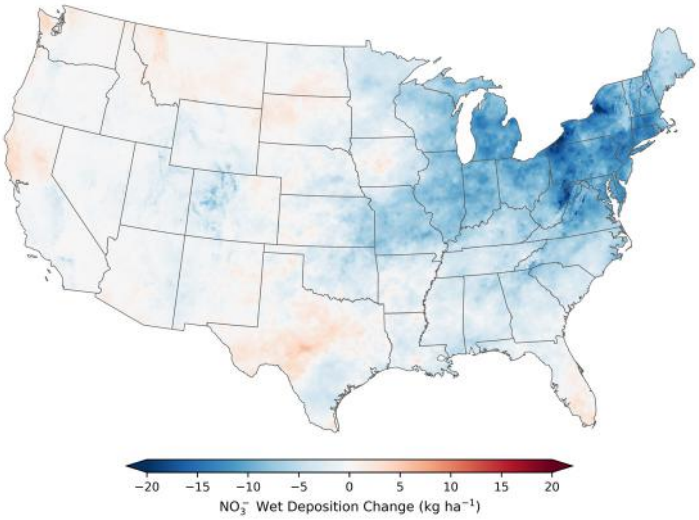
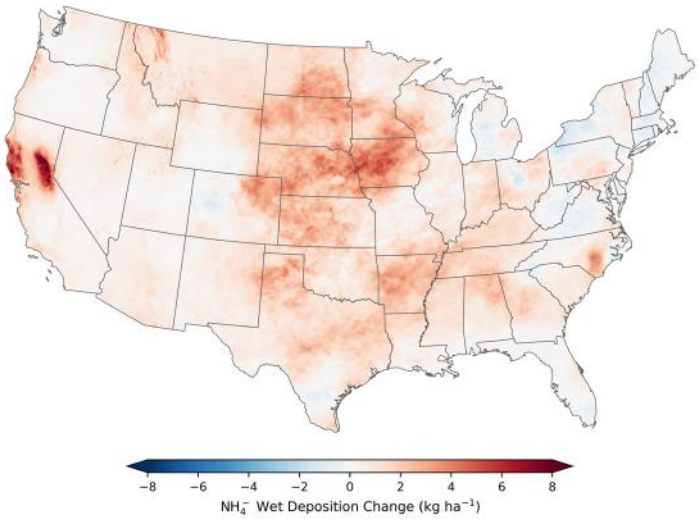
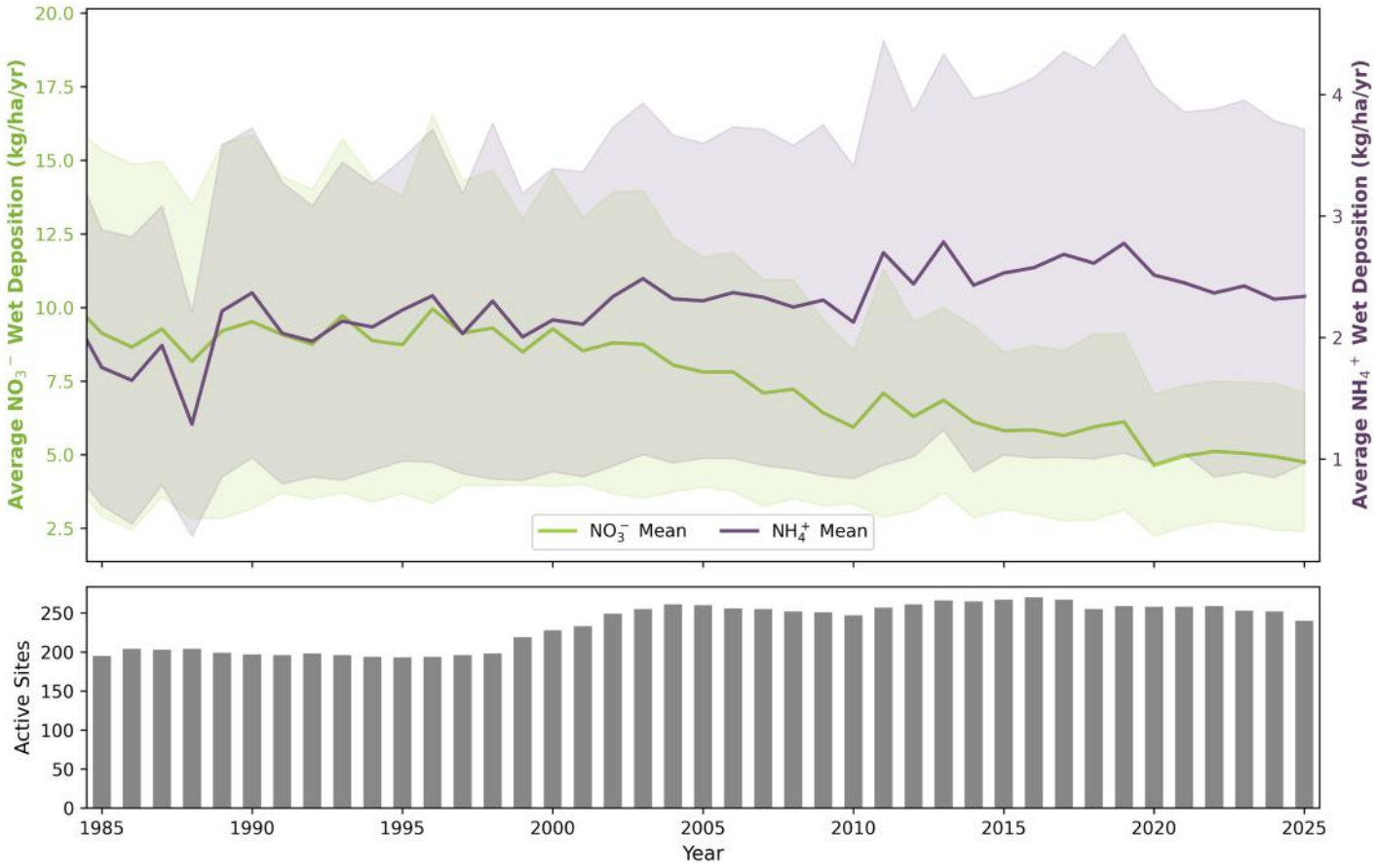
National Atmospheric Deposition Program

2025 Annual Summary

A Changing Nitrogen Landscape: 1985-2025







On the Cover: The cover graphics show long-term changes in wet nitrate (NO_3-) and ammonium (NH_4+) deposition across the National Trends Network (NTN) from 1985 to 2025. The two maps illustrate the spatial distribution of deposition changes (calculated as the difference between 1985 and 2025 maps, which use NADP's typical spatial interpolation techniques). The bottom plot displays nationwide annual wet deposition rates (mean, with shaded areas showing ±1 standard deviation) calculated directly from measured data across all active NTN sites. Wet deposition measures the mass of an analyte delivered to the Earth's surface through precipitation, expressed in kilograms per hectare (kg ha^{-1}). Nitrate and ammonium represent the primary inorganic nitrogen forms monitored by the network.

The time-series plot highlights contrasting long-term changes between the two species: average NO_3- deposition has experienced a steady, substantial decrease over the record, falling from nearly 10 kg ha^{-1} in 1985 to under 5 kg ha^{-1} in 2025. Conversely, average NH_4+ deposition shows an overall upward trend over the same timeframe, rising from approximately 2.0 kg ha^{-1} to over 2.6 kg ha^{-1}, resulting in NH_4+ making up an increasingly dominant share of total wet inorganic nitrogen deposition.

The bottom bar plot displays the number of active monitoring sites over time, showing network growth from under 200 sites in the mid-1980s to roughly 250 sites in recent decades; maintaining this robust network density over time is essential to documenting these spatial changes across the country with high resolution.

Spatially, the difference maps illustrate distinct regional patterns driving these national trends. The NO_3- change map shows widespread reductions across the eastern U.S., with the sharpest decreases (exceeding 15 to 20 kg ha^{-1}) concentrated throughout the Northeast, Mid-Atlantic, and Ohio River Valley. The NH_4+ change map shows increases across much of the country, with peak gains (exceeding 6 to 8 kg ha^{-1}) focused primarily in intensive agricultural regions, notably California's Central Valley, the Upper Midwest, and the Great Plains.

These divergent trends reflect differing environmental drivers: large-scale NO_3- reductions stem primarily from national regulatory controls on nitrogen oxide emissions from power generation and transportation under the Clean Air Act, whereas rising NH_4+ deposition is largely driven by agricultural emissions, including livestock operations, and fertilizer applications.

When referencing maps or information in this report, please use the citation: National Atmospheric Deposition Program, 2026. National Atmospheric Deposition Program 2025 Annual Summary. Wisconsin State Laboratory of Hygiene, University of Wisconsin-Madison, WI.

Contents

2025 Highlights..... 4
NADP Background..... 6
About the Maps..... 8
National Trends Network (NTN).....10
Mercury Deposition Network (MDN) 32
Atmospheric Mercury Network (AMNet)..... 36
Ammonia Monitoring Network (AMoN) 38
Mercury Litterfall Network (MLN)..... 44

2025 Highlights

The National Atmospheric Deposition Program (NADP) has built one of the nation's longest-running records of atmospheric deposition chemistry since beginning sampling in 1978. The NADP delivers high-quality, long-term measurements, generating data trusted by scientists, land managers, policymakers, and the public alike and supporting science-based decisions on environmental and public health issues across the globe.

Data from all networks are provided free of charge on the NADP website (http://nadp.wslh.wisc.edu). The NADP consisted of five networks in 2025, including the National Trends Network (NTN), the Mercury Deposition Network (MDN), the Atmospheric Mercury Network (AMNet), the Ammonia Monitoring Network (AMoN), and the Mercury Litterfall Network (MLN). The table below summarizes the number of measurements from each network in 2025.

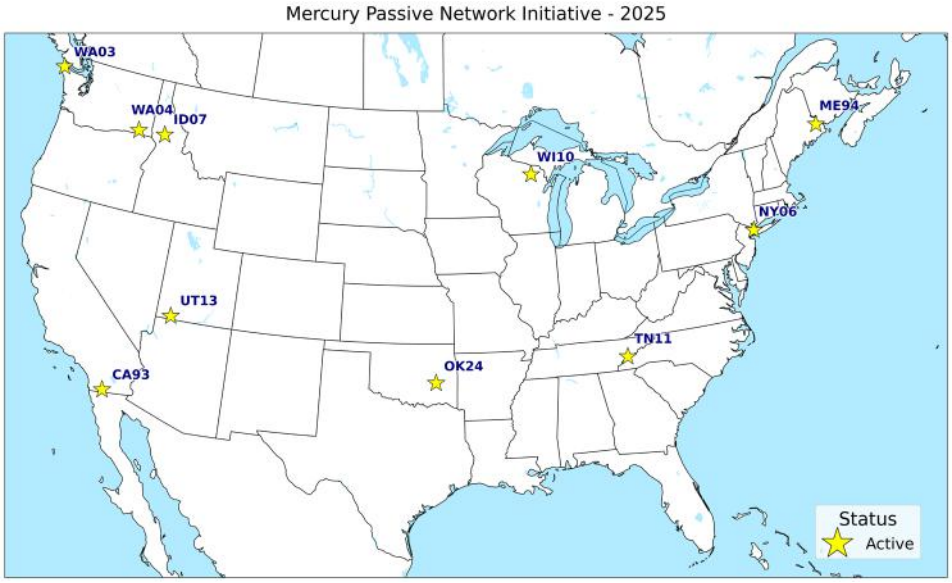
Summary of 2025 Network Measurements

Network	Measurements	Period	No. of sites
NTN	11,772	weekly	240
MDN	3,629	weekly	79
AMNet	35,951	hourly/ 2-hourly	7
AMoN	2,678	two week	104
MLN	25	seasonal	25

Highlights:

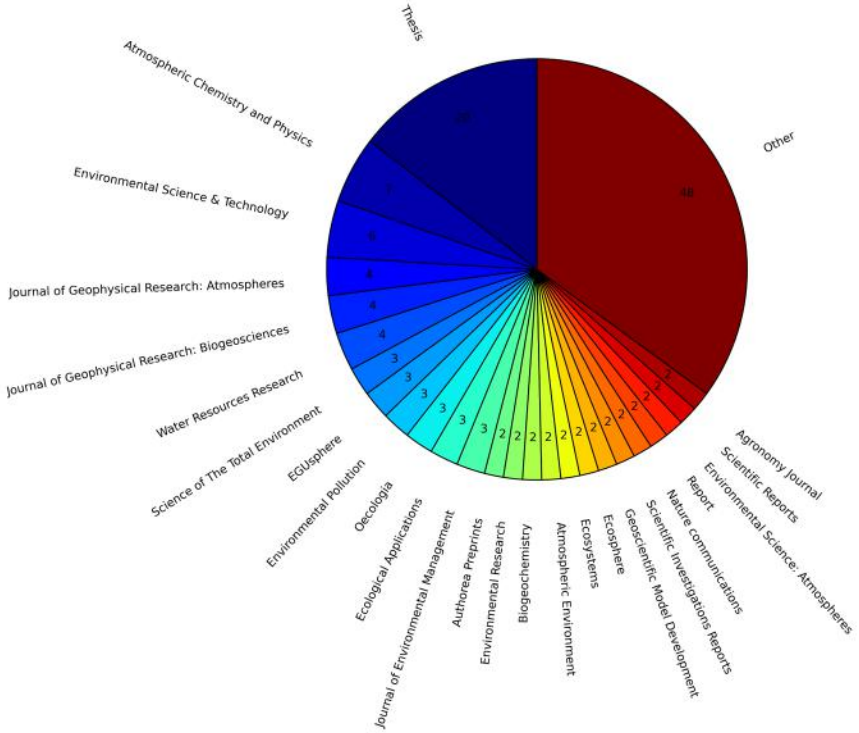
- This report marks the 48th year of continuous operation of the National Atmospheric Deposition Program, which began in 1978. Few environmental monitoring networks can claim this level of longevity and consistency — a testament to the dedication of site operators, state agencies, and partners who have sustained this record for nearly five decades.
- With the NADP Science Symposium shifting from fall to spring, the officers elected in October 2024 remained in their positions through 2025:
    - Chair: Melissa Puchalski, US EPA
    - Vice Chair: Michael McHale, USGS
    - Secretary: David Felix, University of North Carolina-Wilmington
    - Past Chair: Michael Bell, NPS
- Thank you to all our site operators for your dedicated service to NADP. Your sustained, weekly commitment is fundamental to the network's continued success.
- NADP extended the PFAS-NTN (PFN) pilot subnetwork through 2025 to continue building out site coverage and sampling protocols.
- Following recommendations from the 2024 external lab review and network optimization efforts, MLN discontinued routine methylmercury reporting and AMNet discontinued mercury speciation reporting in 2025, streamlining network operations to focus resources on the most informative measurements. Methylmercury analysis remains available through WSLH as a non-standard analyte upon request.

- 2025 marks the first full year of NADP's new Passive Mercury Pilot Network, which began sample collection on December 31, 2024. The pilot uses 90-day passive sampling to explore a lower-cost, lower-maintenance approach to monitoring atmospheric mercury. Sites participating in the Passive Mercury Pilot Network are shown below.



Sites participating in the 2025 Passive Mercury Pilot program

- During the 2025 calendar year, 146 articles and reports were identified as having used NADP data. See the figures below for the distribution of publication journals. Within the publications, there were several non-journal publications, including:
  - 10 doctoral dissertations
  - 9 master's theses
  - 2 undergraduate theses



NADP Background

The NADP 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. The NADP's primary charge was to provide data on the temporal trends and geographic distribution of the atmospheric deposition of acids, nutrients, and base cations by precipitation. In 1978, sites in the NADP precipitation chemistry network first began collecting weekly, wet-only deposition samples. Chemical analysis was performed at the Illinois State Water Survey's Central Analytical Laboratory (CAL), located at the University of Illinois Urbana-Champaign and the Program Coordinator was housed at Colorado State University.

Initially, the NADP was organized as SAES North Central Regional Project NC-141, which all four SAES regions later endorsed in 1982 as Interregional Project IR-7. A decade later, IR-7 was reclassified as the National Research Support Project No. 3 (NRSP-3), which it remains to this day. NRSP projects are multistate activities that support research on topics of concern to more than one state or region of the country. Multistate projects involve the SAES in partnership with the USDA National Institute of Food and Agriculture (NIFA) and other universities, institutions, and agencies.

In October 1981, the federally-supported National Acid Precipitation Assessment Program (NAPAP) was established to further the understanding of the causes and effects of acidic precipitation. This program sought to establish a long-term precipitation chemistry network of sampling sites away from point source influences. Building on its experience in organizing and operating a national-scale network, the NADP agreed to coordinate operation of NAPAP's National Trends Network. Later, to benefit from identical siting criteria, 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.

In October 1992, Atmospheric Integrated Research Monitoring Network (AIRMoN) was formed from the Multistate Atmospheric Power Production Pollution Study (MAP3S), which was operated by the Department of Energy and the National Oceanic and Atmospheric Administration (NOAA). MAP3S measured wet deposition and estimated dry deposition (later discontinued) for the same analytes. AIRMoN sites collected samples daily when precipitation occurred, and were analyzed for the same analytes as NTN samples.

