

# SAES-422 Multistate Research Activity Accomplishments Report

Project No. and Title: NRSP003, The National Atmospheric Deposition Program (NADP) –  
A Long-term Monitoring Program in Support of Research on the  
Effects of Atmospheric Chemical Deposition

Period Covered: 01-2008 through 12-2008

Date of Report: December 14, 2008

Meeting Dates: October 14 - 16, 2008

Participants: <http://nadp.sws.uiuc.edu/meetings/fall2008/minutes/tc2008.pdf>

Meeting Minutes: <http://nadp.sws.uiuc.edu/meetings/fall2008/minutes/tc2008.pdf>

## 1. Accomplishments:

The NRSP-3 provides a framework for cooperation among State Agricultural Experiment Stations (SAES) and governmental and nongovernmental organizations that support the National Atmospheric Deposition Program (NADP), which provides quality-assured data and information on the exposure of managed and natural ecosystems and cultural resources to acidic compounds, nutrients, base cations, and mercury in precipitation. NADP data support informed decisions on air quality issues related to precipitation chemistry.

Researchers use NADP data to investigate the impacts of atmospheric deposition on the productivity of managed and natural ecosystems; on the chemistry of estuarine, surface and ground waters; and on biodiversity in forests, shrubs, grasslands, deserts, and alpine vegetation. These research activities address the “environment, natural resources, and landscape stewardship,” one of the Experiment Station Section’s top five National Research Priorities. Researchers also use NADP Mercury Deposition Network (MDN) data to examine the role of atmospheric deposition in affecting the mercury content of fish, and to better understand the link between environmental and dietary mercury and human health, which fits another National Research Priority, “relationship of food to human health.”

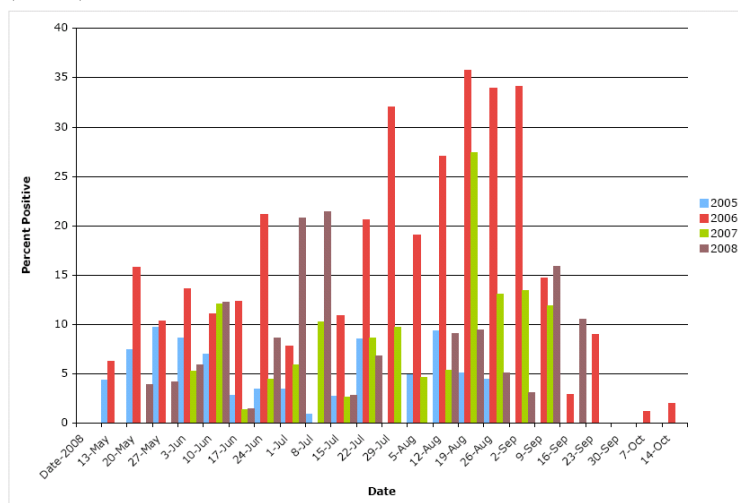
The NADP operates three precipitation chemistry networks: the National Trends Network (NTN), the Atmospheric Integrated Research Monitoring Network (AIRMoN), and the Mercury Deposition Network (MDN). At the end of December 2006, 252 NTN stations were collecting one-week precipitation samples in 48 states, Puerto Rico, the Virgin Islands, and Quebec Province, Canada. The NTN provides the only long-term nationwide record of wet deposition in the United States. Complementing the NTN are the 7-site AIRMoN and the 112-site MDN. Data from daily precipitation samples collected at AIRMoN sites support continued research of atmospheric transport and removal of air pollutants and development of computer simulations of these processes. The MDN offers the only regional

measurements of mercury in North American precipitation, and MDN data are used to quantify mercury deposition to water bodies that have fish and wildlife consumption advisories due to this toxic chemical. In 2008, every state and 10 Canadian provinces listed advisories warning people to limit fish consumption due to high mercury levels. Advisories also were issued for Atlantic Coastal waters from Maine to Rhode Island and North Carolina to Florida, for the entire U.S. Gulf Coast, and for Hawaii.

