network (NTN), 1,200 samples from the 7-site Atmospheric Integrated Research Monitoring Network (AIRMoN), and 5,800 samples from the 110-site Mercury Deposition Network (MDN).

### NADP COLLABORATIONS

In 2004, the U. S. Department of Agriculture (USDA) issued the first report of *Phakopsora pachyrhizi*, or Asian Soybean Rust (ASR) in the continental U.S. ASR is a fungal parasite that can cause significant losses in soybean and other crops. NADP partnered with the USDA Cereal Disease Laboratory (USDA-CDL) to look for ASR spores in NTN samples. From mid-May through mid-September 2008, the CDL found that 8 percent of the tested

precipitation samples were positive for ASR. Weekly counts ranged from a few spores to more than 250 spores per square meter. The figure below shows the sites that had deposition of ASR during the year, along with counties where the disease was present during 2008. These data show the spread of ASR spores, and the usefulness of collaborative monitoring efforts in agricultural applications.

The NADP measures wet deposition. The Clean Air Status and Trends Network (CASTNET) focuses



**Deposition of ASR in NADP samples during the 2008 growing season, along with counties with positive presence of the disease.**

on dry deposition. Collaboratively they yield total deposition estimates. For example, *the map on the cover* shows scaled pie charts depicting the 2008 total nitrogen deposition in kilograms per hectare (kg N/ha) at CASTNET sites. Wet deposition data (blue) are

from NTN “total inorganic nitrogen” measurements [(nitrate + ammonium) ions expressed as nitrogen]. Dry deposition data (pink) are from CASTNET estimates of ammonium and nitrate dry deposition [(nitric acid + nitrate + ammonium) expressed as nitrogen]. A summation of these two components, “Total Inorganic Nitrogen Deposition”, is indicated with each chart. Dry deposition was estimated using the Multilayer Model (MLM). Inputs to the MLM include atmospheric concentrations, meteorological data, and information on land use, vegetation, and surface conditions. Only sites meeting completeness criteria for both networks appear on the map. For more information on CASTNET, see <http://www.epa.gov/castnet>.

In addition to ammonium and nitrate, other nitrogen compounds are present in precipitation. Based on preliminary data, the organic nitrogen fraction may be as high as one-third of total N deposition. Scientists at the U.S. Environmental Protection Agency (USEPA) and the NADP have begun tests to determine whether organic nitrogen deposition can be measured reliably and accurately in weekly NTN samples. Preliminary results from these tests are promising. This added information is particularly important to our understanding of nitrogen deposition patterns.

In 2006, the NADP Executive Committee formed the Critical Loads Ad-Hoc Committee (CLAD). This committee coordinates the efforts of multiple federal and state agencies, scientists, and other partners related to the science of critical loads (<http://nadp.isws.illinois.edu/clad>). CLAD provides a venue for discussion of current and emerging issues regarding the science and application of critical loads for atmospheric deposition in the United States.

The goals of CLAD are to:

- Facilitate sharing of technical information on critical loads topics;
- Identify and fill gaps in critical loads development in the U.S.;
- Provide consistency in development and use of critical loads in the U.S.;
- Promote understanding of the critical loads approach through development of outreach and communications materials.

## **NEW INITIATIVES**

The presence of ammonia gas in the atmosphere and its deposition have prompted the development of a new NADP initiative, the Ammonia Monitoring Network (AMoN). The goal is to deploy and operate a cost-effective passive sampling network for atmospheric ammonia. Two-week integrated measurements are used to quantify the spatial and temporal differences in ammonia concentrations. Currently, quality-assured concentrations from 21 sites are available (<http://nadp.isws.illinois.edu/nh3net>).

Another initiative considers atmospheric mercury. This initiative comprises 20 sites. Quality-assured concentrations for the several mercury fractions are stored for use by the mercury modeling community (<http://nadp.isws.illinois.edu/amn>). Sites follow standard operating procedures, with experienced liaison support and quality assurance provided by the NADP. Additional support is provided by the USEPA and the U.S. Geological Survey (USGS).

# NADP Background

The National Atmospheric Deposition Program was established in 1977 under State Agricultural Experiment Station (SAES) leadership to address the problem of atmospheric deposition and its effects on agricultural crops, forests, rangelands, surface waters, and other natural and cultural resources. In 1978, sites in the NADP precipitation chemistry network first began collecting one-week, wet-only deposition samples for analysis at the Illinois State Water Survey's Central Analytical Laboratory (CAL). The network was established to provide data on amounts, temporal trends, and geographic distributions of the atmospheric deposition of acids, nutrients, and base cations by precipitation. Initially, the NADP was organized as SAES North Central Regional Project NC-141, which all four SAES regions endorsed as Interregional Project IR-7 in 1982. A decade later, IR-7 was reclassified as National Research Support Project NRSP-3, which it remains. NRSP projects are multi-state activities that support research on topics of concern to more than one state and region of the country. Multi-state projects involve the SAES in partnership with the USDA Cooperative State Research, Education, and Extension Service (now National Institute of Food and Agriculture) and other universities, institutions, and agencies.

In October 1981, the federally supported National Acid Precipitation Assessment Program (NAPAP) was established to increase understanding of the causes and effects of acidic precipitation. This program sought to establish a long-term precipitation chemistry network of sampling sites distant from point source influences. Because of its experience in organizing and operating a national-scale network, the NADP agreed to coordinate operation of NAPAP's National Trends Network (NTN). To benefit from identical siting criteria and operating procedures and a shared analytical laboratory, NADP and NTN merged with the designation NADP/NTN. This merger brought substantial new federal agency participation into the program. Many NADP/NTN sites were supported by the USGS, NAPAP's lead federal agency for deposition

monitoring. Under Title IX of the federal Clean Air Act Amendments of 1990, NAPAP continues.

In October 1992, the AIRMoN joined the NADP. AIRMoN sites collect samples daily when precipitation occurs.

In January 1996, the NADP established the third network in the organization, the MDN. The MDN was formed to provide data on the wet deposition of mercury to surface waters, forested watersheds, and other receptors.

## ABOUT THE MAPS

This annual report is a principal product of the NADP. It summarizes the results of network operation for the most recent year in map form. This report has been published since 1981 in various forms. Beginning in 2008, collection efficiency (criterion 4) is no longer a required component of the NADP completeness criteria. This impacts the concentration and deposition maps.

Black dots mark site locations that meet NADP completeness criteria (see the NADP Web site for details). Open circles designate urban sites, defined as having at least 400 people per square kilometer ( $\text{km}^2$ ) within a 15-km radius of the site. Urban sites do not contribute to the contours.

Color contours were created by using site values to compute grid-point values across the nation. Sites within 500 km of each grid point were used in computations. Color contours and the color-filled urban sites represent classes of concentrations or depositions in the legend, with measured values next to each site. Independent grids of concentration and of deposition are used for the maps.

For example, the bottom figure on Page 6 has eight inorganic nitrogen deposition classes or contours. The lightest green color in the legend represents 3.0–4.0 kilograms per hectare ( $\text{kg}/\text{ha}$ ) as summed over the year. Nitrogen deposition values in the area covered by this contour are greater than 3.0  $\text{kg}/\text{ha}$  and less than or equal to 4.0  $\text{kg}/\text{ha}$ .