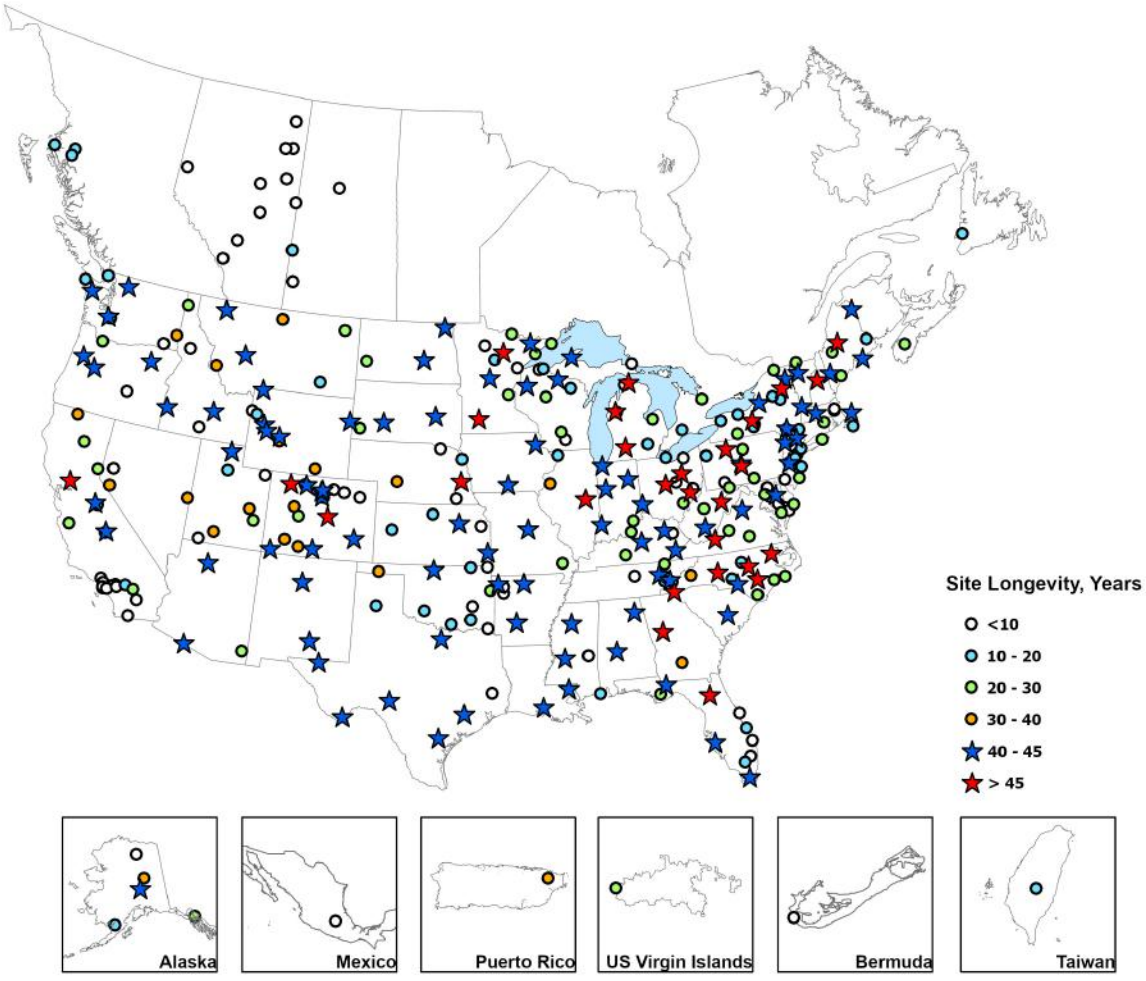
In January 1996, the NADP established the Mercury Deposition Network (MDN), the third network in the organization. The MDN was formed to provide data on the wet deposition of mercury to surface waters, forested watersheds, and other receptors. MDN samples, like NTN samples, are weekly collections.

In October 2009, the Atmospheric Mercury Network (AMNet) joined the NADP as its fourth network. AMNet measures the concentration of atmospheric mercury at high-time resolution using on-site, real-time analyzers.

In October 2010, the Ammonia Monitoring Network (AMoN) joined the NADP. Atmospheric ammonia concentrations are measured every two weeks using passive samplers. The AMoN furthers the understanding of wet and dry deposition and ammonia partitioning in the atmosphere, allowing better assessment of ecosystem impacts and secondary air pollution formation.

Beginning in late 2017 and completed in mid-2018, the NADP Program Office (PO) and Central Analytical Laboratory (CAL, now called NADP Analytical Laboratory, NAL) moved from the University of Illinois at Urbana-Champaign to the Wisconsin State Laboratory of Hygiene at the University of Wisconsin–Madison. In June 2019, the Mercury Analytical Laboratory (HAL) moved to the University of Wisconsin–Madison and incorporated into the NAL. Also in 2019, AIRMoN collected its last sample and the network was closed.

In the fall of 2021, the Mercury Litterfall Network (MLN) joined the NADP. The MLN measures concentrations of total mercury found in plant biomass litterfall. This measurement occurs in monthly samples over the autumn using passive collectors. The MLN provides information of additional mercury deposition in forested canopies.



Global distribution and longevity of NADP sites (years).

About the Maps

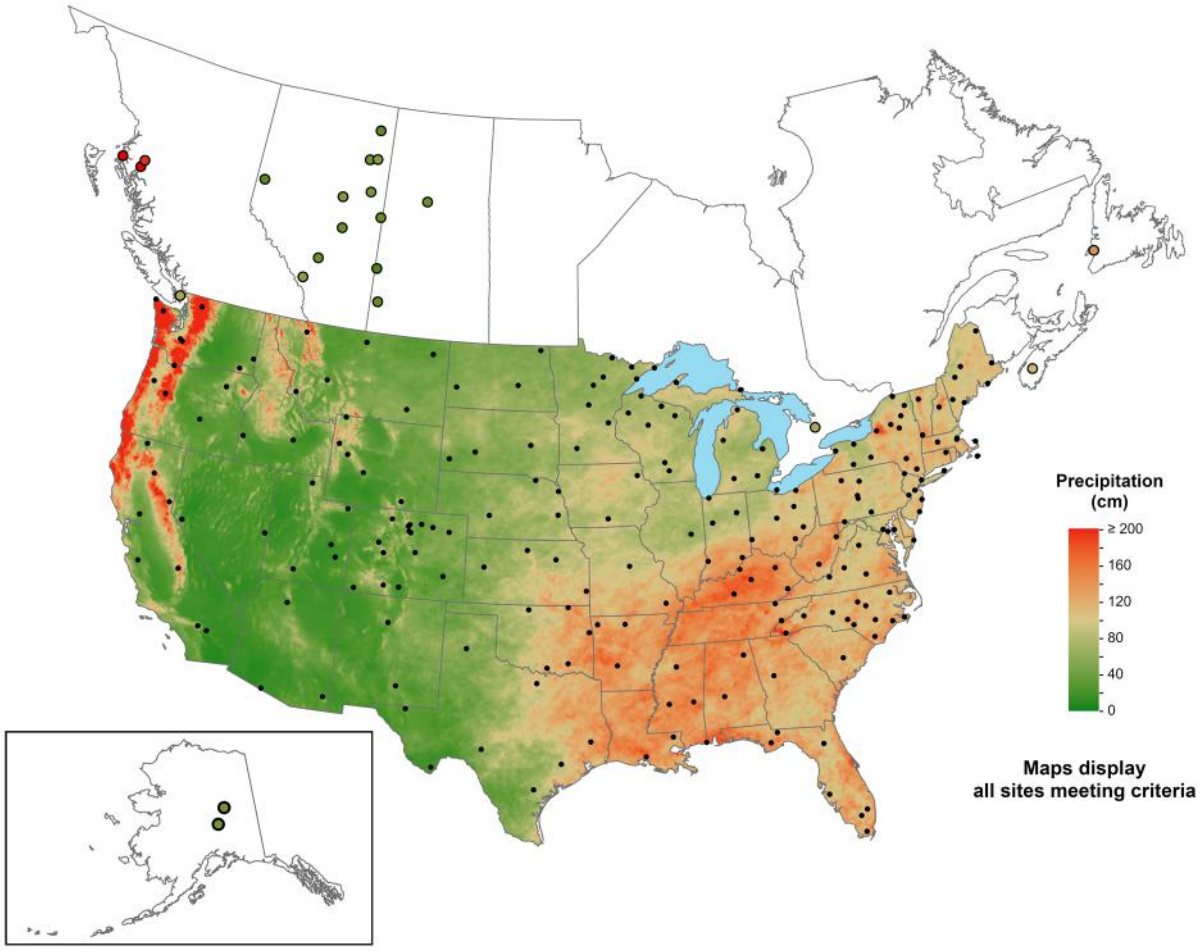
This map summary is a principal product of the NADP, illustrating the results of network operation for the most recent complete calendar year in graphical form. Additional maps, related geographic information, and reviewed analytical results are available on the NADP website.

To be included in a map product, annual site data must meet strict data completeness criteria (see the NADP website for details). Black dots mark site locations that met NADP completeness criteria in 2025. Open circles primarily designate urban sites, defined as having at least 400 people per square kilometer (km2) within a 15-km radius of the site. Specially designated industrial sites, and sites that are too far removed from other observations to extend the contour surface (e.g., Canadian sites) also are represented as color-filled circles.

The map contour surface represents a gridded interpolation. Grid points within 500 km of each site are used in computations. Open circle sites do not contribute to the contour surface. Colors represent interpolated values of concentration, deposition, or precipitation.

The CONUS precipitation surface is a modified version of the U.S. precipitation grid developed by the PRISM Climate Group ("Parameter-elevation Regressions on Independent Slopes Model," http:// prism. oregonstate.edu, data downloaded September 2026). These annual precipitation estimates incorporate point data, a digital elevation model, and expert knowledge of complex climatic extremes to produce continuous grid estimates. NADP precipitation observations are used to supplement the PRISM precipitation grids through an inverse distance weighting within a 20 km radius of each NADP site (see the NADP website for specific information). The resulting precipitation map is used to generate the deposition maps.

The precipitation figure on the next page has a continuous gradient of color from dark green (0 cm of precipitation) to yellow to dark red (greater than 200 cm of precipitation). Concentration and deposition maps follow this same format, with specified units on each map. All maps back to 1985 follow this schema and are available in multiple formats from the NADP website (https://nadp.slh.wisc.edu).



Total annual precipitation for 2025, using precipitation measurements from the NADP and PRISM (in cm).

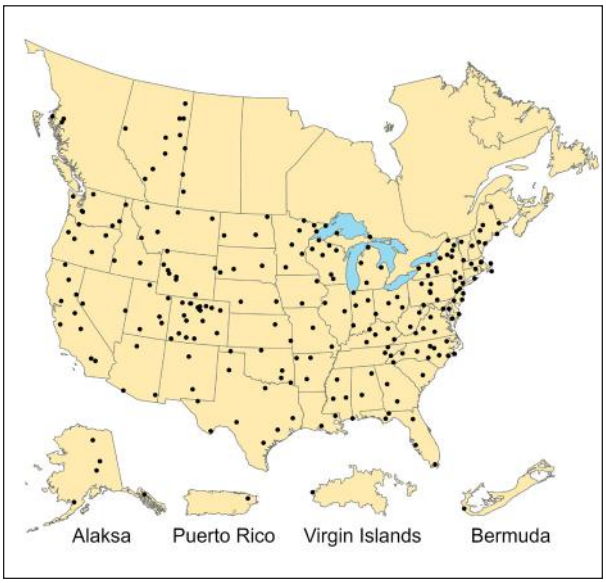
National Trends Network (NTN)

The NTN is the largest network in North America that provides a long-term record of precipitation chemistry. Most sites are located away from urban areas and point sources of air pollution, although urban sites do participate. Each site has a precipitation collector and precipitation gauge. The automated collector ensures that sampling only occurs during precipitation events. Site operators follow standard operating procedures to help ensure NTN data comparability and representativeness across the network. Weekly samples are collected each Tuesday morning, using sampling containers provided by the NADP.

All samples are sent to the NADP laboratory for analysis of free acidity (H^+ as pH), specific conductance, 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 NADP quantifies orthophosphate for quality assurance purposes, as an indicator of potential field contamination. The PO reviews field and laboratory data for accuracy and completeness and flags samples that were mishandled, compromised by equipment failure, or grossly contaminated. Data from the NTN are available on the NADP website (https://nadp.slh.wisc.edu/).

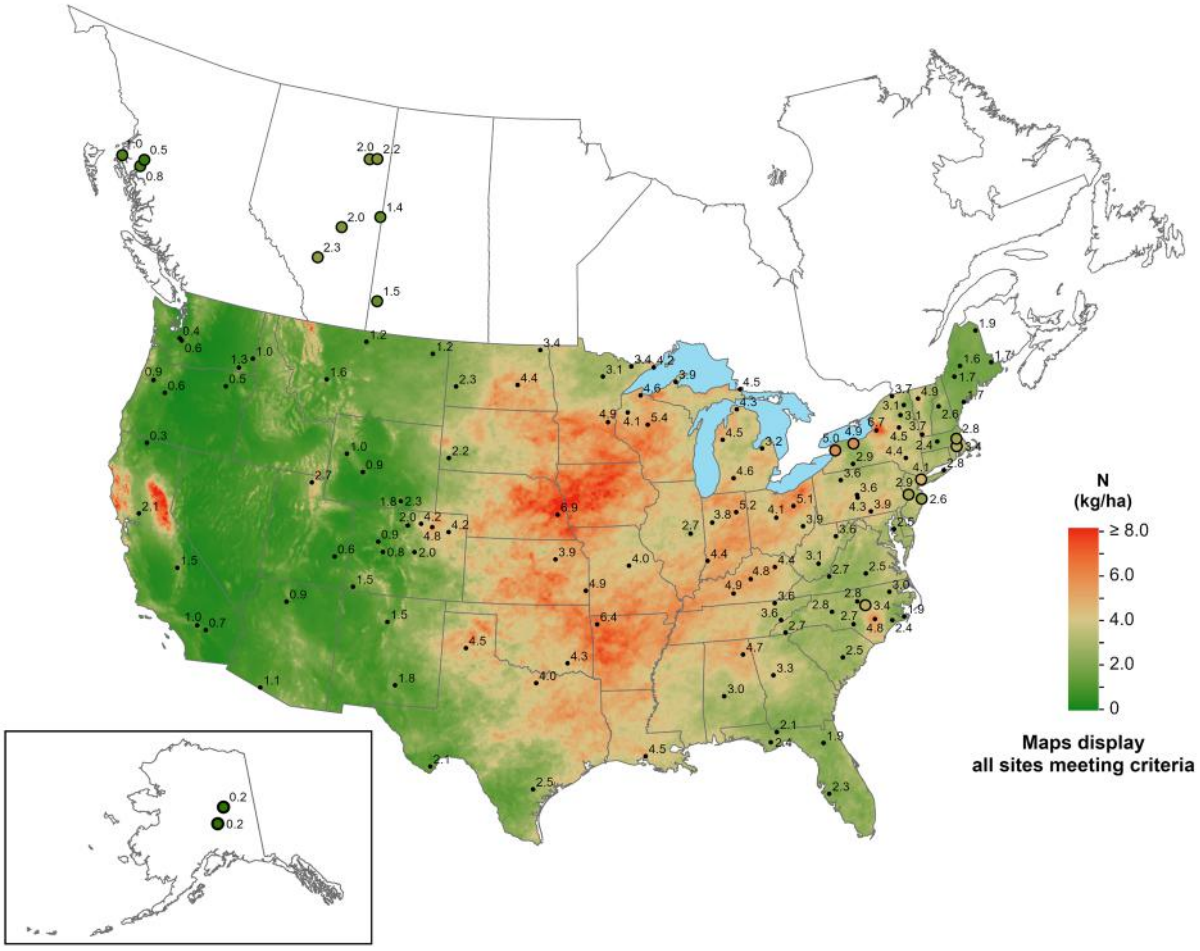
NTN Maps

The maps on pages 11 through 31 show precipitation-weighted mean concentration and annual wet deposition for select acid anions, nutrients, and base

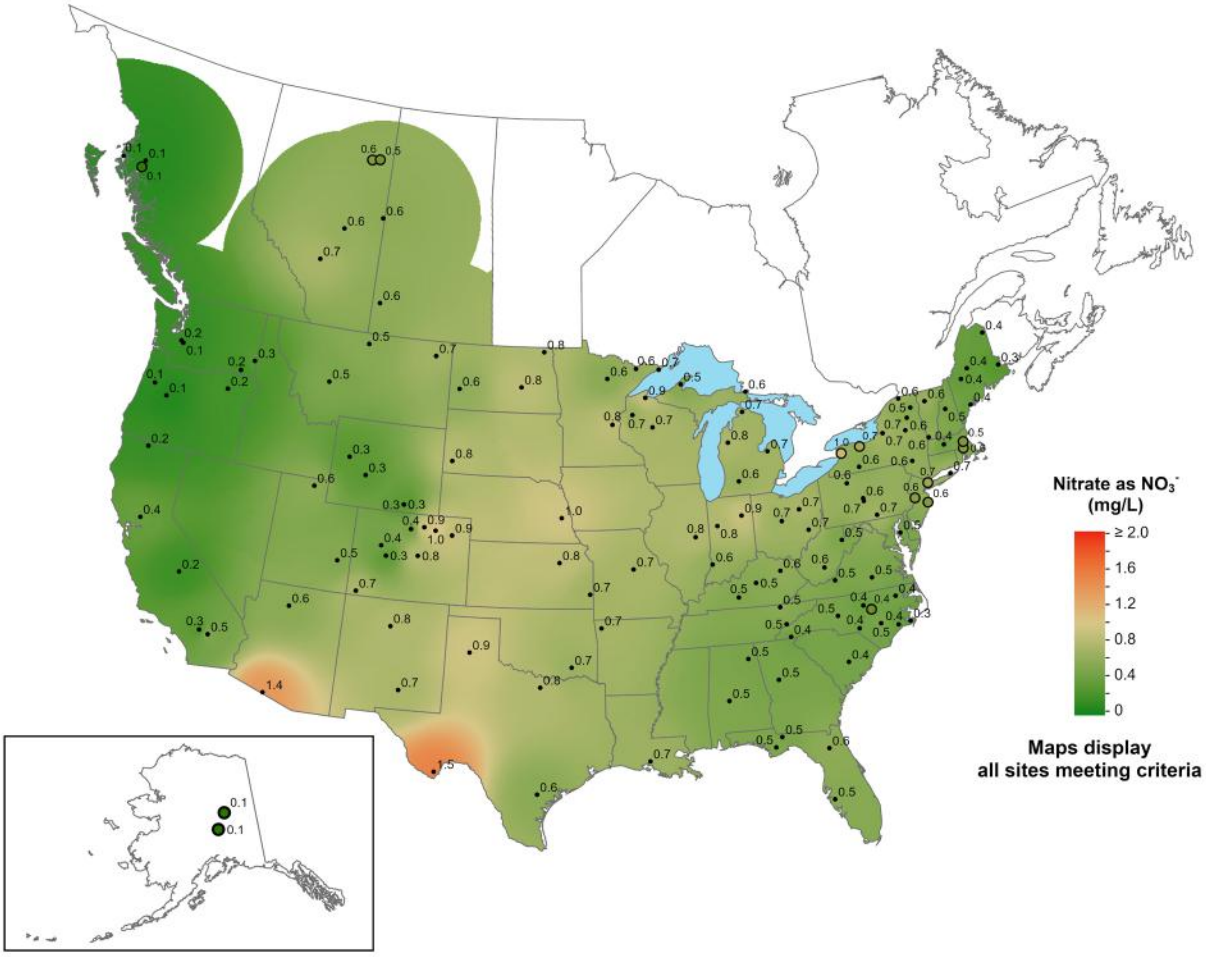


cations. Substantial spatial heterogeneity across the nation is apparent for all measured species. In 2025, 134 of the 240 active sites met NADP completeness criteria. Canadian sites BC22, AB32, and AB36 are located in immediate vicinity of heavy industry. Concentration and deposition maps are included for SO_4^{2-}, NO_3^-, NH_4^+, pH, Ca^{2+}, Mg^{2+}, Cl^-, Na^+ and K^+.