Our principal objective and accomplishment for this project is the collection and analysis of samples for precipitation chemistry. Briefly, the NADP has processed or is currently processing samples that should total 13,600 samples from the 250-site NTN, 1,200 samples from the 7-site AIRMoN, and 5,800 samples from the 110-site MDN.

**NADP Web Site.** Scientists, policymakers, educators, students, and others are encouraged to access data at no charge from the NADP Web site (<http://nadp.sws.uiuc.edu>). This site offers on-line retrieval of individual data points, seasonal and annual averages, trend plots, concentration and deposition maps, reports, manuals, and other data and information about the program. During FY2008, Web site usage continued to grow. There are now more than 37,850 registered users with 358,000 user sessions. This number of registered users is a significant increase over 2007. There were 25,500 data downloads from the site, a 5% increase. The site received more than 1.65 million hits, and 25,000 downloads of color concentration and deposition maps occurred. About 33% of users are from federal and state agencies, 33% from universities, 20% from K-to-12 schools, and the remainder from other organizations. The NADP Web site has registered users from more than 150 countries and from every continent except Antarctica. These statistics demonstrate that NADP continues to be relevant to the scientific and educational communities, and to attract new users.

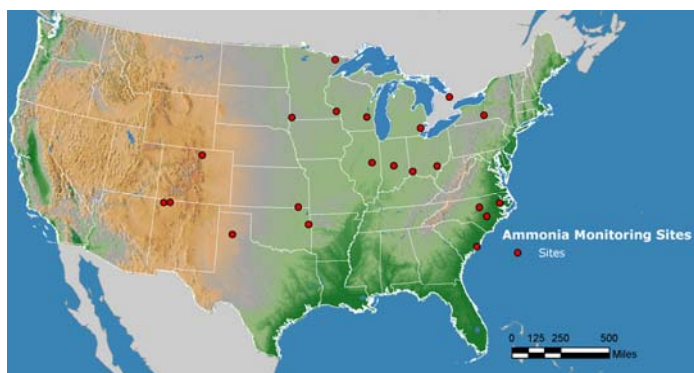
**Emerging Issues.** In November 2004 the USDA Animal and Plant Health Inspection Service issued the first report of *Phakopsora pachyrhizi*, commonly known as Asian Soybean Rust (ASR), in the continental United States. ASR is an obligate fungal parasite that can cause



significant losses in soybean and other leguminous crops. From infected plants, ASR spreads through the aerial release and dispersal of spores. These airborne spores can be scavenged in and below clouds and deposited by rain on uninfected host plants hundreds of kilometers from an existing infection. During the 2008 growing season, NADP again partnered with the USDA Cereal Disease Laboratory (CDL) to look for

ASR spores in NTN samples (4<sup>th</sup> year). With partial support from the Agricultural Research Service, weekly samples from 85 eastern U.S. NTN sites were filtered in entirety. Filters were desiccated, sealed, and sent to the CDL, where they were assayed for an ASR-specific DNA sequence. From mid-May through mid-September 2008, the CDL reported that of the 1226 assays, 99 (8.1%) were positive for ASR. Additionally, this year researchers were able to estimate spore deposition rate by week and site. These weekly rates range from a few spores to more than 250 spores per square meter at individual sites. The above graph shows frequency of ASR positives by week for the past four years. These data are being examined to study spore dispersal and the spread of ASR and show again the tremendous usefulness of these monitoring efforts for agricultural applications.

The presence of ammonia gas in the atmosphere and its association with agricultural operations has become a very important air quality topic. The NADP has initiated a new



monitoring network for ammonia gas across the Midwest. The goal is to develop, deploy, and operate a cost-efficient *passive* sampling network for basic ammonia gas concentrations. These two-week integrated values will be used to quantify the spatial and temporal differences in atmospheric ammonia concentrations. The network includes an appropriate quality-assurance program to

document the accuracy of passive samplers. Following NADP methods, the resulting quality-assured concentrations will be reported and made available for use by all. Currently, 21 sites have been operating during the 2008 calendar year, with plans for at least another year of operation. More information can be found at <http://nadpweb.sws.uiuc.edu/>.