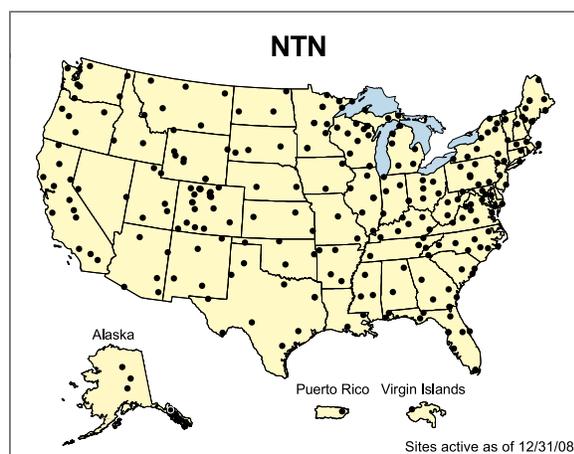
# National Trends Network (NTN)

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

Site operators follow standard operational procedures to help ensure NTN data comparability and representativeness across the network. Weekly samples are collected each Tuesday morning, using containers provided by the Central Analytical Laboratory (CAL) at the University of Illinois. All samples are sent to the CAL for analysis.

The CAL measures free acidity ( $H^+$  as pH), specific conductance, and calcium ( $Ca^{2+}$ ), magnesium ( $Mg^{2+}$ ), sodium ( $Na^+$ ), potassium ( $K^+$ ), sulfate ( $SO_4^{2-}$ ), nitrate ( $NO_3^-$ ), chloride ( $Cl^-$ ), and ammonium ( $NH_4^+$ ) ions. The CAL also measures orthophosphate ions ( $PO_4^{3-}$ , the inorganic form), but only for quality assurance as an indicator of sample contamination.

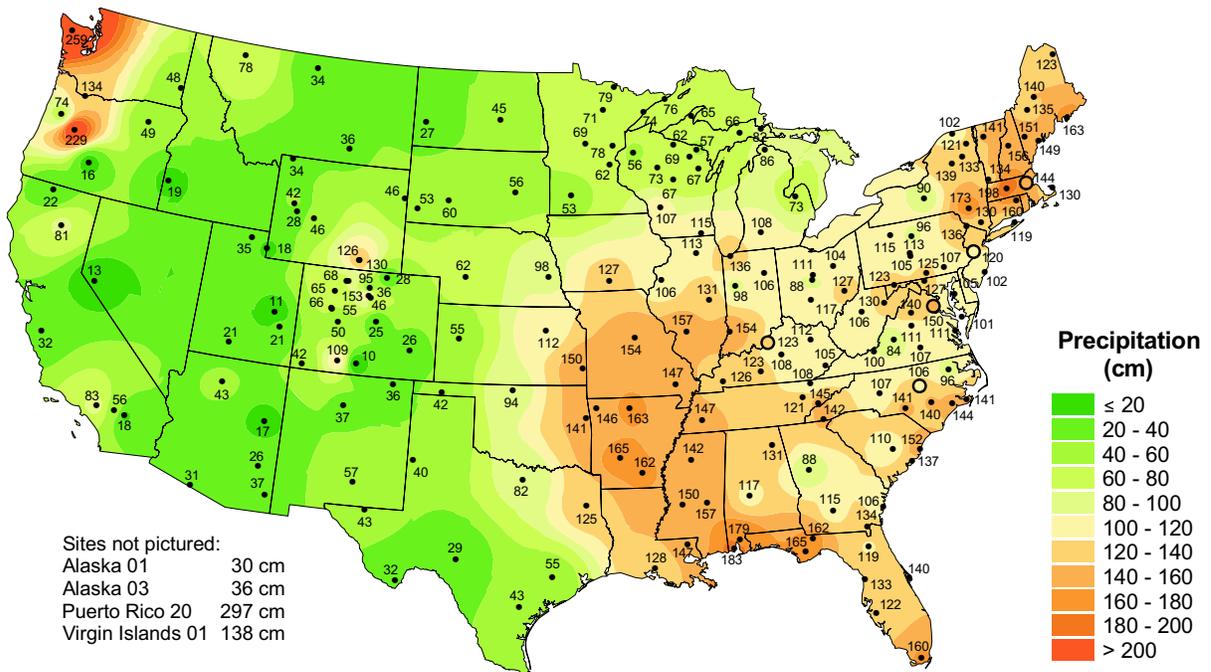
The CAL reviews field and laboratory data for accuracy and completeness, and flags samples that were mishandled, compromised by precipitation collector failures, or grossly contaminated. The Program Office stores all NADP data and information in a database system accessible from the NADP Web site. Valid NTN data can be retrieved from this online retrieval system.



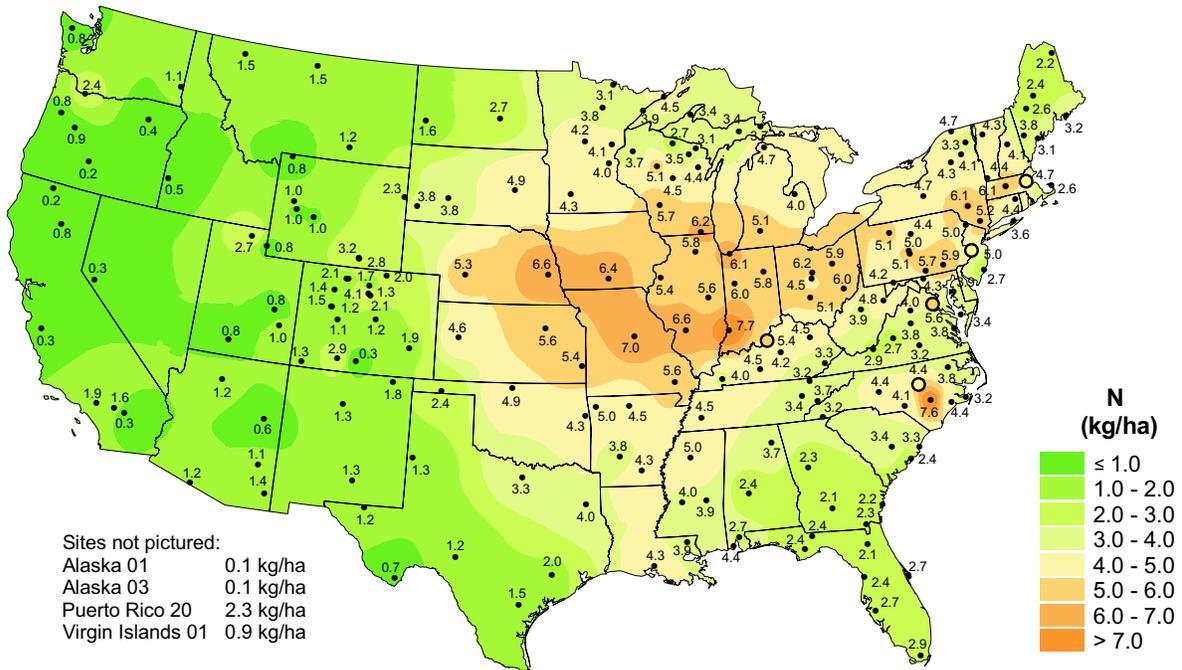
## NTN MAPS

The NTN maps on pages 6 through 11 show spatial variability in the precipitation-weighted mean concentration and annual 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 2008, 206 sites met these criteria.