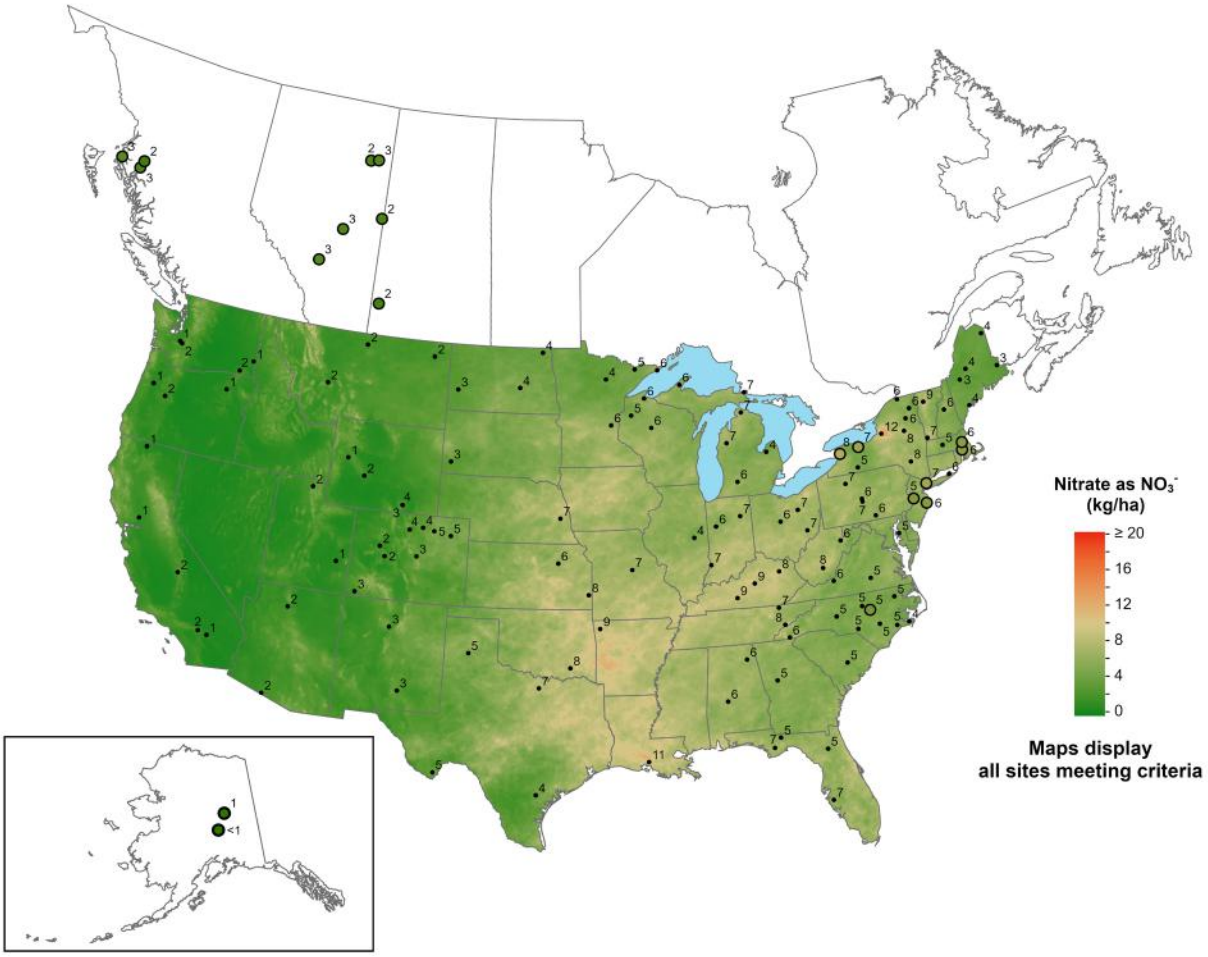
Annual maps for wet deposition of inorganic nitrogen (i.e., $NO_3^- + NH_4^+$) and sulfur + nitrogen (S + N) are also included. S + N (i.e., $SO_4^{2-} + NO_3^- + NH_4^+$) deposition is mapped as hydrogen ion equivalents per hectare (eq/ha).



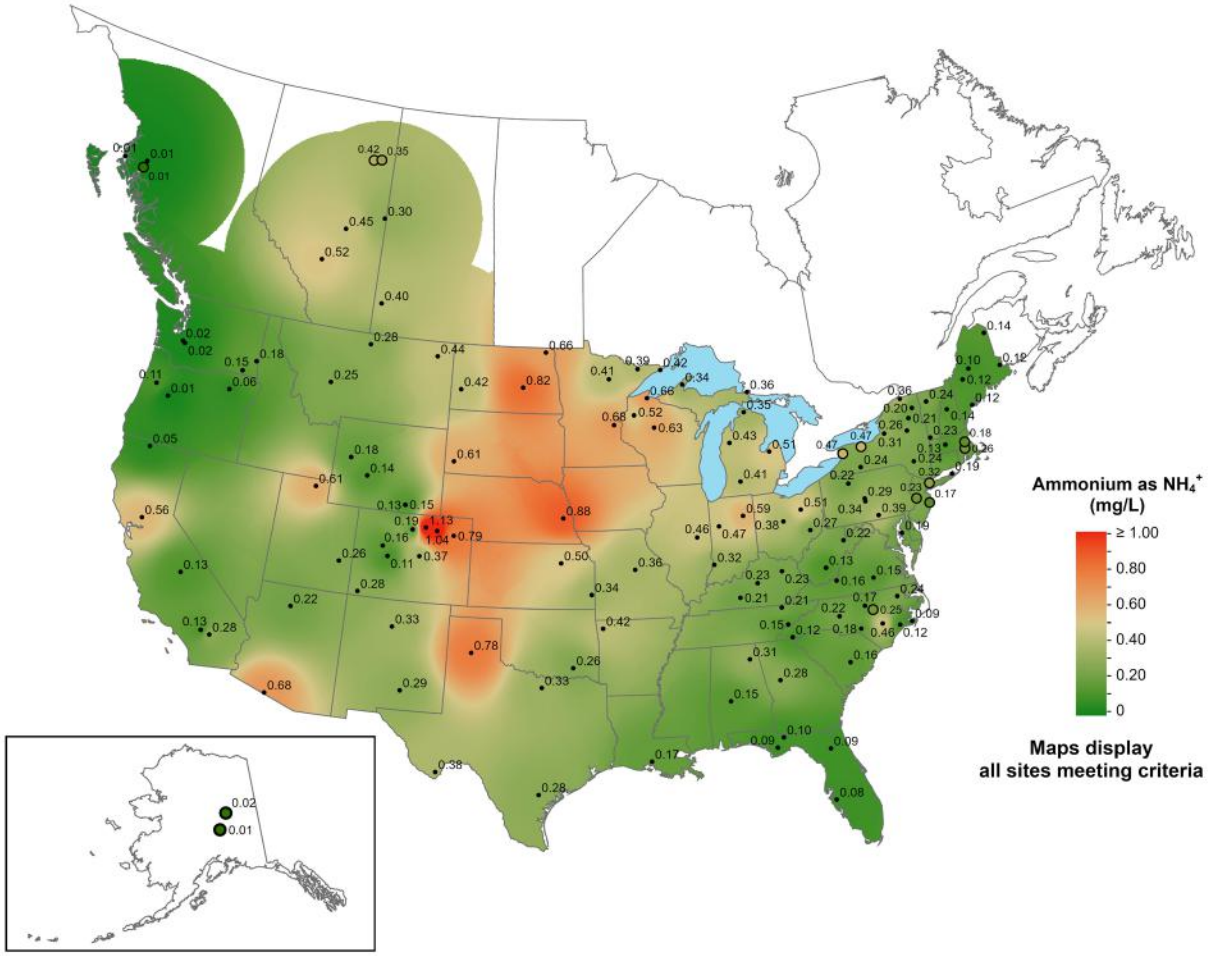
Inorganic nitrogen wet deposition from nitrate and ammonium, 2025.



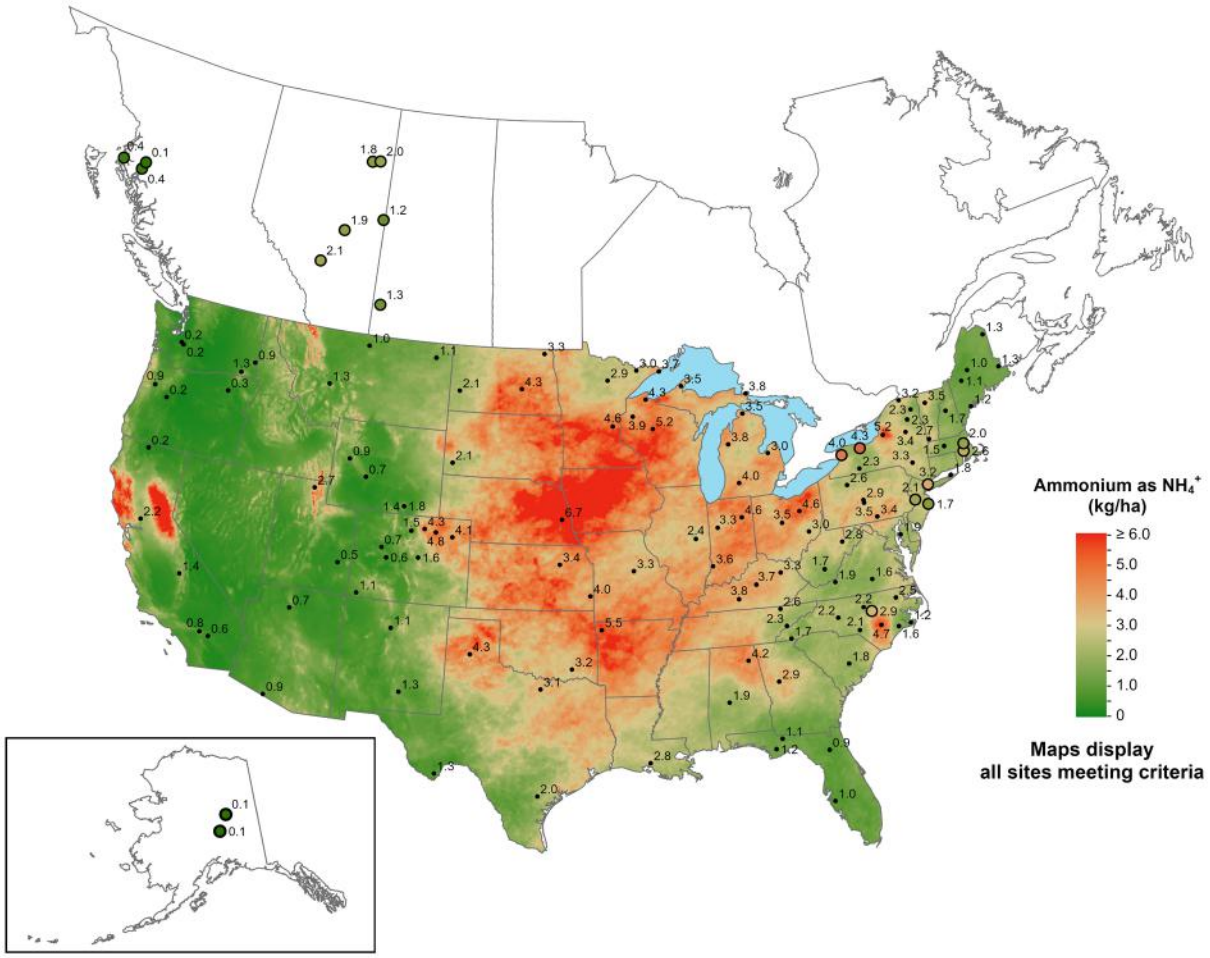
Nitrate ion concentration, 2025.



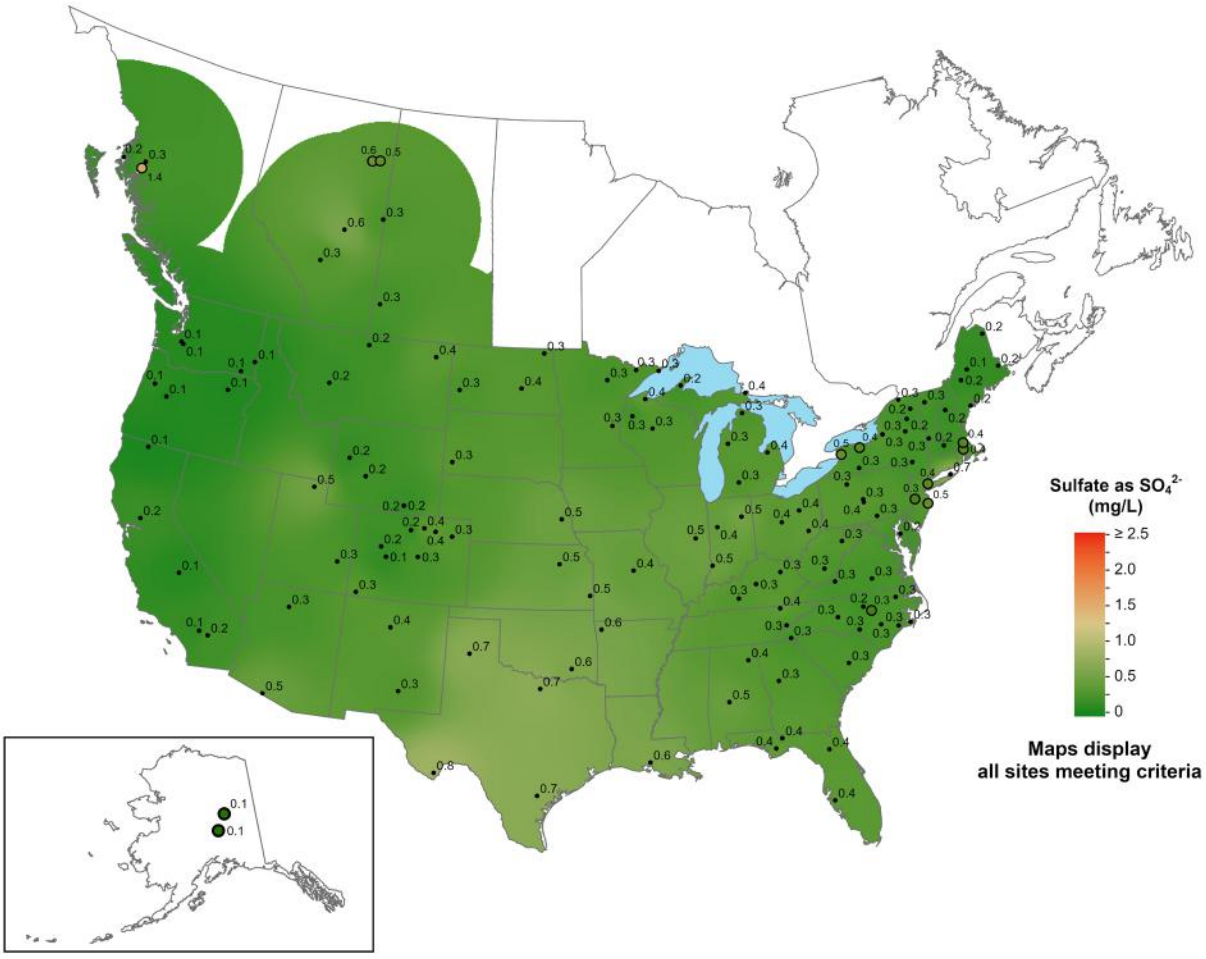
Nitrate ion wet deposition, 2025.



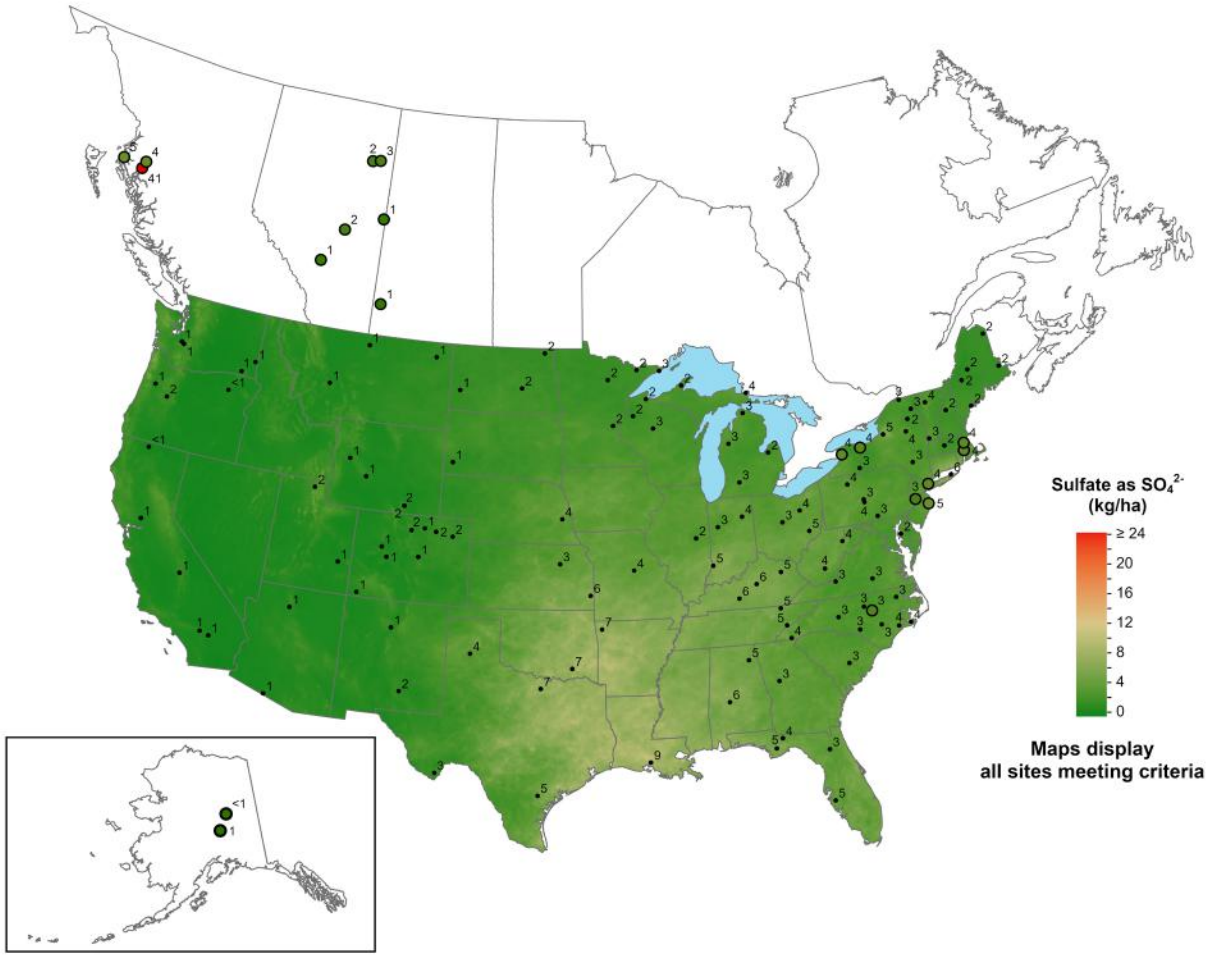
Ammonium ion concentration, 2025.