Currently, the NADP measures ammonium and nitrate deposition, but not total N deposition. But other nitrogen compounds are present in precipitation. Particularly, organic nitrogen is thought to be as high as one-third of total N deposition. We have begun the basic analytical tests to determine this fraction in our samples. The method has been identified and the preparation completed. Adding this component to monitoring programs would be particularly important to the agricultural community since nitrogen deposition (organic or inorganic) is limited in agricultural systems, which can be sources of organic nitrogen.

**Educational/Extension Activities.** NADP staff participated in several outreach activities during the year. Among them included:

- Continued effort to assist authors and publishers to introduce NADP isopleth maps into new college textbooks. The latest chemical text is *Chemistry Matters* and its

associated study guide. It highlights the NTN acid deposition map for its discussion of how acid precipitation is formed and identifies the impacts of acid precipitation in North America.

- A teaching activity with a U of I statistics class (STAT 427). NADP provided project data and pertinent questions for the class to study and answer. NADP received answers for network improvement, and provided students with specific research questions and training in the scientific method using real data/situations. This is an ongoing relationship.
- Staff (Bowersox) served on the Feb. 2008 meeting of the Precipitation Chemistry Science Advisory Group, a World Meteorological Organization committee that coordinates efforts to gather precipitation chemistry data and provide guidance to countries needing assistance in improving their measurement programs.
- Staff served with the Tribal Air Monitoring Support Center to train American tribal nations to monitor their own environment (in this case, deposition monitoring). This outreach included steering committee membership, speaking engagements, and two different teaching appointments for training courses.

***Supporting informed decisions on air quality issues.*** In its most recent progress report, *Acid Rain and Related Programs, 2006 Progress Report*, the U.S. Environmental Protection Agency (USEPA) described the NADP networks as a critical link in the “chain of accountability” that allow policymakers to determine if required emission decreases (1990 Clean Air Act Amendments) have in fact reduced acidic deposition, which translates into ecosystem recovery. In its report, the USEPA used NTN data to demonstrate the efficacy of the Act in many different ways. The report compared average 1989-1991 and 2004-2006 sulfate and dissolved inorganic nitrogen (DIN) deposition in four eastern regions: Mid-Atlantic, Midwest, Northeast, and Southeast. Over this 15-year period, sulfate deposition decreased in all four regions, where averages ranged from 21 to 35% and were consistent with sulfur dioxide emission reductions at electric generating units targeted by the Act. Inorganic nitrogen deposition is also decreasing in the East with reduced emissions; average decreases are between 5 and 25%. These measurements are taken directly from NADP activities.

In its most recent report, *United States - Canada Air Quality Agreement, Progress Report 2006*, the binational Air Quality Committee used NADP data to evaluate progress under the agreement’s Acid Rain Annex. Since signing the agreement in 1991, U.S. and Canadian governments have acted to reduce acidic precipitation by requiring sulfur dioxide and nitrogen oxide emission reductions. With major reductions in both sulfate and nitrate deposition highlighted with NADP data, the report acknowledges that “without substantial atmospheric deposition monitoring networks, it would be impossible to accurately track and confirm that air quality improvements are taking place.”

In its 2004 report, *Air Quality Management in the United States*, the National Research Council (NRC) recommended “investigating the use of critical loads as a potential mechanism to address the need for alternative air quality standards to protect ecosystems. A critical load is the quantitative estimate of the exposure to one or more pollutants below which significant harmful effects on sensitive elements of the environment do not occur ....” The same was called for by a subsequent workshop (<http://nadp.sws.uiuc.edu/cladws>). This recommendation was acted upon by the NADP Executive Committee during 2006 by forming the NADP Critical Loads AD hoc committee (CLAD). The CLAD committee continues to meet in conjunction with other spring and fall NADP committee meetings and has a page on the NADP Web site for further information (<http://nadp.sws.uiuc.edu/clad/>).

### **Plans for 2009.**

***-Serving science and education.*** The NRSP-3 will continue to support researchers and educators by providing up-to-date, quality-assured data and information on nutrients, acidic compounds, base cations, and mercury in precipitation. Work is proceeding on an overhaul of the NADP Web site. The new site is currently about 50% completed with its redesigned organizational structure. The redesigned site will be better organized and feature ready-access to maps and tabular and graphical data summaries. The Program Office will continue to develop data products that target user needs.