In addition to the maps of total precipitation and inorganic nitrogen ("N", i.e.,  $NH_4^+ + NO_3^-$ ) wet deposition, concentration and deposition maps are included here for  $NH_4^+$ ,  $NO_3^-$ ,  $SO_4^{2-}$ ,  $Ca^{2+}$ , and laboratory-measured pH. Maps of  $Mg^{2+}$ ,  $Na^+$ ,  $K^+$ , and  $Cl^-$  are not included but are available from the NADP Web site.

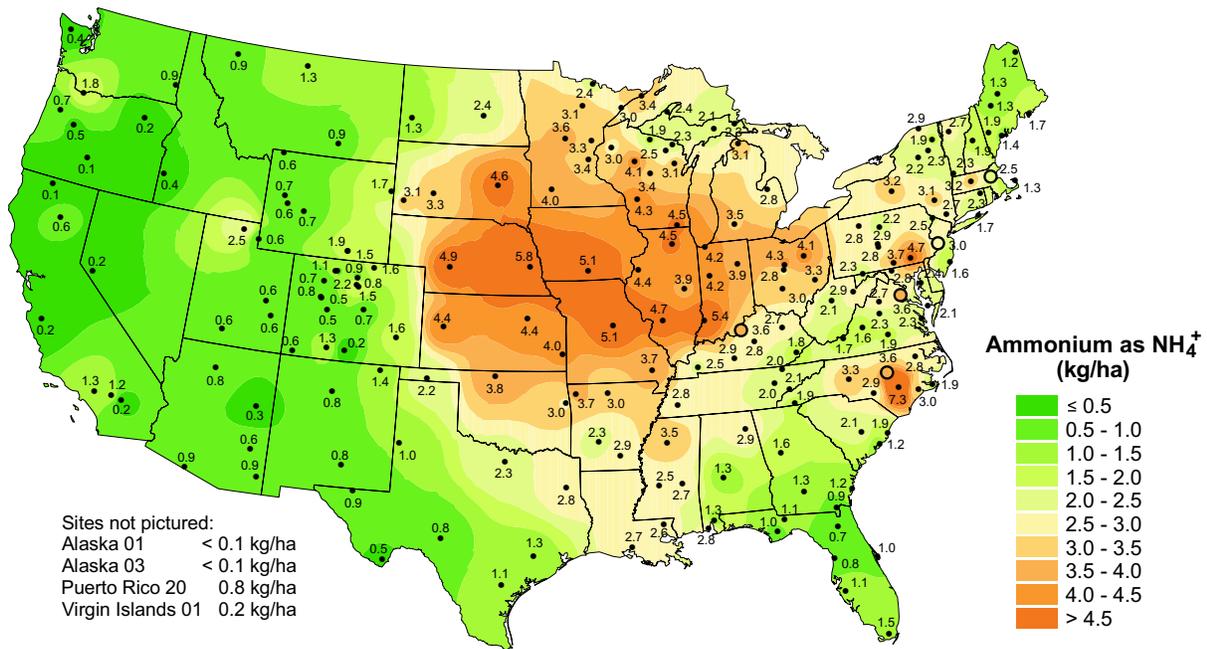
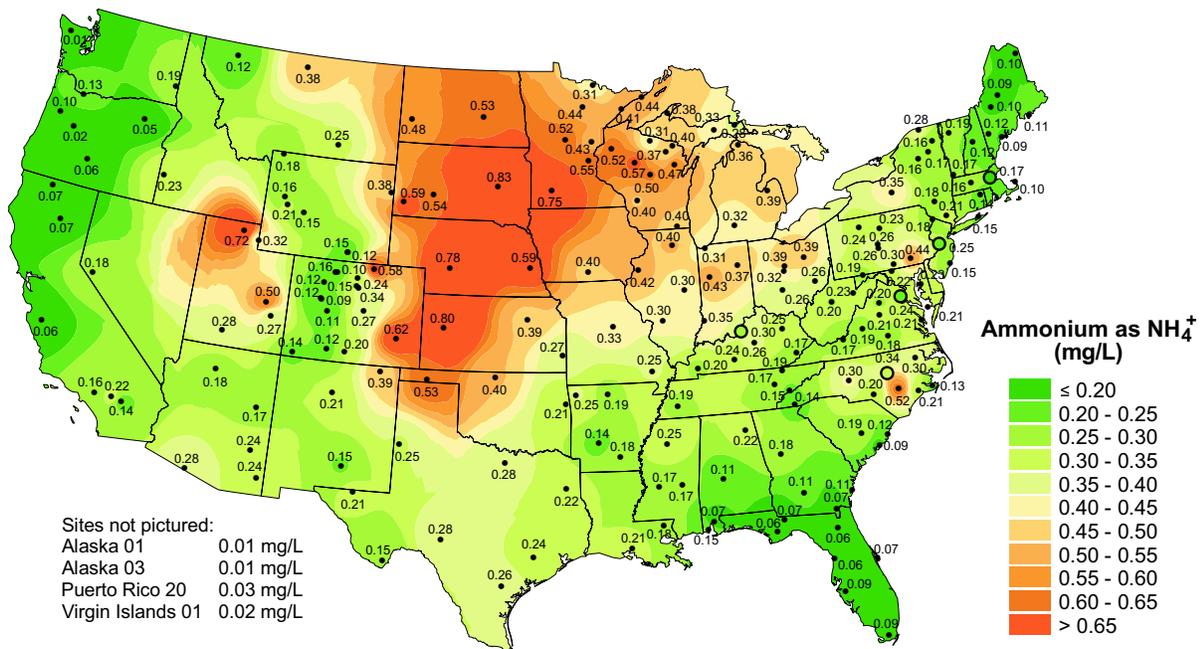