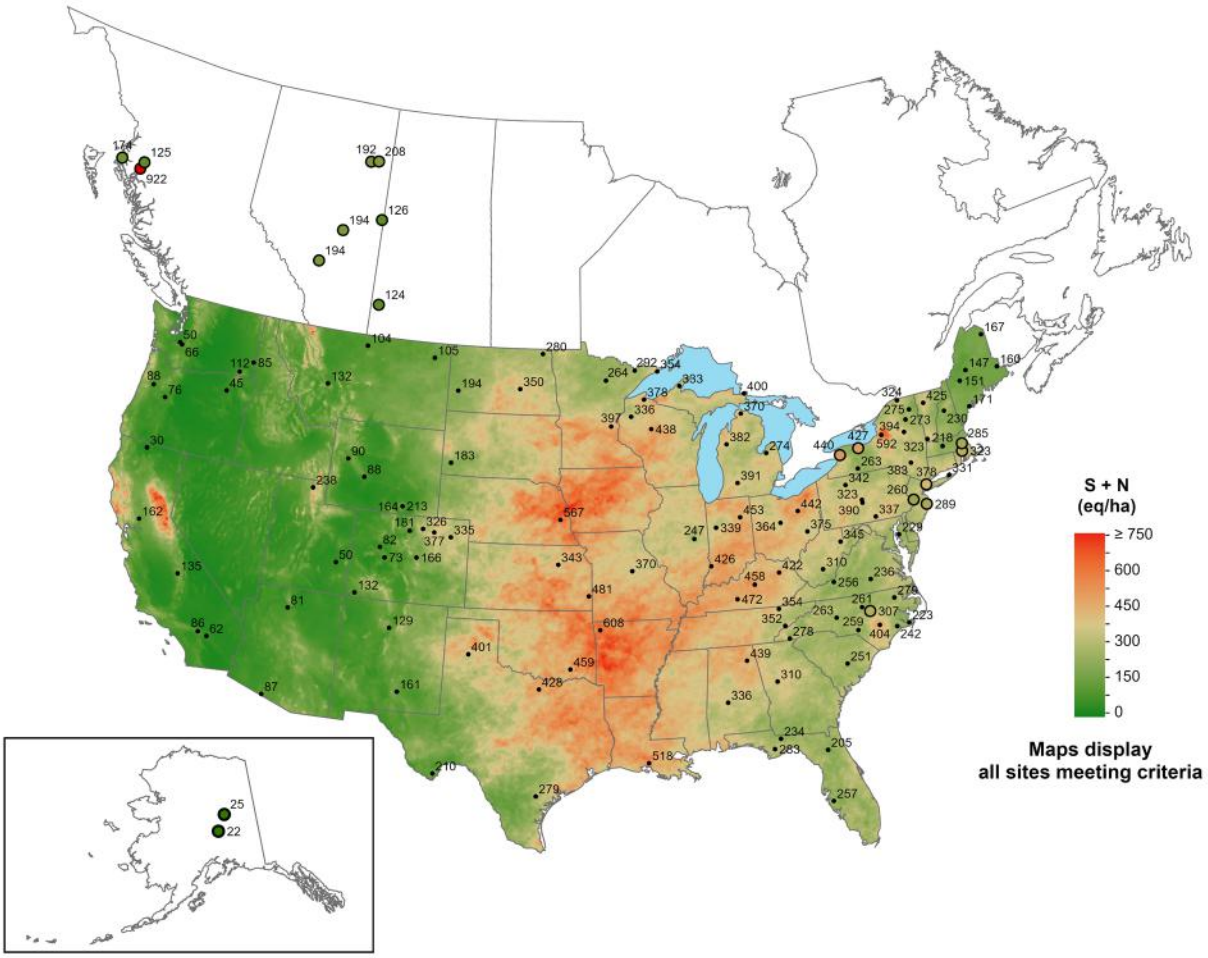
Ammonium ion wet deposition, 2025.



Sulfate ion concentration, 2025.

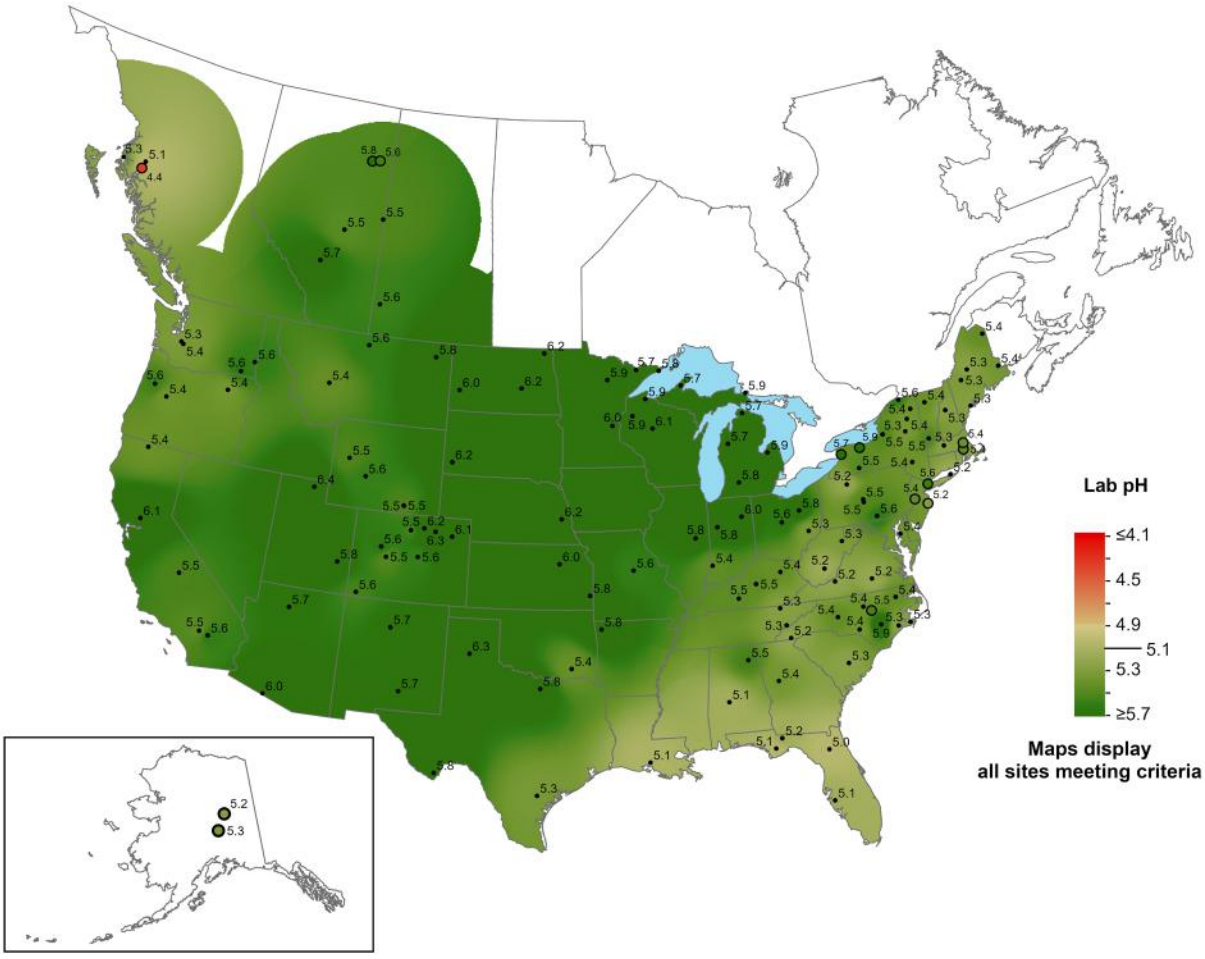


Sulfate ion wet deposition, 2025.

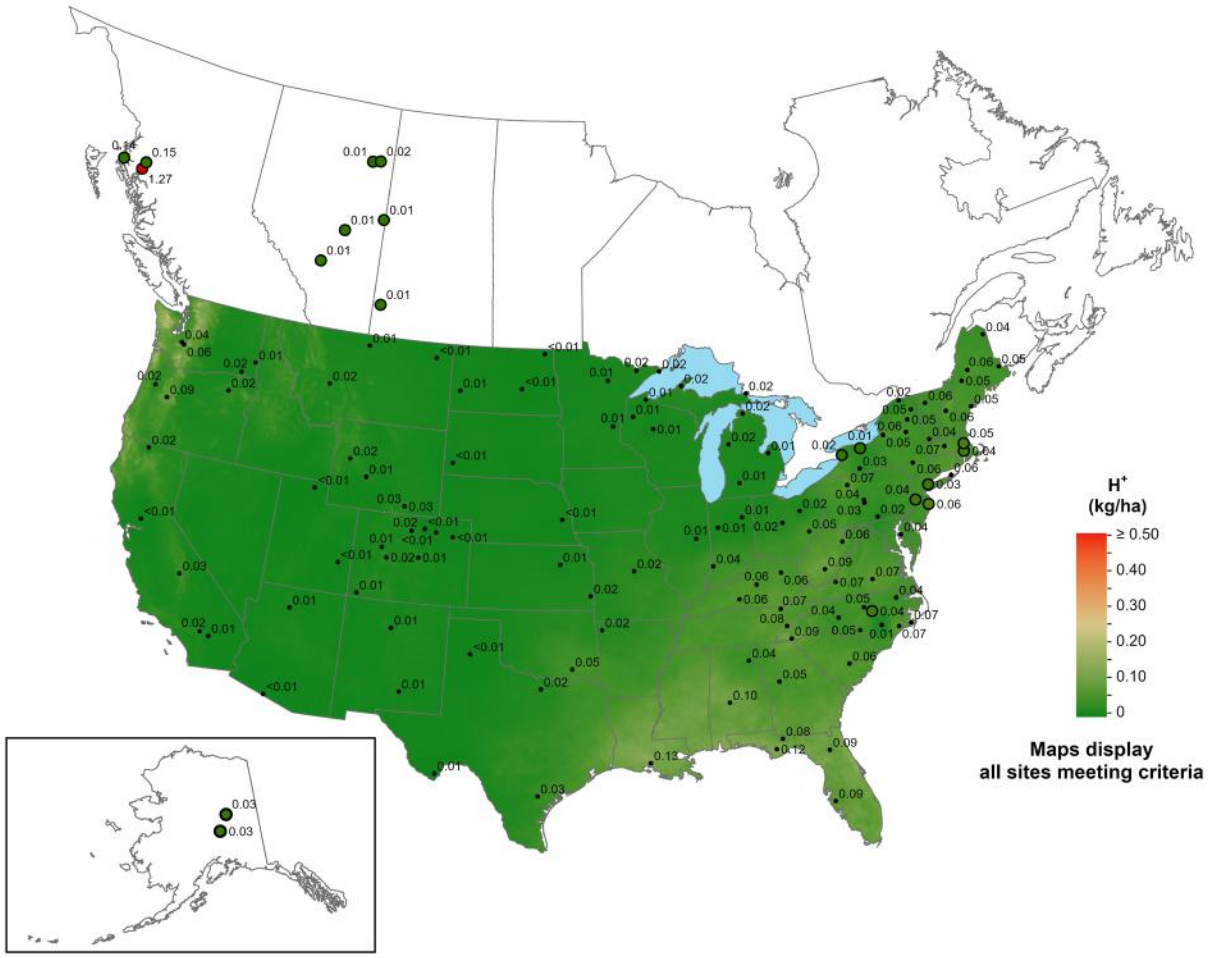


Sulfur plus nitrogen wet deposition from sulfate, nitrate and ammonium, 2025.

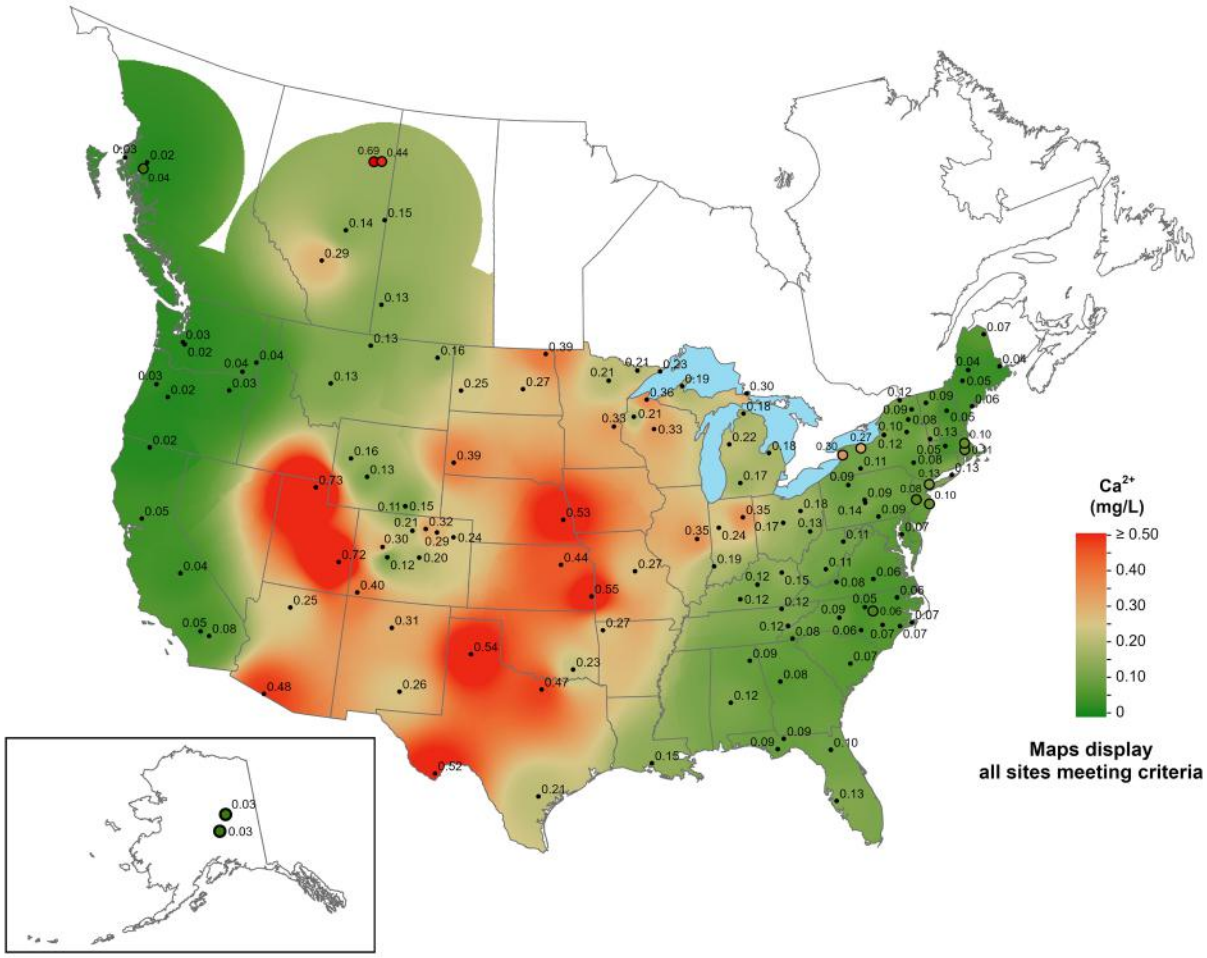
This page intentionally left blank.