A major equipment upgrade was begun during 2008 and will continue through 2009. Older raingages are being replaced with digital models. Over 75 of our 300 sites (25% of 3 networks) have purchased and converted to the new digital standard gages, and most sites should be converted by the end of 2009. This improvement will provide both enhanced and increased amounts of precipitation data for users for many years to come.

***- Supporting informed decisions on air quality issues.*** In 2005, the USEPA promulgated the Clean Air Interstate Rule, which seeks to lower fine particle and tropospheric ozone levels by reducing SO<sub>2</sub> and NO<sub>x</sub> emissions in 28 eastern states. Recent evidence suggests that gaseous ammonia also has an important and increasing role in fine particle formation. NADP/NTN and AIRMoN measure aqueous ammonium, but gaseous ammonia has not been measured routinely. During 2008, NADP initiated its pilot gaseous ammonia network (see above). These measurements will continue through 2009 at the current 20 sites, with hopes of increasing the number of monitoring sites and becoming a standing network within the NADP. *This network has numerous implications to agriculture, including directly addressing Challenge Area #2 in The Science Roadmap for Agriculture (Update 2006), and directly measuring an important agricultural gas in agricultural areas of the U.S.*

Although NADP/MDN data are used to evaluate the relationship between mercury emissions and wet deposition, there are no comparable airborne mercury measurements. Other estimates suggest mercury dry deposition levels may be three times that of wet

deposition in some areas. Recognizing the need for routine, regionally representative measurements, the NADP Executive Committee endorsed a limited study for measuring airborne elemental, reactive gaseous, and particle-bound mercury in 2007. This network is developing, and we expect a minimum of 15 sites will be operating during 2009.

*-Investigating emerging issues.* Along with the soybean rust, ammonia, and mercury ongoing new issue responses, we are partnering with several other researchers to investigate the presence of NADP samples (past and present) for new and different compounds, along with other topics. These include:

- Perchlorate compounds, Texas Tech. University;
- Oxygen isotope variation to predict past temperatures, University of Southern CA;
- Perfluorocompounds, Environment Canada;
- Fluoride concentrations, University of Texas;
- Base cation dilution and isotope hydrograph separation, University of Maine; and
- Unusual precipitation events in New Mexico and Arizona, West Texas S. U.

The NADP will run a small pilot network during 2009 to measure total nitrogen deposition, with a major goal of defining the organic nitrogen component. EPA will fund this work at a small, 50-site network. Sample collection should begin in the early spring of 2009. This may become another component of wet deposition data that NADP can provide to its agriculture and ecological scientists since total nitrogen deposition is important in many situations.

## **2. Impacts:**

1. During the 2008 growing season, Asian Soybean Rust (ASR) spores were found in a relatively large percentage of Midwestern NTN samples by applying nested polymerase-chain-reactions to amplify an ASR-specific DNA sequence to the point where it could be detected.
2. A modeling study of Gulf of Mexico hypoxia suggested that agriculture sources provide most of the N and P to the Gulf. Specifically, corn and soybean cultivation contributes 52%, with atmospheric deposition being the second most important source (16%). Phosphorus contributions are dominated by agricultural manure on pastures and rangelands. Data from 188 NADP sites back to 1980 were used to determine source relevance.
3. A mass balance approach with isotopic measurements was used to show that nitrate input to a Northeast forest is dominated by atmospheric deposition and this nitrate is used very efficiently. Nitrate flow into streams is principally microbial with less than 3% of atmospheric nitrate moving into streams unchanged, suggesting that almost all atmospheric nitrate is used in the system.

4. Butler and others used MDN data to identify decreasing mercury concentrations in precipitation over 8 years, correlating with decreasing emissions. Stronger relationships were found in the Northeast and Midwest, but few trends were found in the Southeast. Significant trends were on the order of 1.5 to 3% per year.