National Atmospheric Deposition Program/National Trends Network



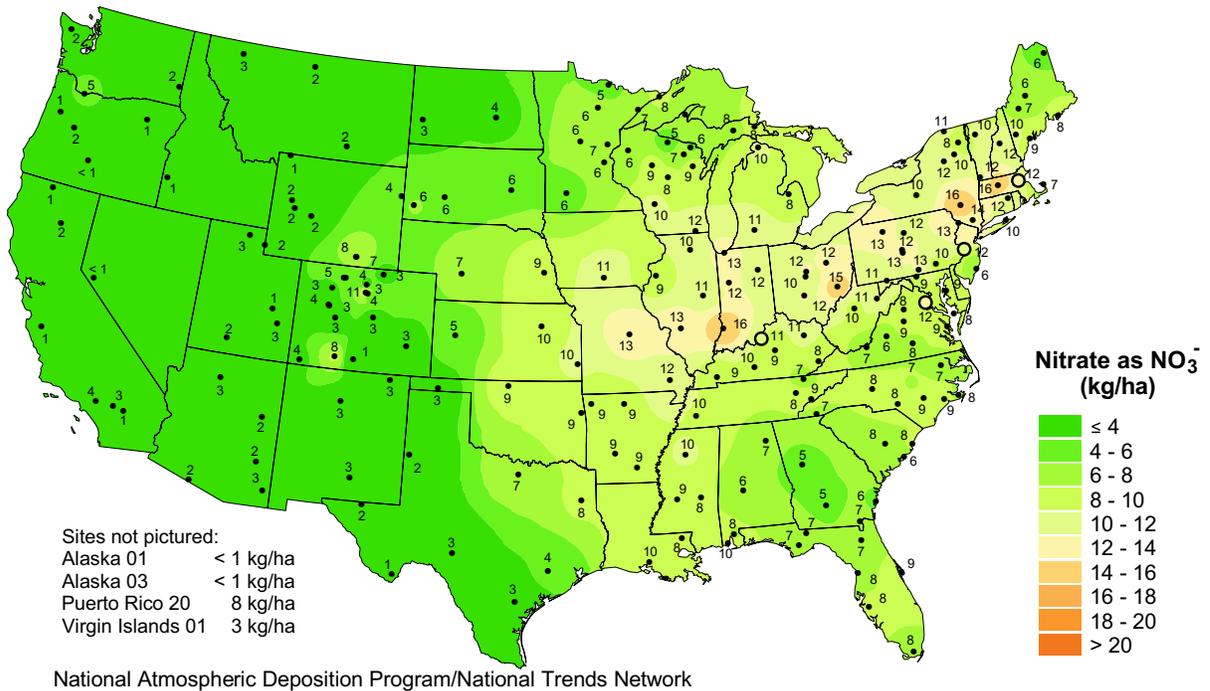
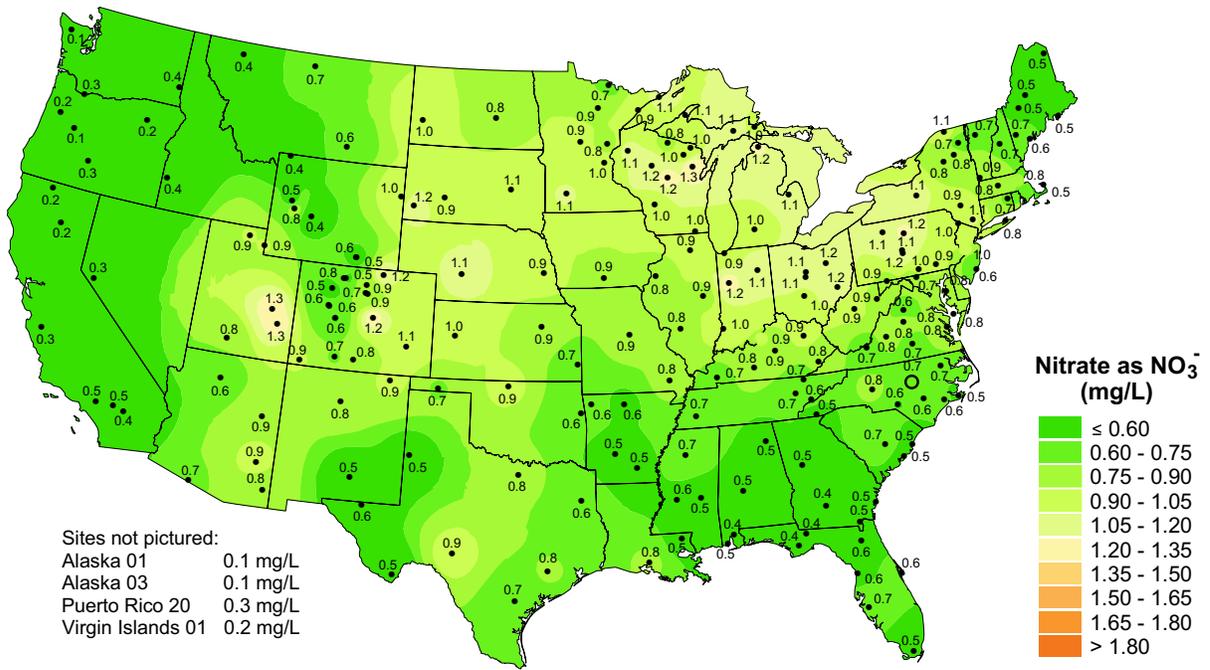
National Atmospheric Deposition Program/National Trends Network

**Total precipitation (top) and inorganic nitrogen wet deposition from nitrate and ammonium (bottom), 2008.**

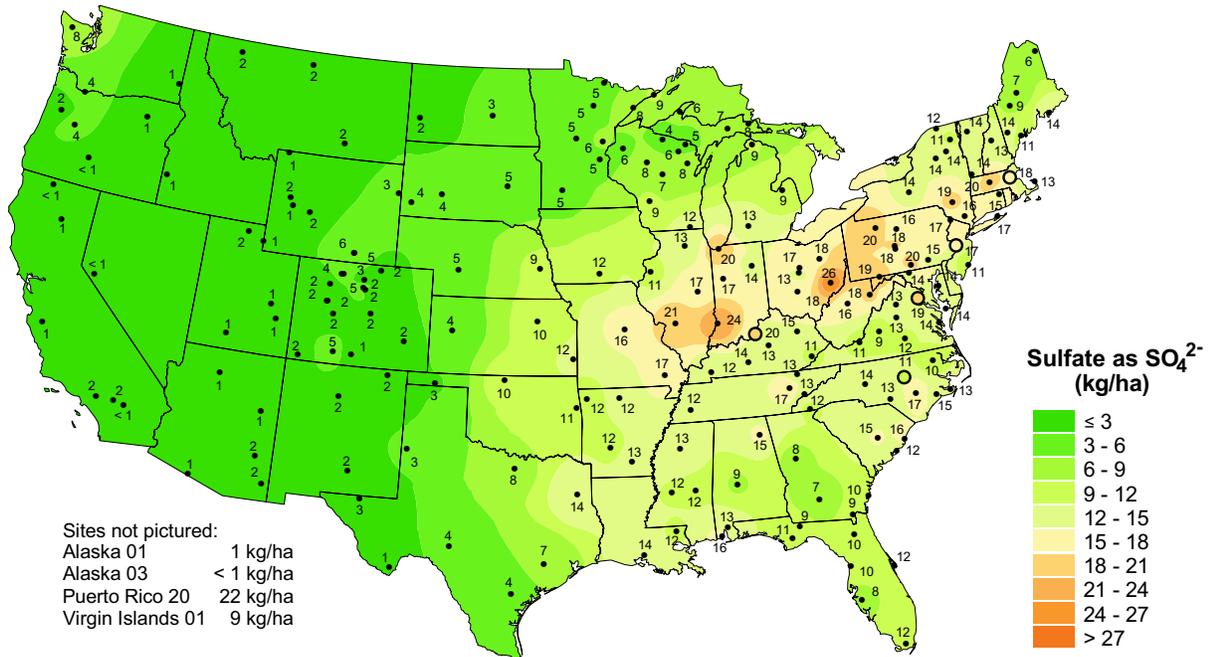
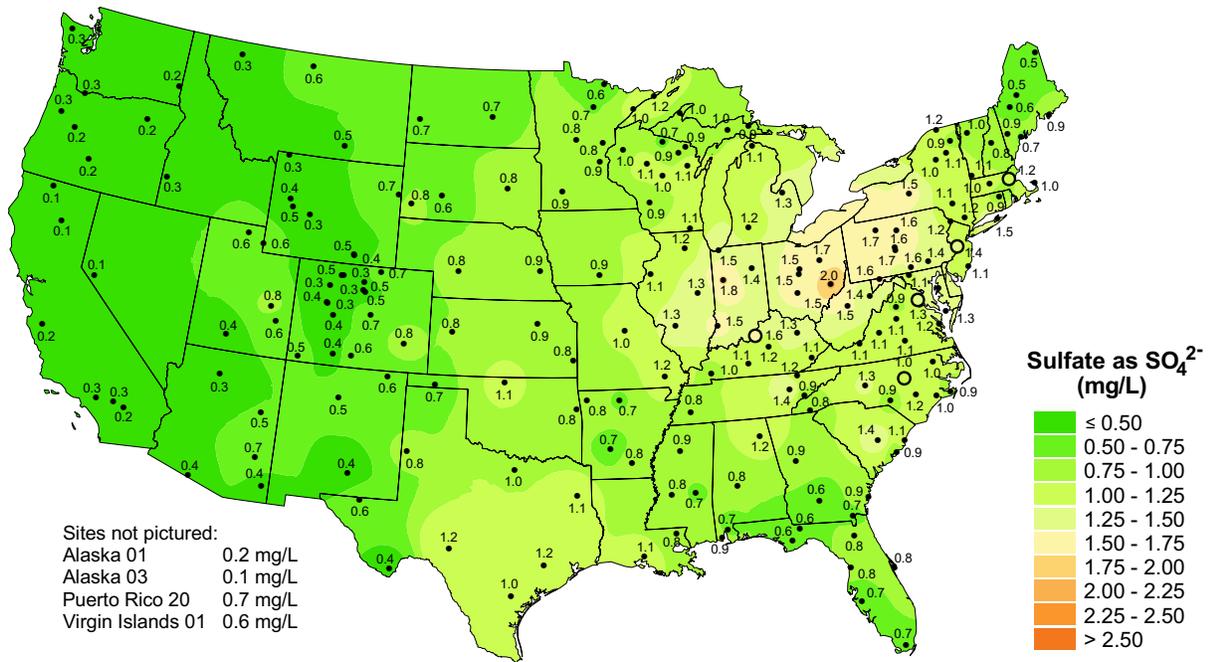