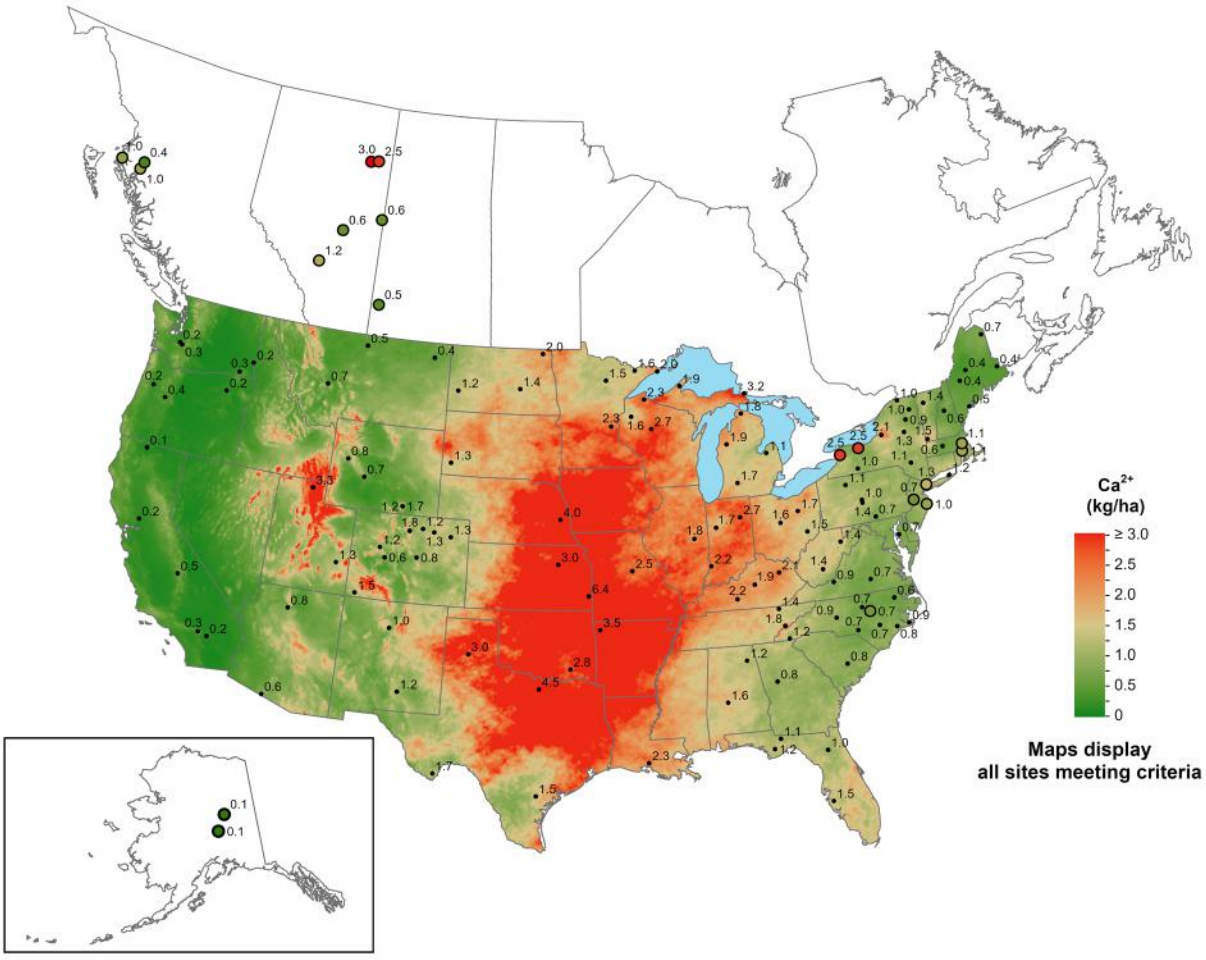
Hydrogen ion concentration as pH, 2025.
Typically, a precipitation pH of less than 5.1 is considered acidic precipitation.



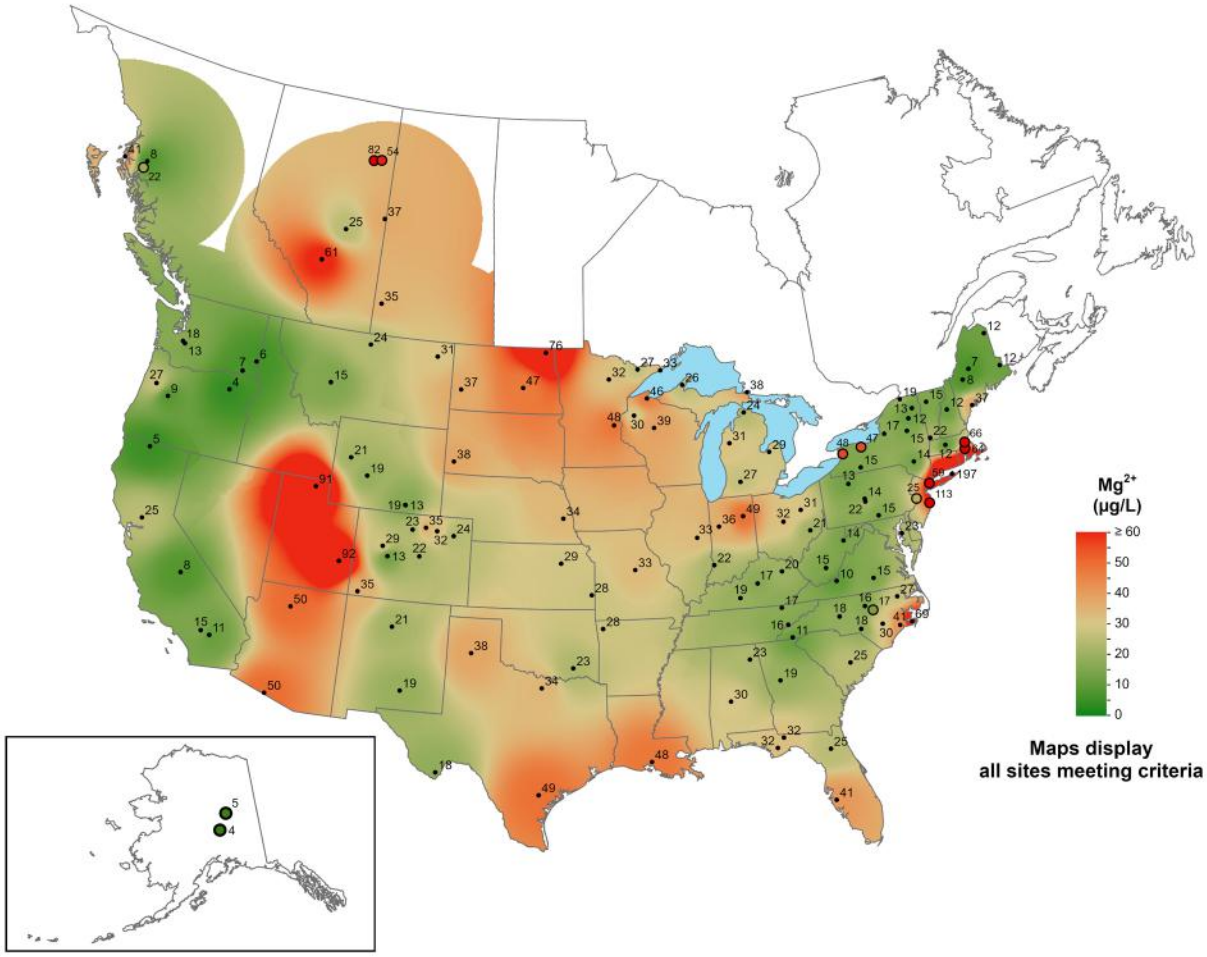
Hydrogen ion wet deposition, 2025.



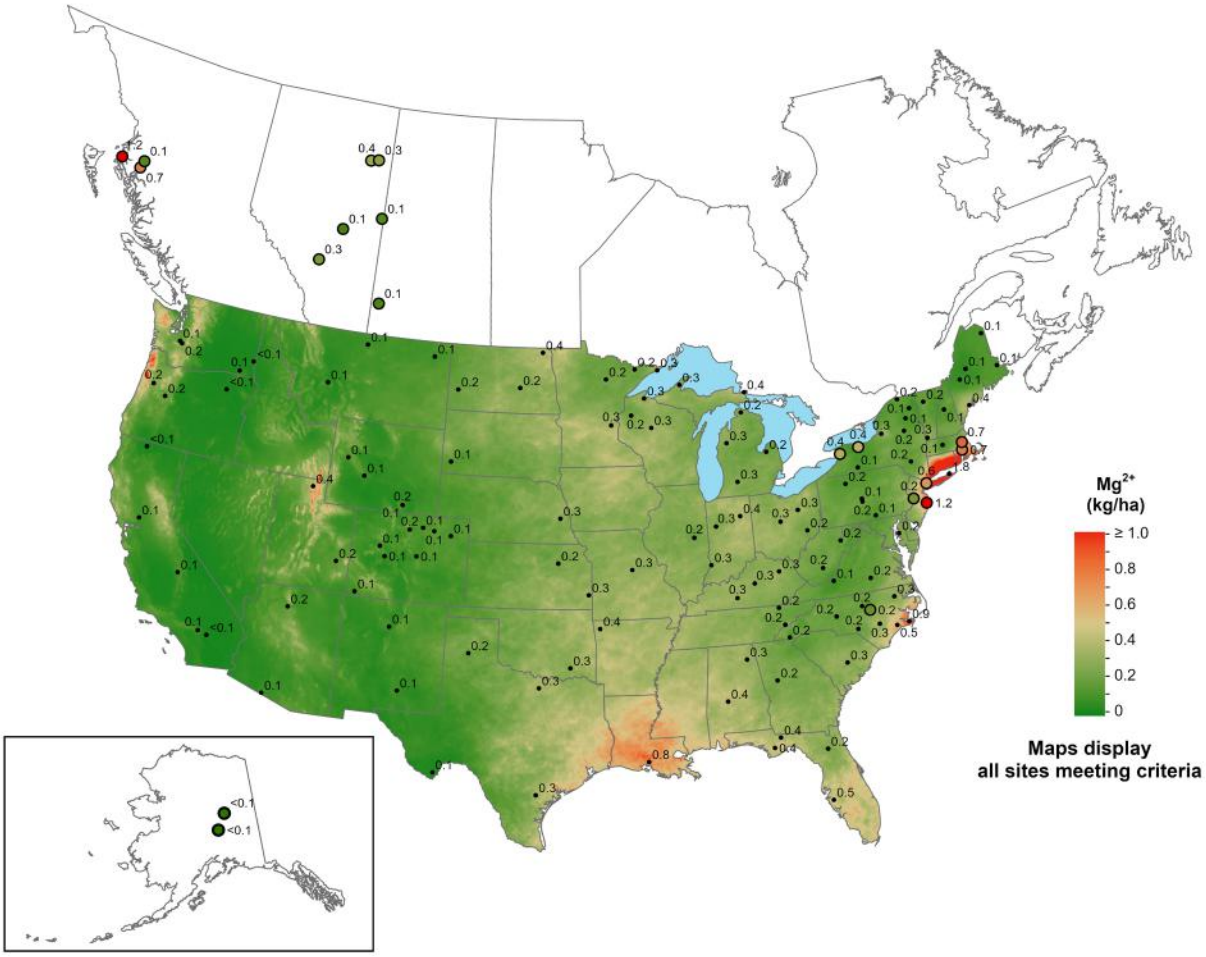
Calcium ion concentration, 2025.



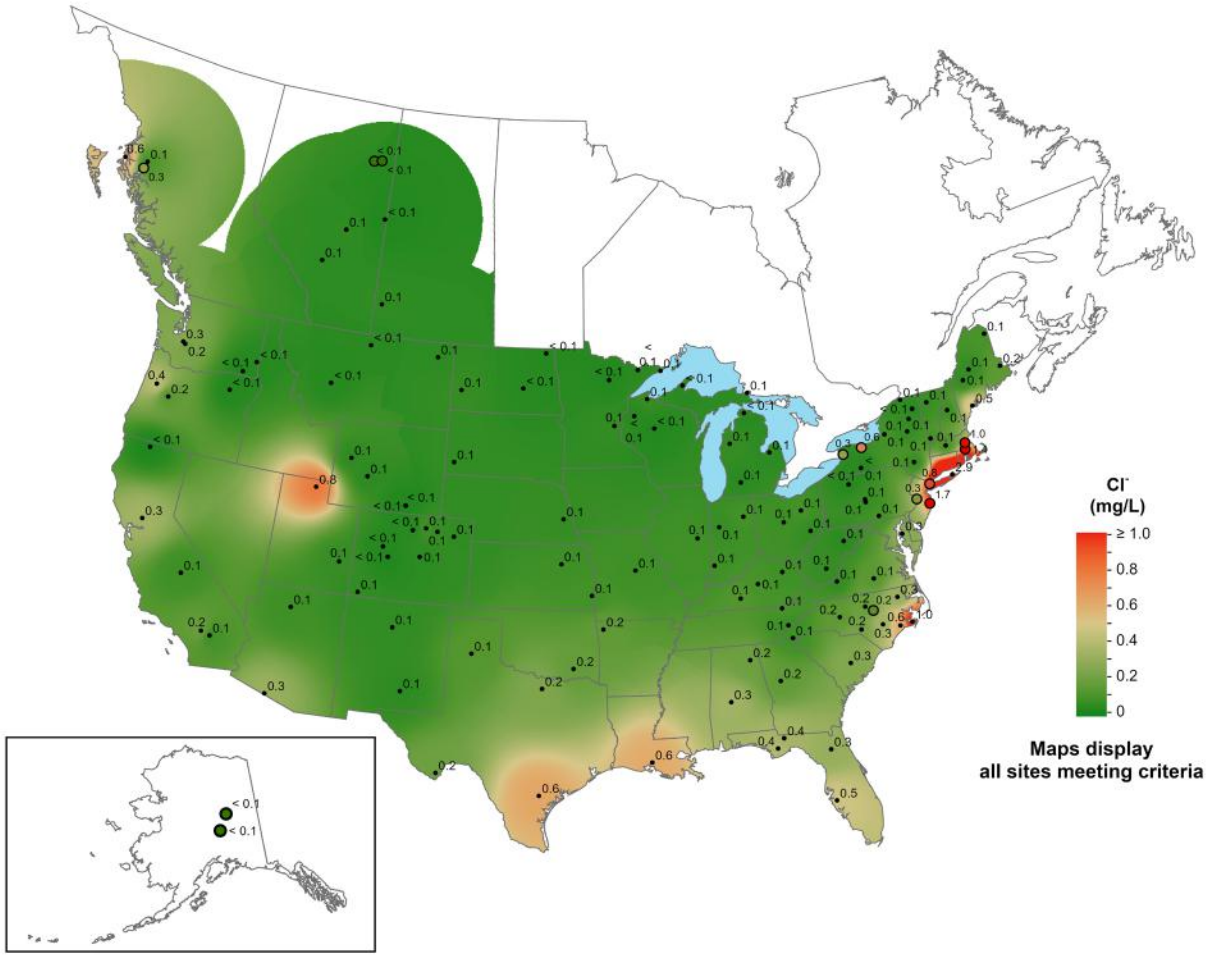
Calcium ion wet deposition, 2025.



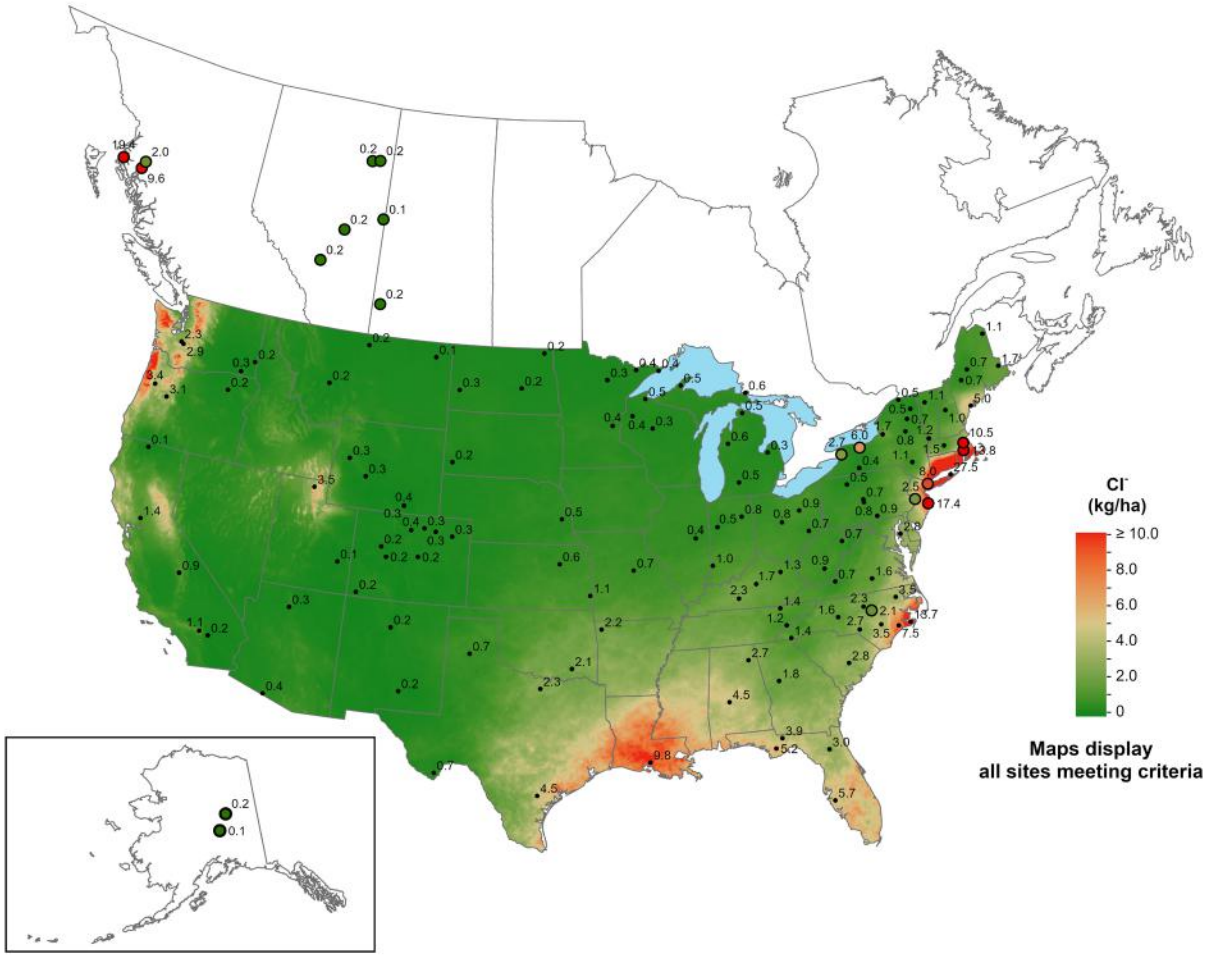
Magnesium ion concentration, 2025.