5. USDA Forest Service scientists evaluated different proposed management strategies (prescribed fire, etc.) within the Appalachian forests. Many forests were historically nitrogen-limited, but could be reaching “impending nitrogen saturation” due to current deposition increases and fire suppression nitrogen accumulation. If deposition trends continue at the current rate (NAPD defined), one should expect fewer management alternatives for these forests.

6. With large and continuing increases in nitrogen deposition over pre-industrial times, the authors report low chronic N increases leading to reduced species numbers (-17%) in a 23-year field experiment. Rates of species reduction were more pronounced with lower N additions, suggesting that the expected chronic, low-level deposition increases could be very important. With cessation of N addition, the number of species should recover.

7. Nitrogen deposition from southeast North Carolina confined animal feeding operations (CAFOs) has a very large impact on local areas. Their results followed NADP ammonium wet deposition patterns, and an emissions/deposition model suggested that much of the local ammonia emission is transported only a short distance before it is redeposited. Therefore, local ammonia sources have a large impact on the local nitrate deposition.

8. USDA Forest Service scientists developed a nutrient cycling model to predict sulfate deposition effects on wilderness areas, specifically studying North Carolina forests with current NADP depositions. Results suggest that these wilderness areas are stressed by acidic deposition and aluminum, and that the forests had little sulfate retention in the soils; however, these forests could slowly recover with reduced acidic input (multiple decades).

9. USGS scientists compared trends in wet deposition (16 NADP sites) to snow pack trends (54 sites) in the Rocky Mountains over 11 years. The authors found particularly important increasing trends in ammonium and nitrate concentrations and depositions for the central/southern Rockies snowpack, but the opposite for wet sites. This suggested dry depositional differences between the datasets. Sulfate trends were decreasing in all data.

10. Krupa and others investigated uncertainties in emissions of agriculturally emitted gases, focusing on nitrogen species and other semi-volatile organic compounds. The authors gather information about atmospheric ammonia and nitrate emission trends from NADP wet deposition measurements since no routine atmospheric measurements are not made.

11. Trends in agricultural emissions and precipitation ammonium from 59 NTN sites were compared in North Carolina where ammonia atmospheric concentrations were not increasing as quickly after a swine population moratorium was established. In the Midwest, inconsistently increasing ammonium depositions vs. emissions were seen.

12. The authors estimated total deposition of nitrogen (wet, dry organic, dry inorganic) to a forested ecosystem in North Carolina, and suggested that wet deposition (as measured at NTN sites) was about 45% of total deposition.

13. The authors investigated forest health for North America, and determined that nitrogen and sulfate deposition was an important contributor to local conditions. NADP data for North America is used throughout the report. The authors also show critical loading exceedances in Canada for N and S deposition.

14. The authors used a mass balance approach to transboundary movement of S and N. They concluded that eastern U.S. emissions are responsible for 55 to 80% of wet sulfate and nitrate deposition in Eastern Canada and that any future reductions in eastern Canada deposition will depend upon U.S. emission reductions.

15. Investigators modeled dry deposition rates of ammonia from NC swine production, and determined total N deposition with NTN-based wet deposition. Dry deposition rates are approximately 3.5 times that of wet deposition within 500 meters of production facilities, but drop off rapidly.

16. The authors use modeling to show the transport and fate of local ammonia emissions, and compared their results to the NADP data to determine the accuracy in time and space for their predictions of both precipitation and deposition.

### **Publications:**

There were more than 124 publications using NADP data or resulting from NRSP-3 activities in 2008 (excluding December). A publically available on-line database that lists citations using NADP data is accessible at <http://nadp.sws.uiuc.edu/lib/bibsearch.asp>.

Selected journal articles referenced above:

Alexander, R.B., Smith, R.A., Schwarz, G.E., Boyer, E.W., Nolan, J.V., and Brakebill, J.W. 2008. Differences in phosphorus and nitrogen delivery to the Gulf of Mexico from the Mississippi river basin. Environ. Sci. Technol. 42:822–830, DOI: 10.1021/es0716103.



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- Wu, S., Krishnan, S., Zhang, Y., and Aneja, V. 2008. Modeling atmospheric transport and fate of ammonia in North Carolina—Part I: Evaluation of meteorological and chemical predictions. *Atmospheric Environment* 42:3419-3436.