National Atmospheric Deposition Program/National Trends Network

**Ammonium ion concentration (top) and wet deposition (bottom), 2008.**

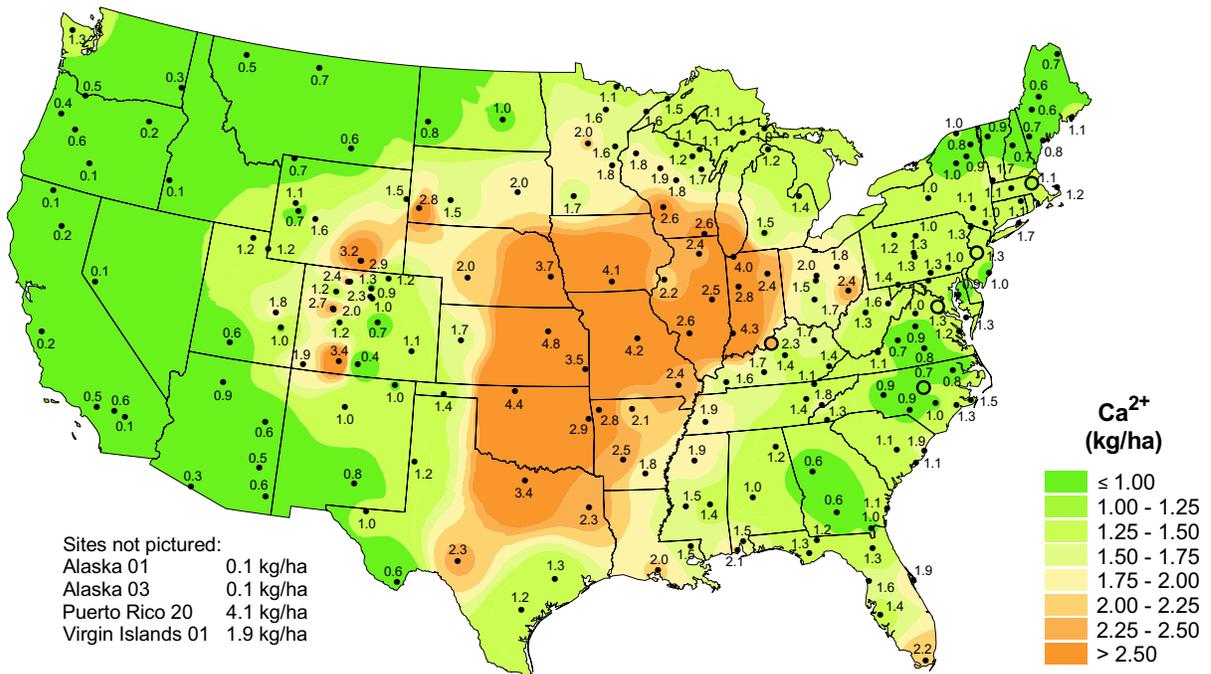
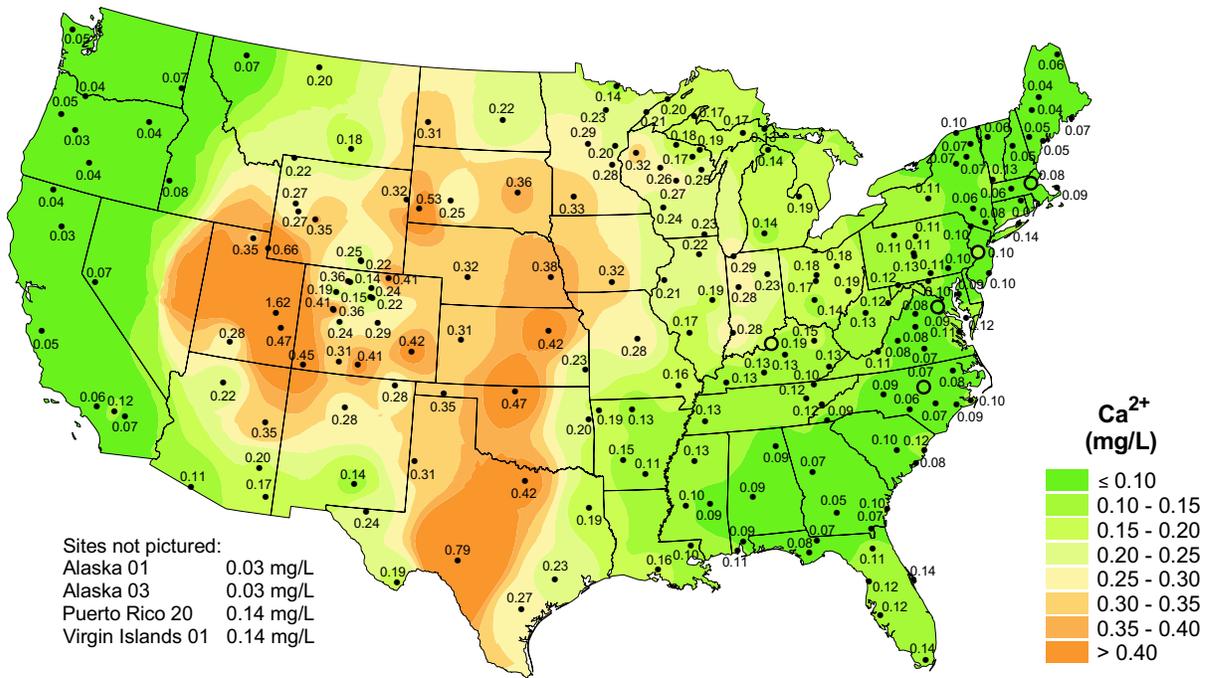