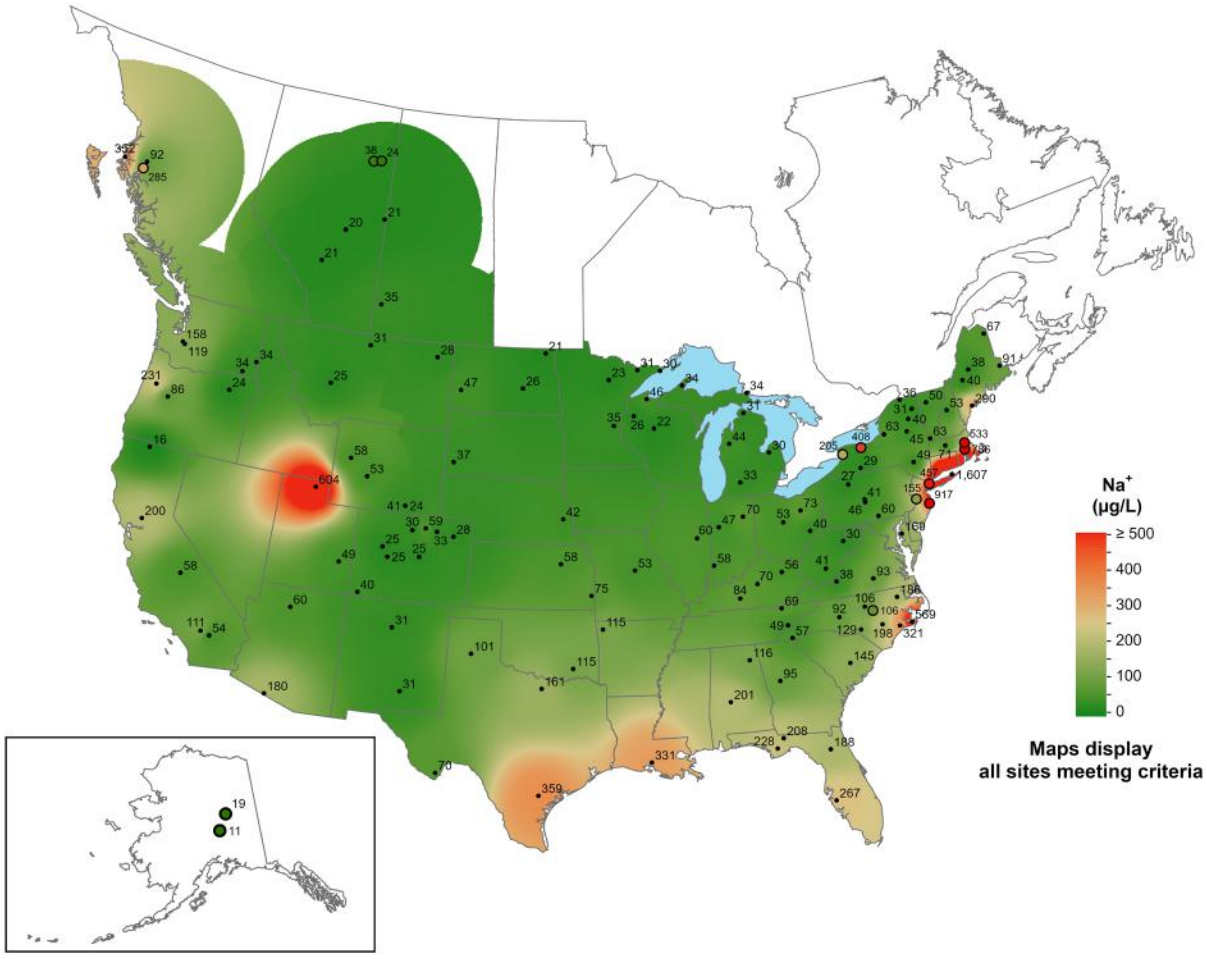
Magnesium ion wet deposition, 2025.



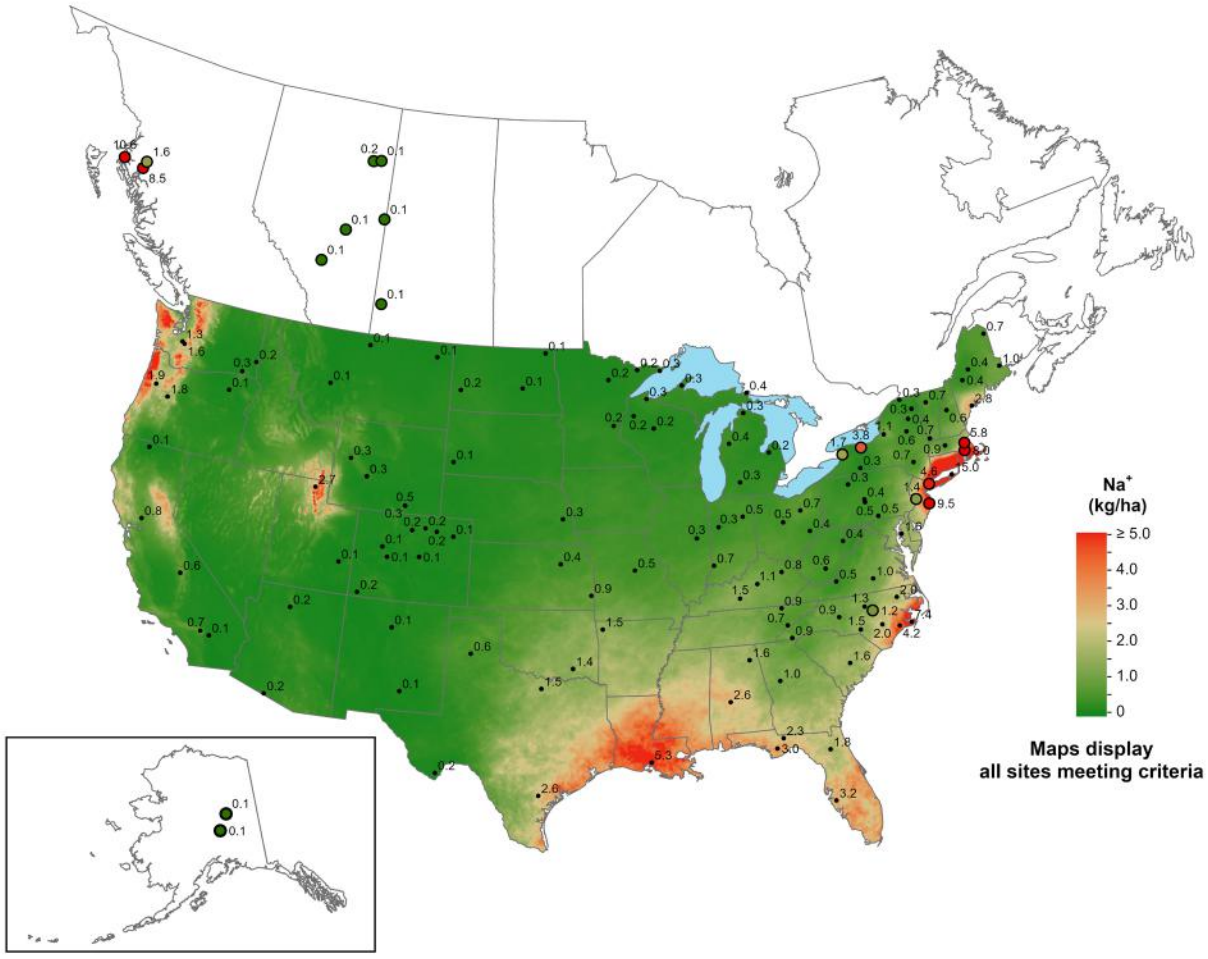
Chloride ion concentration, 2025.



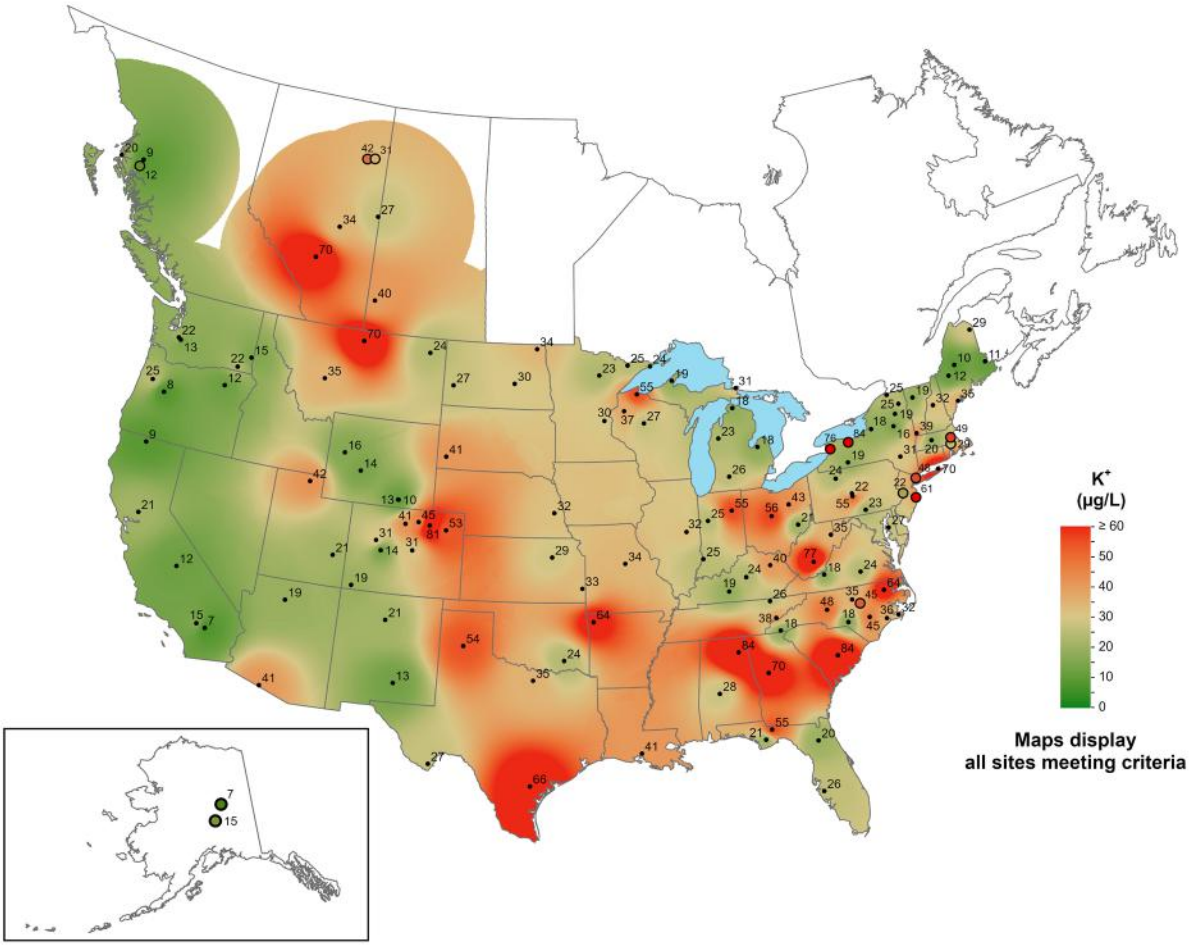
Chloride ion wet deposition, 2025.



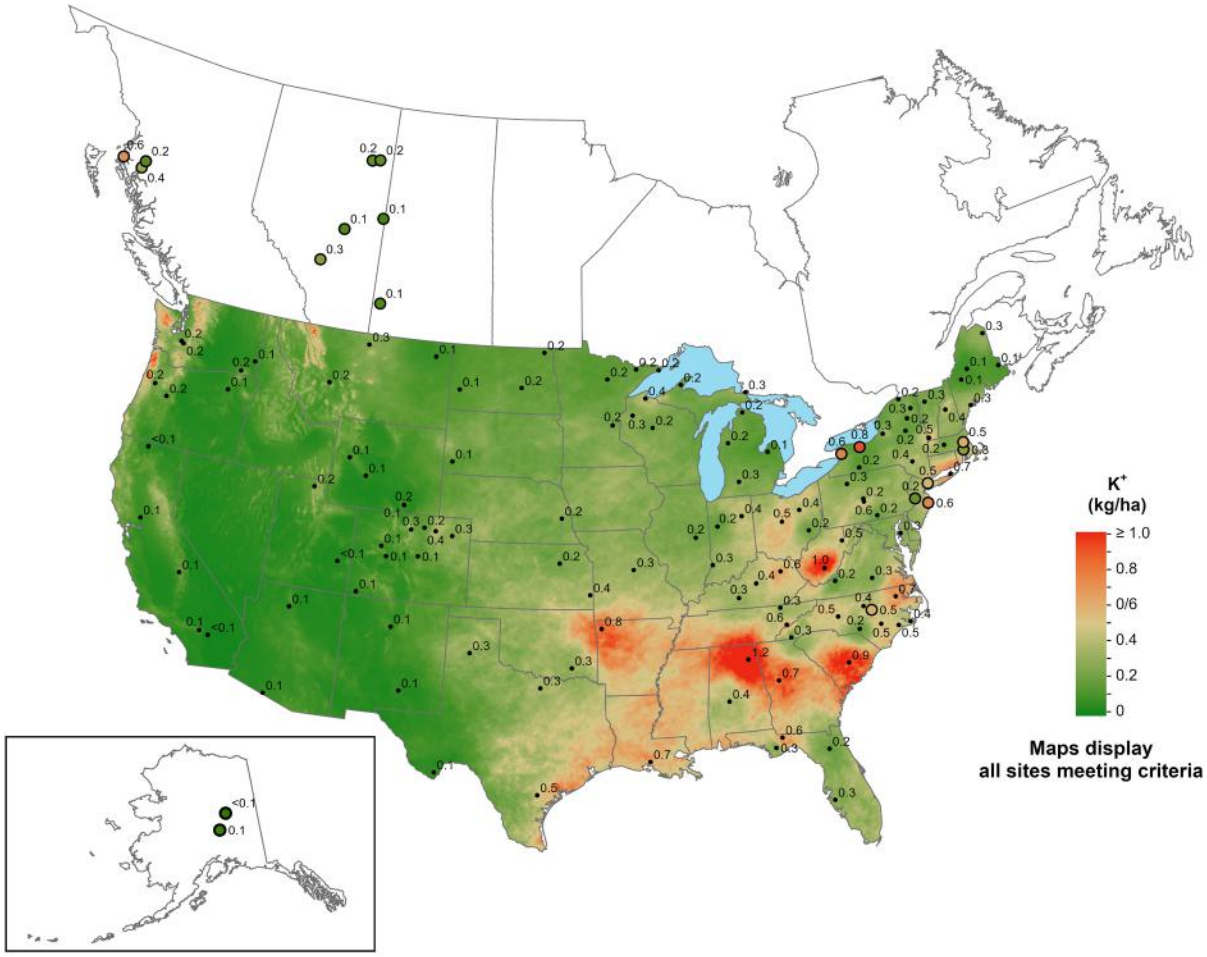
Sodium ion wet concentration, 2025.



Sodium ion wet deposition, 2025.



Potassium ion concentration, 2025.



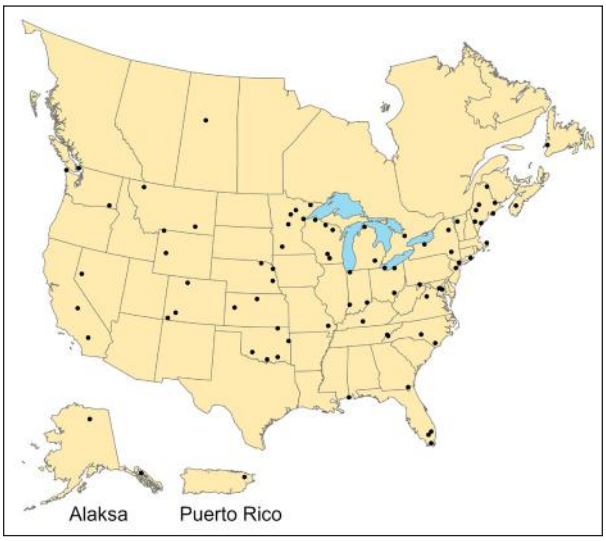
Potassium ion wet deposition, 2025.

Mercury Deposition Network (MDN)

The MDN is the only network providing a long-term record for the concentration of mercury (Hg) in precipitation in North America. MDN sites follow standard procedures and use approved precipitation collectors and precipitation gauges. The automated collector is similar to the NTN collector, but it is modified to optimally preserve mercury. Site operators collect samples every Tuesday morning. Starting in January 2025, the MDN began testing two-week collection at a handful of sites. Chemical analysis of the MDN samples is performed by the NAL.

All MDN samples are analyzed for total mercury concentration. The NADP reviews field and laboratory data for accuracy and completeness, and identifies samples that were mishandled, compromised by equipment failure, or grossly contaminated.

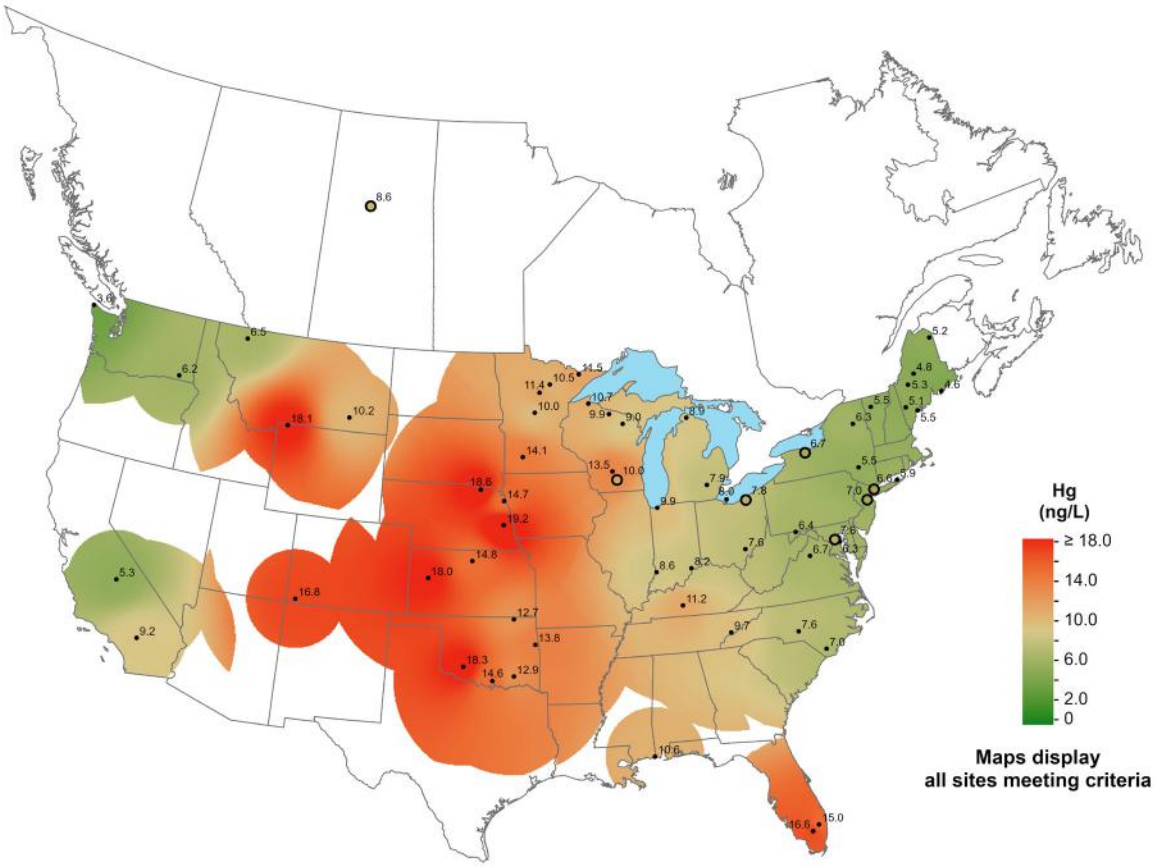
As of December 2025, there were 79 active MDN sites. Data from the MDN is available on the NADP website (http://nadp.slh.wisc.edu). Details about sample collection and analysis are available on the NADP website.