**Nitrate ion concentration (top) and wet deposition (bottom), 2008.**



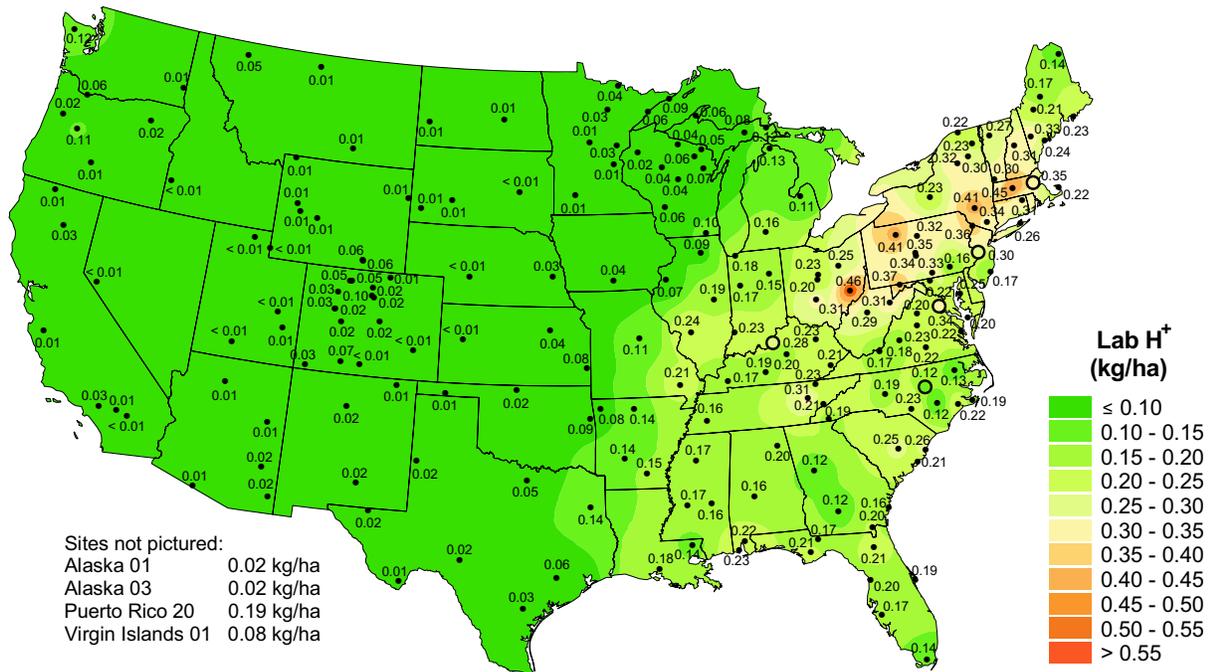
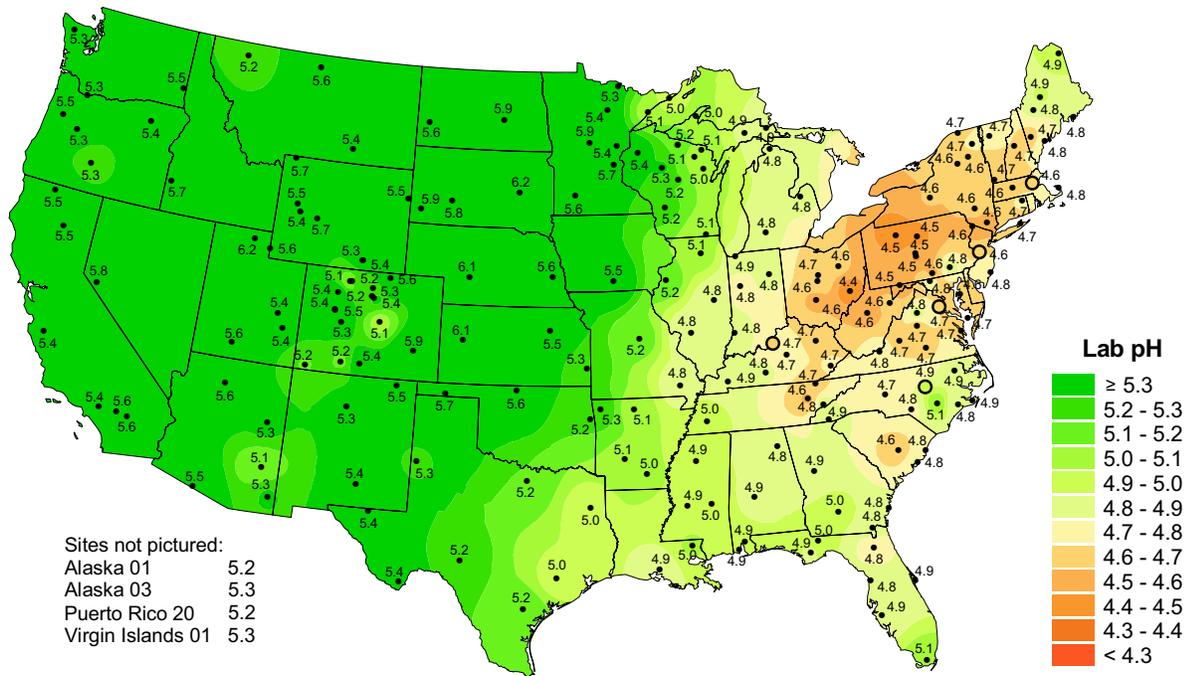
National Atmospheric Deposition Program/National Trends Network

**Sulfate ion concentration (top) and wet deposition (bottom), 2008.**



National Atmospheric Deposition Program/National Trends Network

Calcium ion concentration (top) and wet deposition (bottom), 2008.



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, 2008.**

# Atmospheric Integrated Research Monitoring Network (AIRMoN)

At AIRMoN sites, samples are collected daily within 24 hours of the start of precipitation, often providing data for individual storm events. 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. AIRMoN sites are equipped with the same wet-only deposition collector used at NTN sites. Each site also has a National Weather Service (NWS) standard gage for reporting storm total precipitation. Samples are refrigerated after collection and are sent in chilled, insulated shipping containers to the CAL; samples remain refrigerated until they are analyzed. This retards potential chemical changes, such as with  $\text{NH}_4^+$  and  $\text{PO}_4^{3-}$ . Chemical analyses and data screening procedures for AIRMoN and NTN are similar.

## AIRMoN DATA

The trend charts on page 13 show concentration and deposition trends for active AIRMoN sites. Trends are indicated for sulfate, nitrate, ammonium, hydrogen ion, chloride, sodium, potassium, calcium, magnesium, phosphate, and sum of cations ( $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{K}^+$ ,  $\text{Na}^+$ ,  $\text{NH}_4^+$ ) and anions ( $\text{PO}_4^{3-}$ ,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{Cl}^-$ ) for all valid observations between 1992 and 2008. Trends were investigated using the non-parametric Seasonal Kendall trend test over the 16-year period for DE02, IL11, NY67, PA15, TN00, and VT99. For WV99 an 8-year period of record was used (2000–2008). All chemical species are arranged in the same



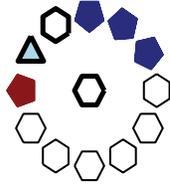
clock position, following the World Meteorological Organization (WMO) custom. Differences from this WMO sequence are indicated by a black border around the symbol.

Statistical significance was determined at the 90% confidence level. Non-significant results are grouped as “no change” and are represented by an open hexagon. Statistically significant trends are shown as one of four categories based on the Sen’s Trend Estimator: large decrease, decrease, increase, and large increase. A large decreasing trend ( $\leq -2\%$  per year) is represented by a dark blue pentagon. A decreasing trend ( $-2\%$  to  $0$  per year) is represented by a light blue triangle. An increasing trend ( $0$  to  $+2\%$  per year) is represented by a red triangle. A large increasing trend ( $\geq +2\%$  per year) is represented by a dark red pentagon. Precipitation trends are included in the center of each figure.

**DE02**

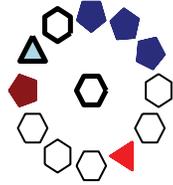
**Concentration**

Number of Observations: 1520



**Deposition**

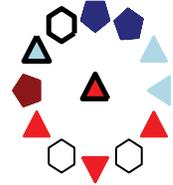
Number of Observations: 1520



**IL11**

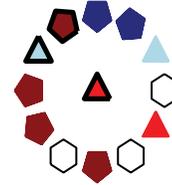
**Concentration**

Number of Observations: 1584



**Deposition**

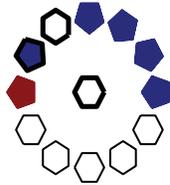
Number of Observations: 1584



**NY67**

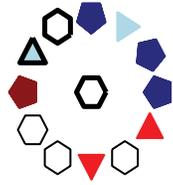
**Concentration**

Number of Observations: 1995



**Deposition**

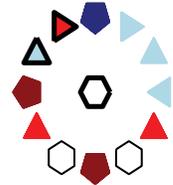
Number of Observations: 1995



**PA15**

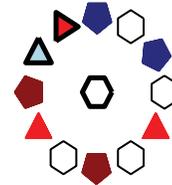
**Concentration**

Number of Observations: 1837



**Deposition**

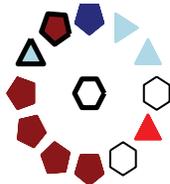
Number of Observations: 1837



**TN00**

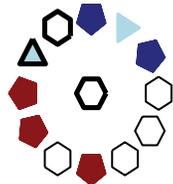
**Concentration**

Number of Observations: 1737



**Deposition**

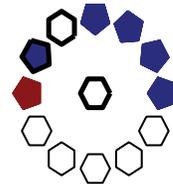
Number of Observations: 1737



**VT99**

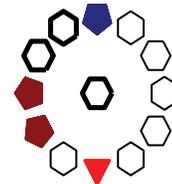
**Concentration**

Number of Observations: 2143



**Deposition**

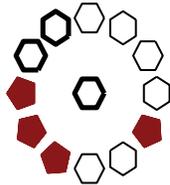
Number of Observations: 2143



**WV99**

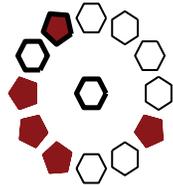
**Concentration**

Number of Observations: 1060



**Deposition**

Number of Observations: 1060



**Species**

Cations H<sup>+</sup> SO<sub>4</sub><sup>2-</sup>  
 Anions NO<sub>3</sub><sup>-</sup>  
 PO<sub>4</sub><sup>3-</sup> precipitation Cl<sup>-</sup>  
 Mg<sup>2+</sup> NH<sub>4</sub><sup>+</sup>  
 Ca<sup>2+</sup> K<sup>+</sup> Na<sup>+</sup>

**Trend Indicators**

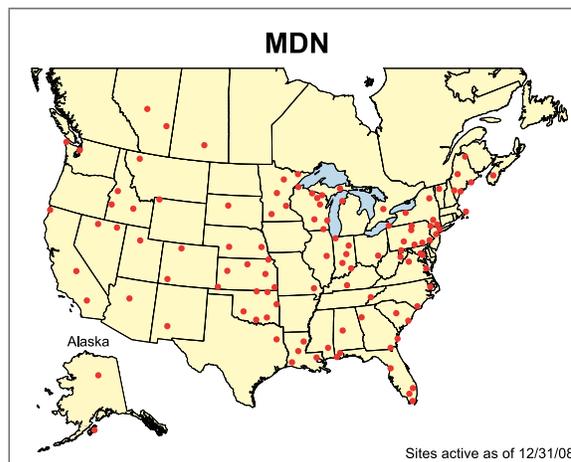
- Large Decrease
- Decrease
- No Change
- Increase
- Large Increase

**AIRMoN trend charts for valid observations between 1992 and 2008. Statistical significance determined at the 90% confidence interval using seasonal Kendall Trend Test, and magnitude determined by Sen's Trend Estimator.**