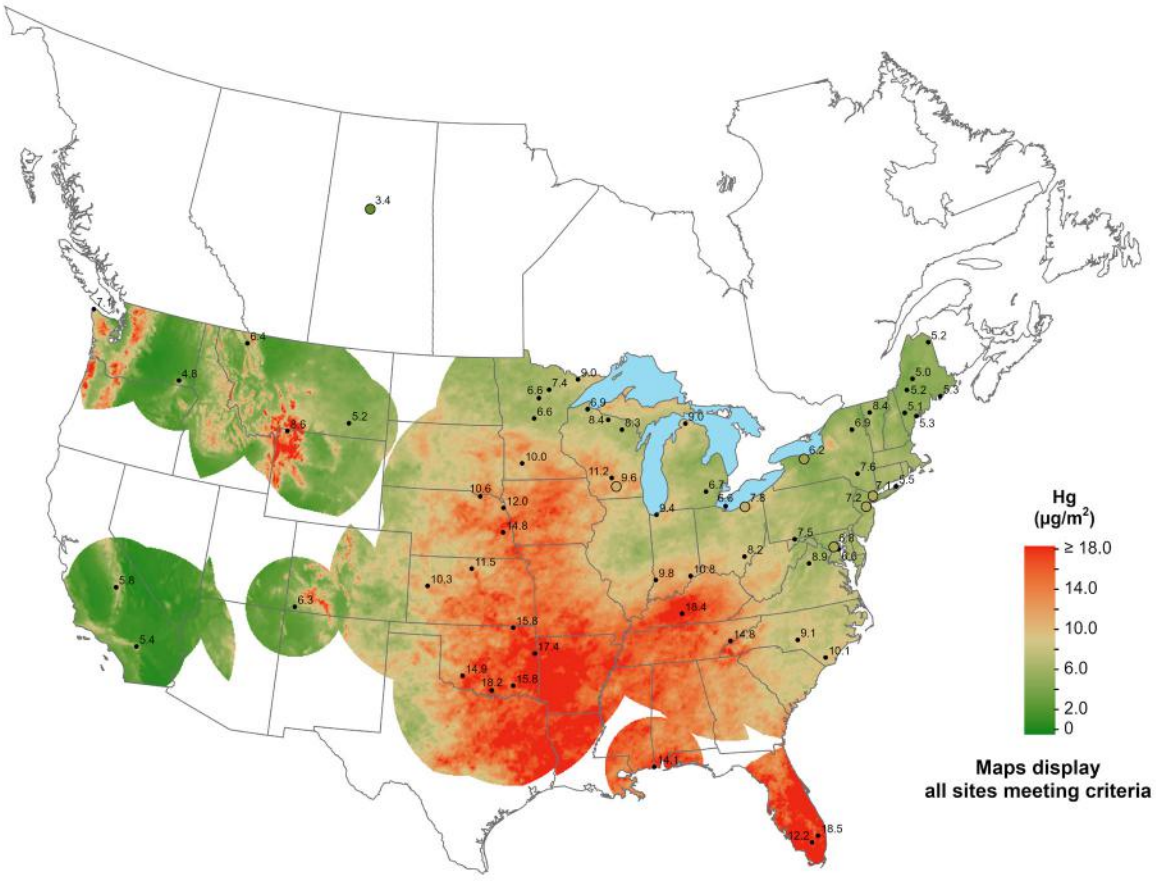
MDN Maps and Graphs

The maps on pages 33-34 show spatial variability in the precipitation-weighted mean concentration and wet deposition of total mercury across the United States.

Only sites meeting NADP completeness criteria are included. In 2025, 60 of 79 active sites met these criteria. Large variations in both mercury concentrations and wet-deposition are observed across the nation.



Total mercury concentration, 2025.



Total mercury wet deposition, 2025.

This page intentionally left blank.

Atmospheric Mercury Network (AMNet)

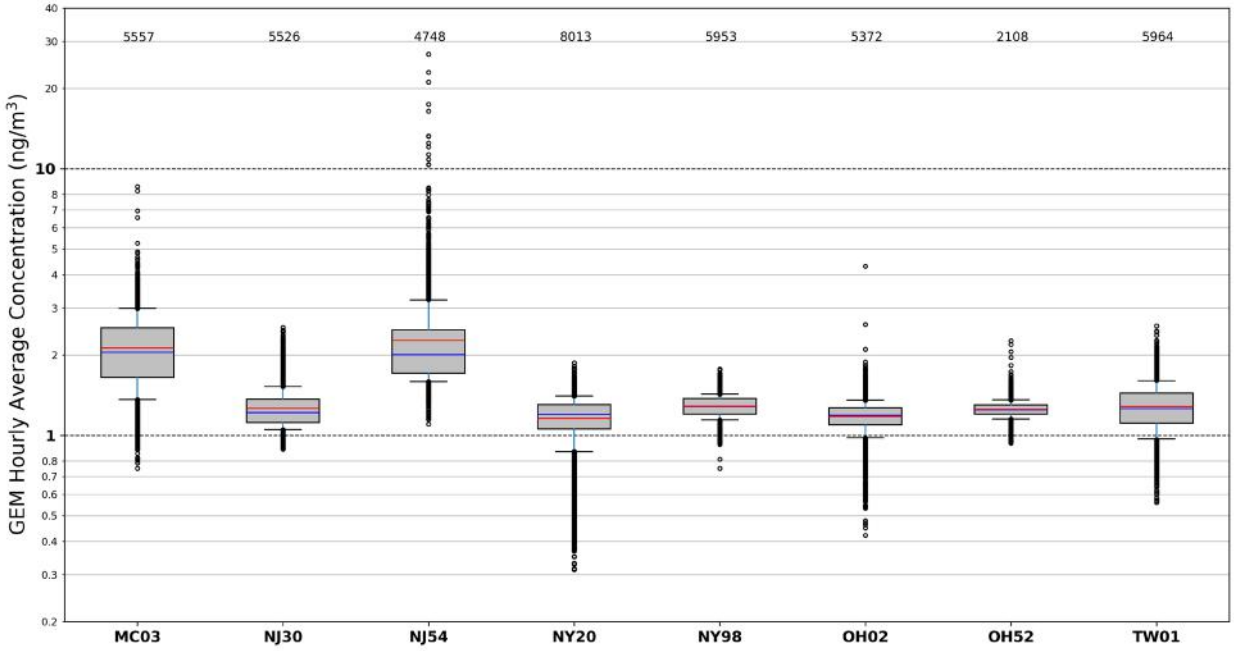
AMNet sites measure ambient atmospheric mercury using automated, continuous measurement systems in order to understand the impact of atmospheric mercury on deposition. Quality-assured measurements are made using NADP standardized methods.

AMNet measurements are made continuously (five minute and two-hour averages). Data is qualified and averaged to one-hour (gaseous elemental mercury, GEM) values. In May 2025, the Executive Committee voted to approve the discontinuation of AMNet speciation measurements due to known biases. Quality-assured measurements are made using NADP standardized methods. As of December 2025, there were 7 AMNet sites. Data from the AMNet are available on the NADP website (https://nadp.slh.wisc.edu).

The figure on page 37 shows the distribution of atmospheric mercury concentrations for each site. Hourly GEM concentrations are in ng/m^3 for each AMNet site. For each data set, the mean GEM value is indicated in red and median in blue.

Concentrations are plotted logarithmically, and with different scale ranges, to highlight the range of measured values for each site.





Hourly GEM concentration in ng/m3 for each AMNet site in 2025. Numerical values indicated across the top show the number of valid concentrations observed during the year. The mean is denoted in red, while the median is shown in blue.

Ammonia Monitoring Network (AMoN)

The AMoN measures atmospheric concentrations of ammonia (NH_3) gas. The network uses a passive diffusion-type sampler that provides cost-effective, accurate, and time-integrated measurements.

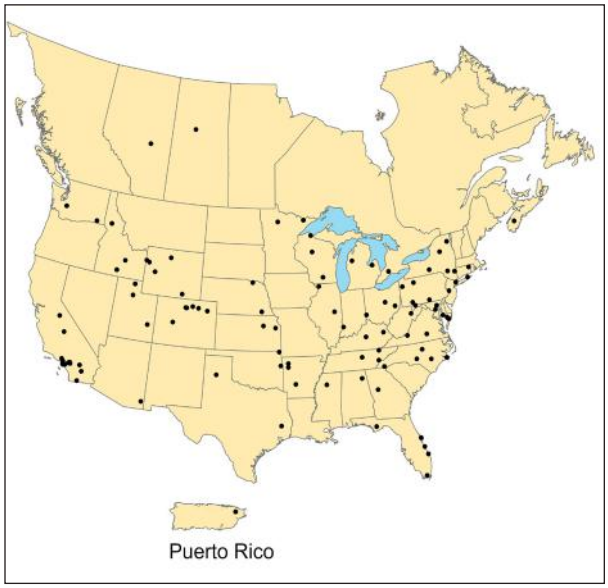
Sampling occurs over a two-week period, and all sites collect additional quality assurance samples on a rotating basis. This data is used to assess long-term NH_3 trends and changes in atmospheric chemistry, and to provide information for model development and verification.

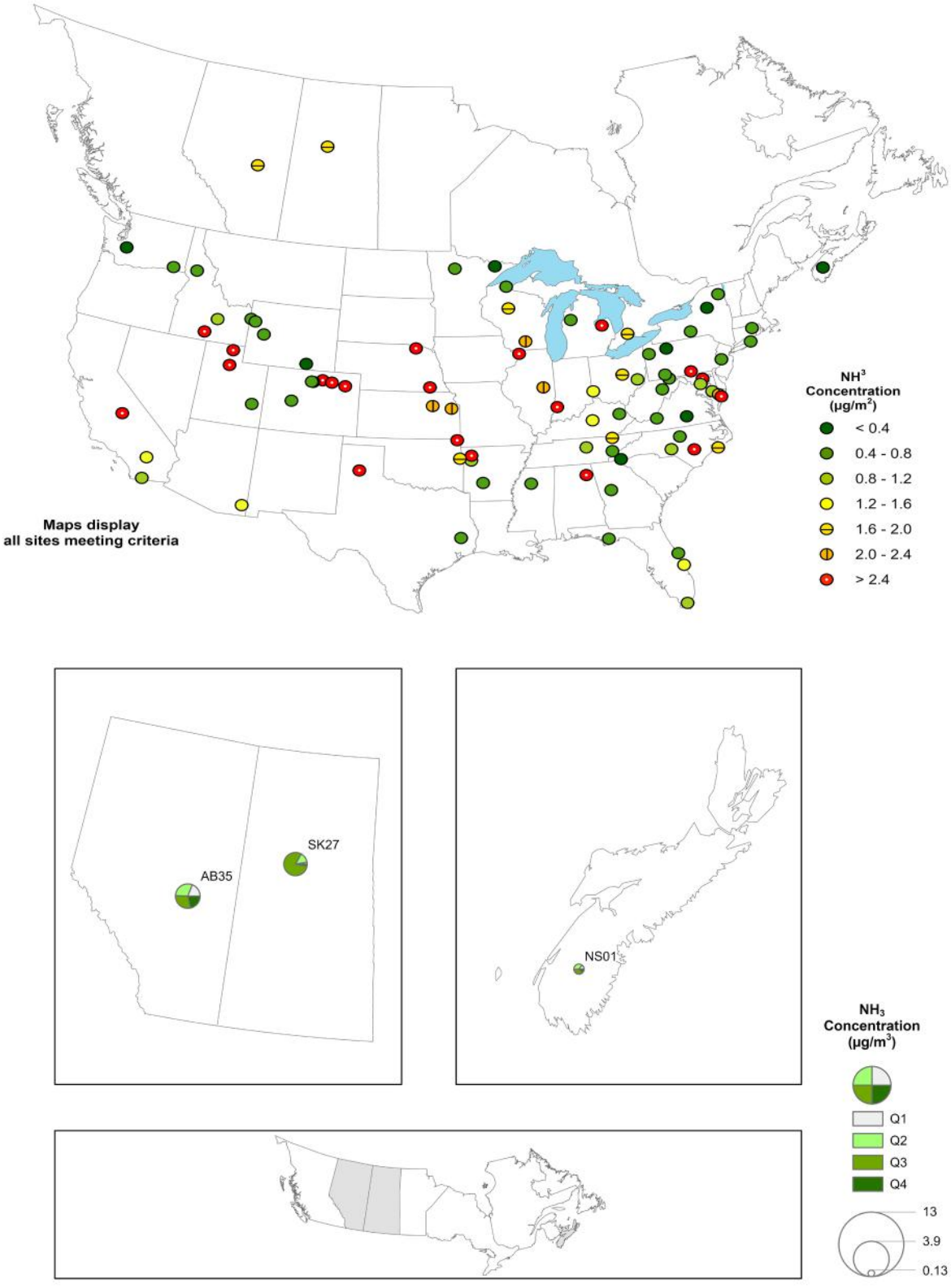
As of December 2025, there were 104 AMoN sites. Data from the AMoN are available on the NADP website (https://nadp.slh.wisc.edu).

The figures on pages 39-42 show the distribution and seasonality of gaseous ammonia concentrations for each site meeting completeness criteria. In 2025, 86 of 104 active AMoN sites met NADP completeness criteria.

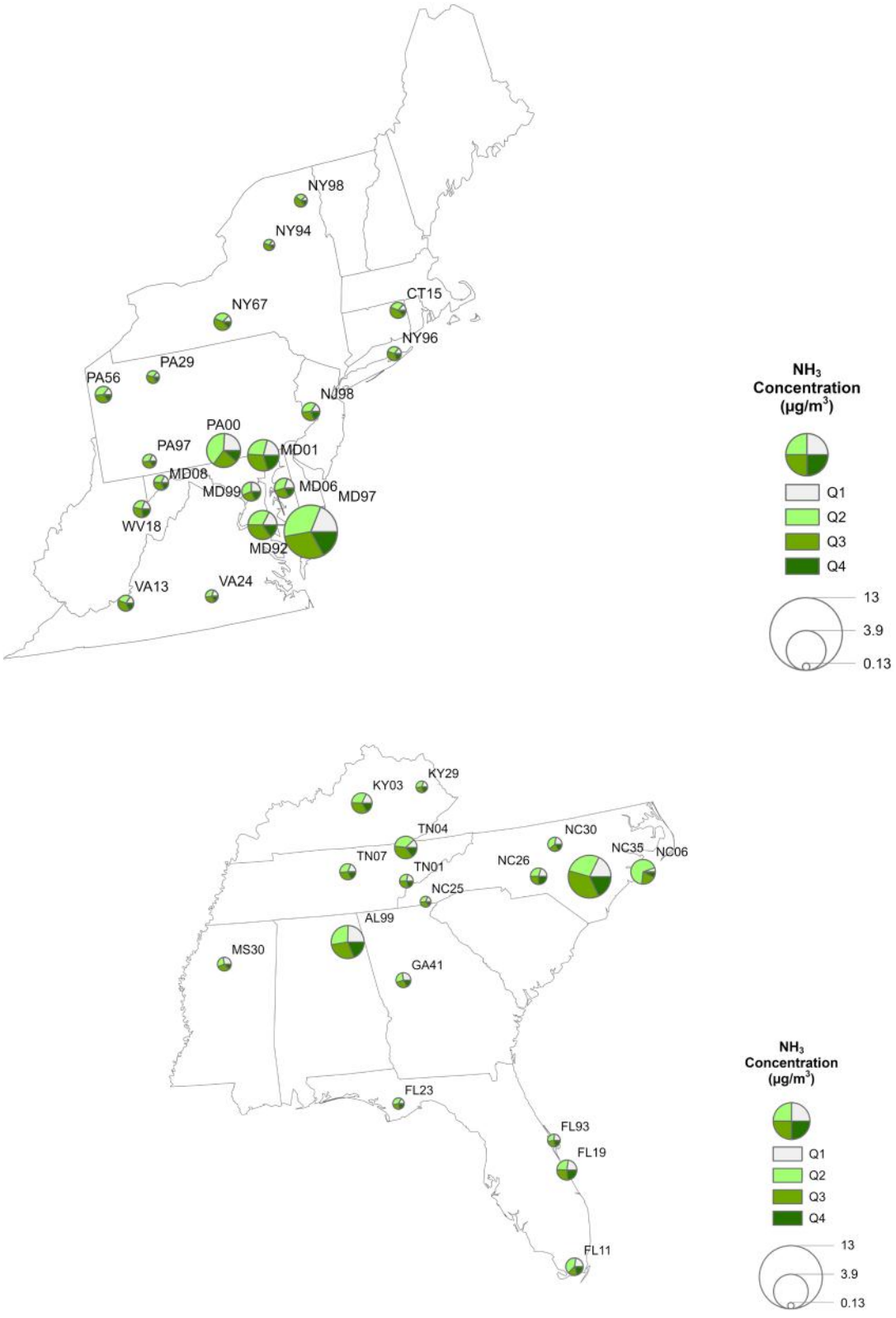
In the first figure, circles represent annual average concentrations in micrograms per cubic meter (µg/m^3) at each site. In the following figures, the relative concentration for each site is shown for each calendar quarter.

The size of the wedge is the relative percentage for the quarter. The area of the pie chart is proportional to the annual average for the site.