## Mercury Deposition Network (MDN)

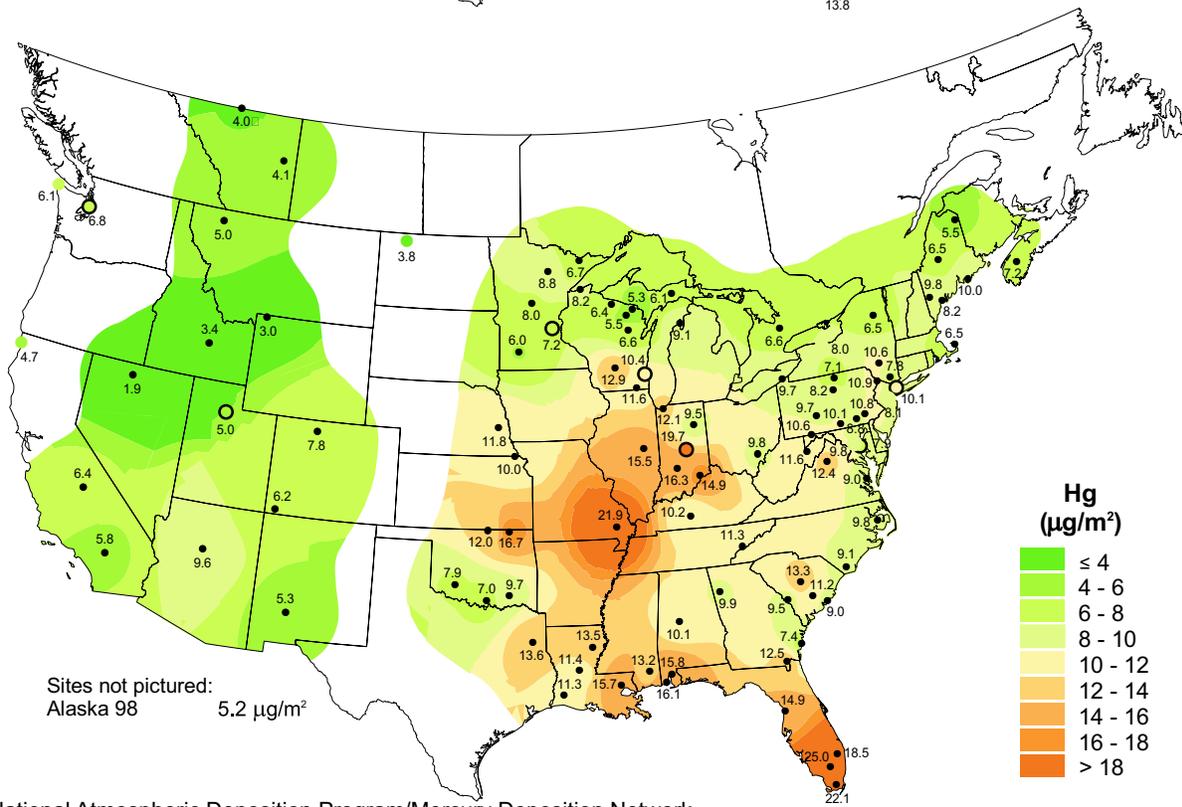
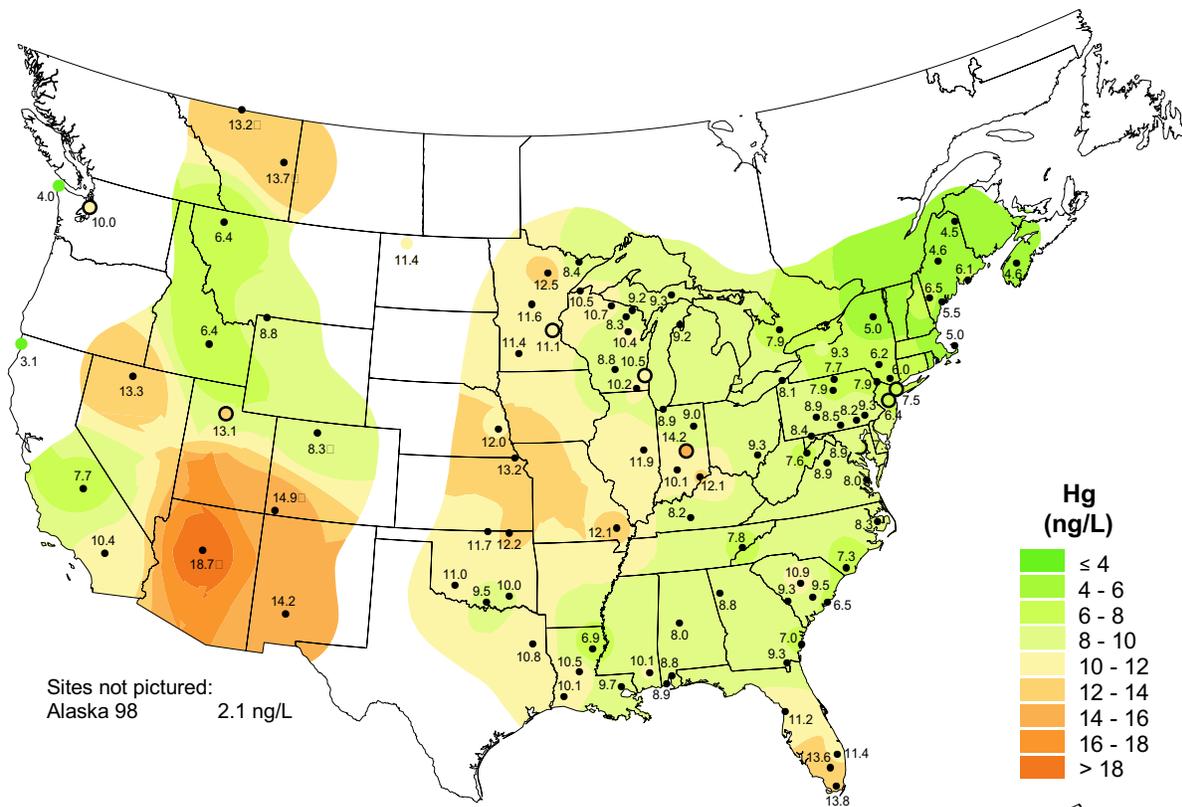
The MDN is the only network providing a long-term record of mercury (Hg) concentrations in precipitation in North America. All MDN sites follow standard procedures and have uniform precipitation collectors and gages. The automated collector has a similar design to the NTN collector, but it is modified to preserve mercury. Site operators collect samples either every Tuesday morning or daily within 24 hours of the start of precipitation. In 2008, the Devil's Lake site in south-central Wisconsin (WI31), the Underhill site in northern Vermont (VT99), and the Yorkville site in northwestern Georgia (GA40) opted to collect daily samples. With each MDN sample, the entire sampling train is replaced with one that is provided by the Mercury Analytical Laboratory (HAL) at Frontier Geosciences, Inc., Seattle, Washington. The MDN is able to measure mercury concentrations below 1 part per trillion (<1 nanogram/liter).

All MDN samples are analyzed for total mercury concentration. At the end of 2008, 18 MDN sites also opted to measure methyl mercury concentrations. The HAL reviews field and laboratory data for accuracy and completeness, and flags samples that were mishandled, compromised by precipitation collector failures, or grossly contaminated. Data are made available on the NADP Web site.



### MDN MAPS

The maps on page 15 show spatial variability in the precipitation-weighted annual average concentration and wet deposition of total mercury. Only sites meeting NADP completeness criteria are included. In 2008, 100 sites met these criteria.



National Atmospheric Deposition Program/Mercury Deposition Network

**Total mercury concentration (top) and wet deposition (bottom), 2008.**

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 (now National Institute of Food and Agriculture, under agreement no. 2008-39134-19508). Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the sponsors or the Illinois State Water Survey.

Champaign, IL

September 2009

---

ISWS Miscellaneous Publication 189 and NADP Data Report 2009-01

The NADP Program Office is located at the Illinois State Water Survey, a division of the Institute of Natural Resource Sustainability at the University of Illinois.

All NADP data and information, including color contour maps in this publication, are available from the NADP Web site: <http://nadp.isws.illinois.edu>.

For further information, data requests, or to obtain copies of this publication, contact: NADP Program Office, Illinois State Water Survey, 2204 Griffith Dr., Champaign, IL 61820, Tel: (217) 333-7871, Fax: (217) 333-0249, E-mail: [nadp@isws.illinois.edu](mailto:nadp@isws.illinois.edu).

Note: When referencing maps or information in this report, please use the citation: National Atmospheric Deposition Program. 2009. *National Atmospheric Deposition Program 2008 Annual Summary*. NADP Data Report 2009-01. Illinois State Water Survey, University of Illinois at Urbana-Champaign, Champaign, IL.