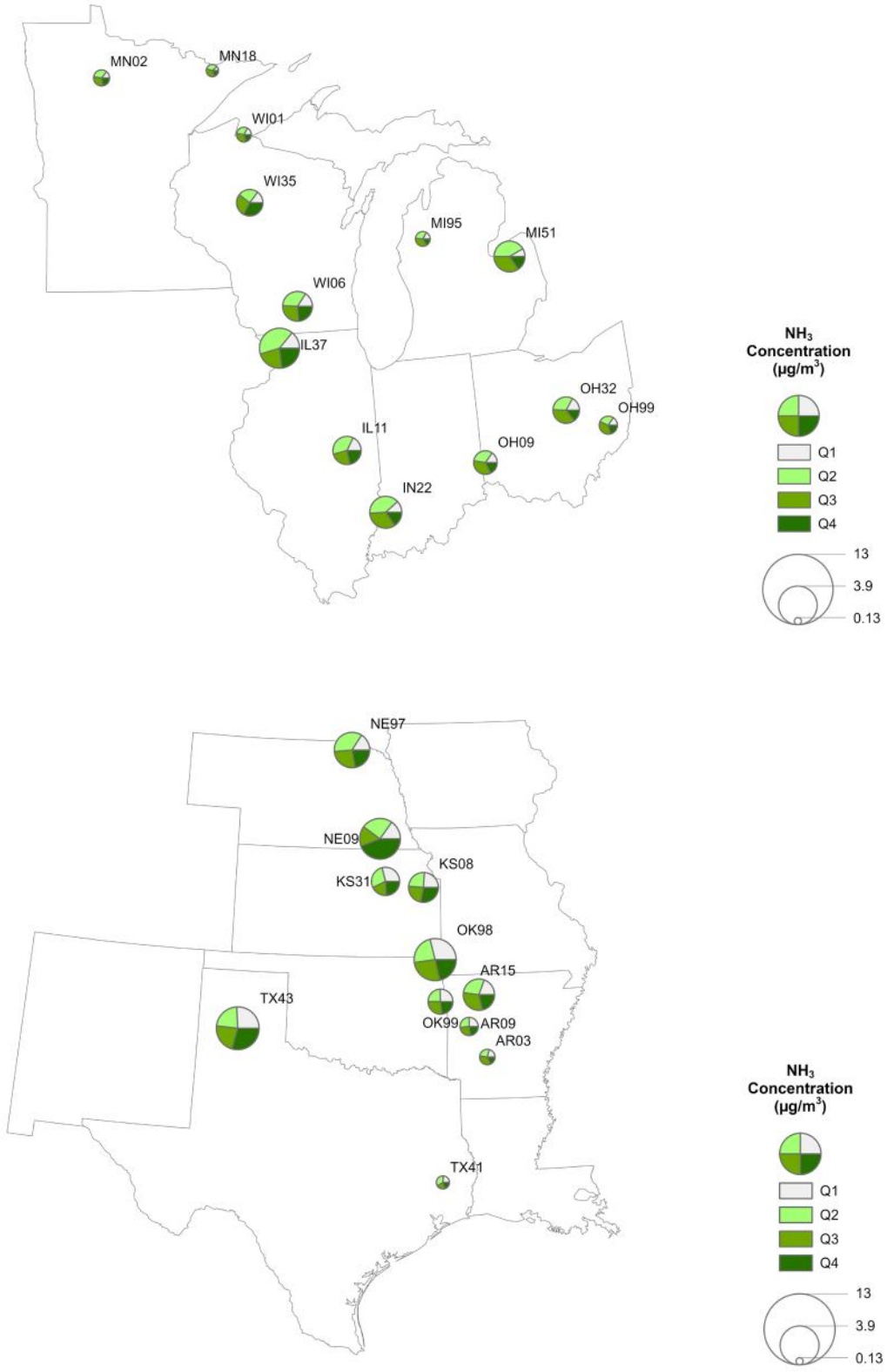




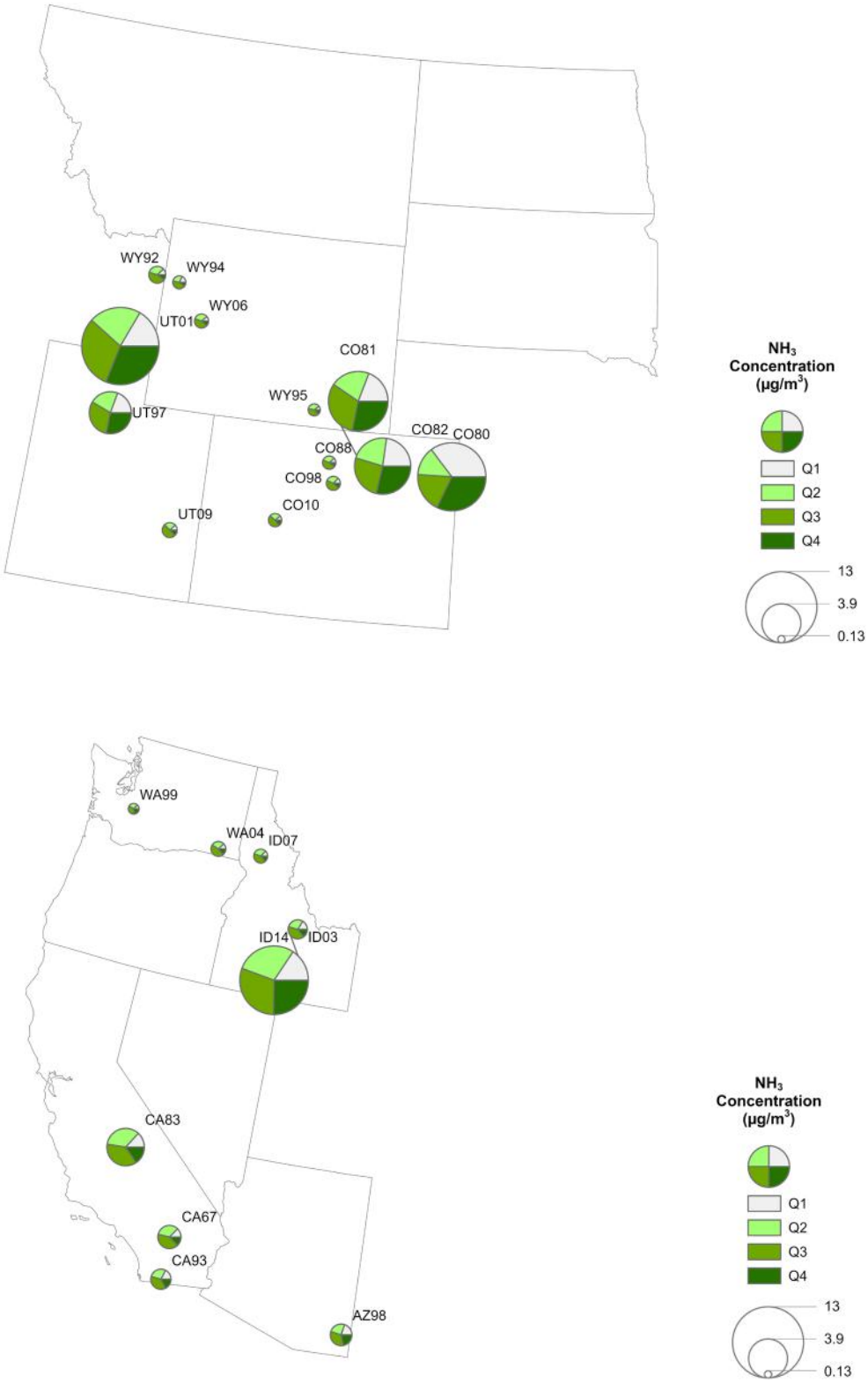
Average ammonia concentrations as measured by AMoN (first figure), and quarterly relative percentage (Q1 = January, February, March, etc.) for each AMoN site (in the subsequent figures), 2025. Size of the symbol in the bottom plot is relative to the annual concentration.



Quarterly relative percentage (Q1 = January, February, March, etc.) for each AMoN site (all figures), 2025. Size of the symbol in the bottom plot is relative to the annual concentration.



Quarterly relative percentage (Q1 = January, February, March, etc.) for each AMoN site (all figures), 2025. Size of the symbol in the bottom plot is relative to the annual concentration.



Quarterly relative percentage (Q1 = January, February, March, etc.) for each AMoN site (all figures), 2025. Size of the symbol in the bottom plot is relative to the annual concentration.

This page intentionally left blank.

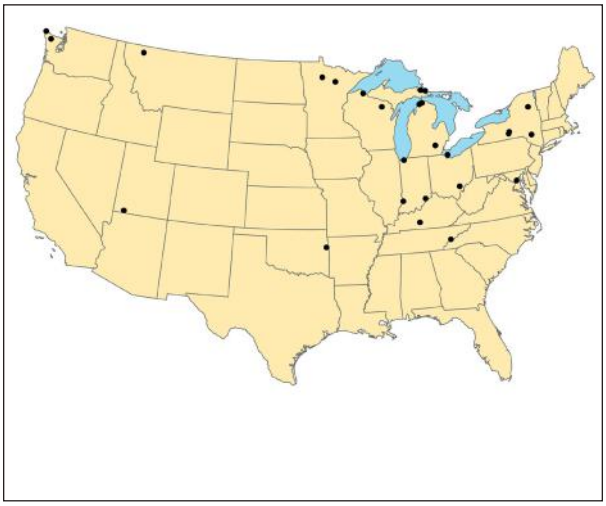
Mercury Litterfall Network (MLN)

MLN sites measure concentrations of total mercury found in plant biomass litterfall associated with a forest overstory (leaves, twigs, debris, etc.) that fall to the forest floor. The network uses four passive collection samplers per site. The collectors are placed on the ground in randomized locations each year to estimate the deposition of biomass and associated total mercury.

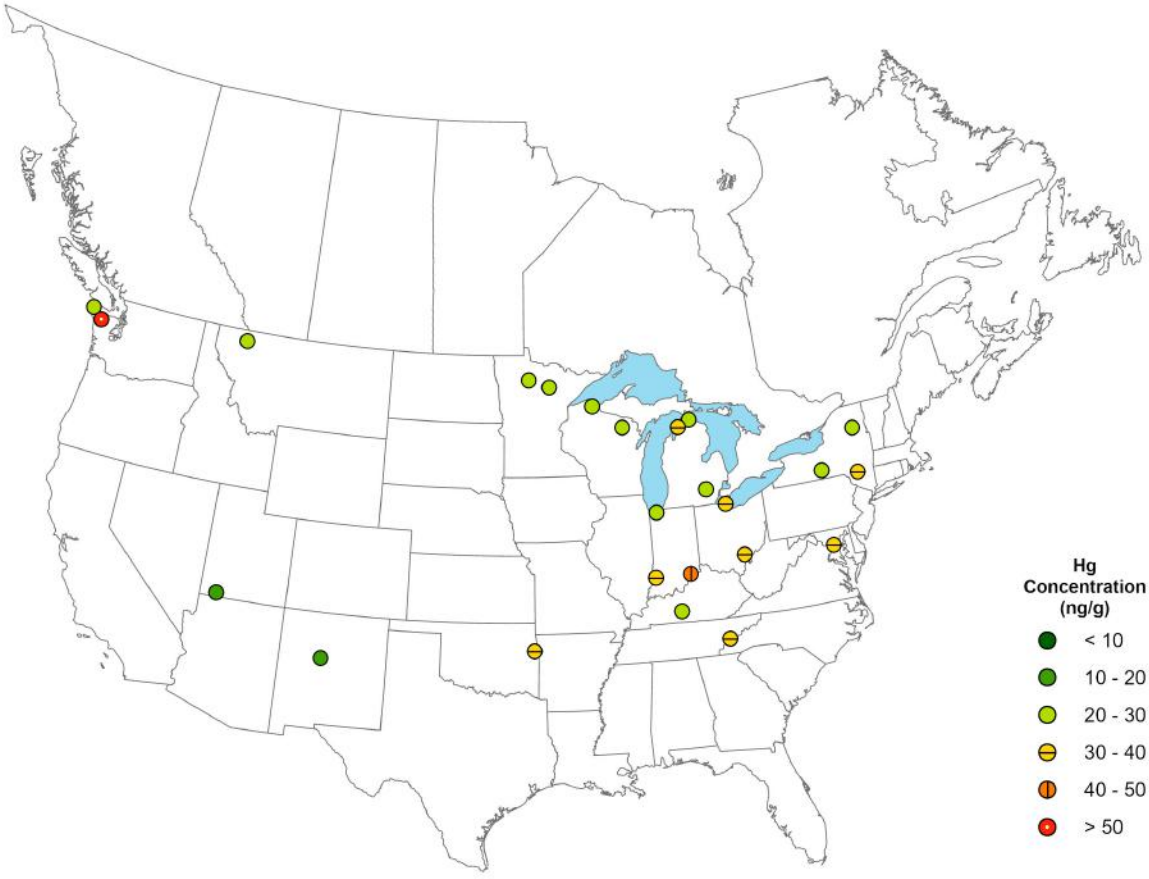
Sampling occurs over a several month period (generally September to December) with monthly biomass collections retrieved from each collector. These monthly collections are dried, composited by collector, and ground. Total mercury is measured in each of the four composites, and a weighted mean seasonal mercury concentration (ng Hg/gram biomass) is calculated. Using the seasonal mercury concentration and seasonal biomass deposition (g/m^2/season), a flux of mercury (µg Hg/m^2/season) to the forest floor is calculated.

This data is used to assess deposition in this manner, for further study and comparisons to traditional wet and dry deposition of mercury in MDN and other measures. These measurements can be used for trends over time, and to provide information for model development and verification.

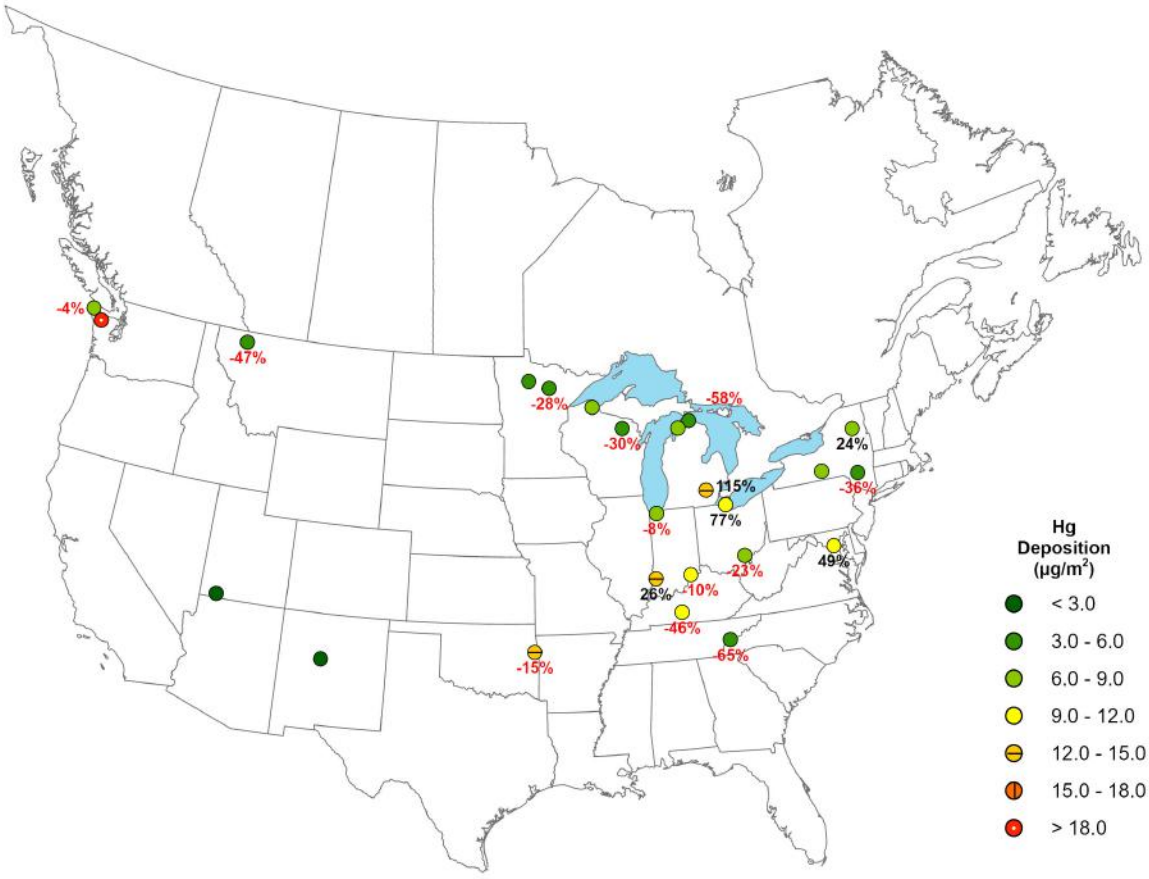
As of December 2025, there were 25 MLN sites. Data from the MLN are available on the NADP website (https://nadp.slh.wisc.edu).



The figures on page 45-46 show the total mercury concentration and deposition in biomass for the sampling season. The top figure shows the average concentration of total mercury per gram of biomass (ng Hg/g biomass) over the sampling season at each site. In the bottom figure, the total mercury deposition is shown as a function of the total biomass deposited at each site (µg Hg/m^2/season). The numerical value associated with each site is the percentage above (black, positive) or below (red, negative) total mercury deposition as compared to the wet deposition of total mercury at the same site.



Average total mercury concentration in biomass, 2025.



Average total mercury flux with biomass per season, 2025. Numerical values are percentages of mercury biomass flux more than (black) and less than (red) the colocated MDN wet deposition flux.

This page intentionally left blank.

National Atmospheric Deposition Program

The NADP is the 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 non-governmental organizations, universities, local and state government agencies, State Agricultural Experiment Stations, national laboratories, Native American organizations, Canadian government agencies, the U.S. Geological Survey, the U.S. Environmental Protection Agency, the National Park Service, the U.S. Fish & Wildlife Service, the U.S. Department of Agriculture - Forest Service, the U.S. Department of Agriculture - Agricultural Research Service, and the U.S. Department of Agriculture - National Institute of Food and Agriculture under agreement no. 2022-39133-38451. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the authors and should not be construed to represent any official USDA or U.S. Government determination or policy, the opinions of any of the program sponsors, or the University of Wisconsin-Madison.





http://nadp.slh.wisc.edu

Madison, WI: October 2026

All NADP data and information, including color contour maps in this publication, are available free of charge from the NADP website: https://nadp.slh.wisc.edu. Alternatively, contact: NADP Program Office, Wisconsin State Laboratory of Hygiene, 465 Henry Mall, Madison, WI 53706, Tel: (608) 263-9162, E-mail: nadp@slh.wisc.edu.

The NADP Program Office is located at the Wisconsin State Laboratory of Hygiene (WSLH), at the University of Wisconsin–Madison.