Basic Information

- **Project No. and Title:** NRSP3 : The National Atmospheric Deposition Program (NADP)
- **Period Covered:** 11/01/2021 to 10/31/2022
- **Date of Report:** 01/05/2023
- **Annual Meeting Dates:** 11/14/2022 to 11/18/2022

Participants

An attendee listing for our Fall Meeting and Science Symposium (FY22) is available at our meetings page (https://nadp.slh.wisc.edu/conferences/). The fall meeting had 169 registered participants for this hybrid meeting.

Brief Summary of Minutes of Annual Meeting

The NADP is comprised of a technical committee (all participants), an executive committee, several scientific committees, and a series of subcommittees focusing on specific areas of the ongoing project, including operations, quality assurance, critical loads and total deposition, outreach, and data management. All approved meeting minutes from our FY19 Spring and FY2019 Fall Meetings (and all other meetings) are available on the website (http://nadp.slh.wisc.edu/committees/minutes.aspx). Posting of committee minutes is controlled by each committee chair; some subcommittee minutes may be delayed for approval.

Part 1: In 2-3 sentences, briefly describe the issue or problem that your project addresses.

Atmospheric chemical constituents or air pollutants are continually being transferred from the atmosphere to the managed and natural ecosystems at the earth's surface through both wet and dry deposition.

Many of these pollutants are transferred in amounts large enough to change the ecosystem that they are deposited into, and result in significant problems such as acidic precipitation, nitrogen fertilization and changing species composition, eutrophication of waters (algal growth and low oxygen), etc.

The National Research Support Project – No. 3 (NRSP3) provides a framework for cooperation among State Agricultural Experiment Stations (SAES), the U.S. Department of Agriculture-National Institute of Food and Agriculture, and other cooperating governmental and non-governmental organizations to measure and monitor these transfers of chemical pollutants, and share the data with research scientists and policy professionals.

Specifically, researchers use NADP data to investigate the impacts of atmospheric deposition on the productivity of managed and natural ecosystems; the chemistry of estuarine, surface, and ground waters; and the biodiversity in forests, shrubs, grasslands, deserts, and alpine vegetation.

Part 2: Briefly describe in non-technical terms how your major activities helped you achieve, or make significant progress toward, the goals and objectives described in your non-technical summary.

As of September 2022, NADP supported sample collection in almost all of the US States, Puerto Rico, the Virgin Islands, several Canadian sites, a new site in Bermuda (Sept 22) and conducted scientific outreach and monitoring support in Mexico and Southeast Asia. Operational sites included 259 NTN, 80 MDN, 16 AMNet, and 102 AMoN locations across North America. Currently, 48 NTN sites are operated by and located on SAES areas (sites specific for this report). In addition, there are quality assurance and testing sites in Colorado and Wisconsin (SAES).

The NTN provides the only long-term nationwide record of base ion wet deposition in the U.S. Sample analysis includes free acidity (H+ as pH), specific conductance, and concentration measurements for calcium, magnesium, sodium, potassium, sulfate, nitrate, chloride, and ammonium. NADP also measures orthophosphate ions in the inorganic form, but for quality assurance purposes. The MDN offers the only long-term and routine measurements of mercury in North American precipitation. These measurements are used to quantify mercury flux primarily to water bodies.

The NADP operates two gaseous atmospheric chemistry networks: the Atmospheric Mercury Network (AMNet) and the Ammonia Monitoring Network (AMoN). The goal of these networks is to provide atmospheric concentrations of mercury and ammonia, respectively, to estimate the rate of dry deposition (without precipitation), and to support the measurements required to understand atmospheric chemical processing and total deposition of nutrients and pollutants. Fourteen AMNet sites were collecting five-minute measurements of gaseous elemental mercury and (for a subset of sites) twohourly average concentrations of gaseous oxidized mercury and particulate bound mercury. The AMoN measures two-week average concentrations of atmospheric ammonia using passive sample cartridges, at 102 sites. These data are particularly important to the agricultural community, since many sources of ammonia are related to agricultural processes and ammonia deposition contributes to the total nitrogen deposition.

During the performance period, all three NADP goals were met. Our major accomplishment was smooth and consistent operation of the monitoring networks. Operation, maintenance, management, quality assurance, and data distribution from these networks is the major outcome of this grant and project.

The principal NADP deliverable is the database of precipitation chemistry and deposition rates, along with atmospheric gaseous concentrations intended for the development of dry deposition fluxes. This database is available free to all users (https://nadp.slh.wisc.edu/networks/national-trends-network/, NTN data as example).

Principal Outcomes of the NADP for the project period include the following.

NADP Database and Samples Collected: NADP's principal output is the collection and analysis of precipitation and atmospheric chemistry samples obtained from network operations. The website (recently completely revamped) database offers online 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 and from the NADP measurements. The NTN database is now populated by 466,000 observations of precipitation chemistry for all sites and all years (an increase of 11,730 during the 9/1/21 to 8/31/22 period). Most of these samples are now online and available (delay due to QA system is normal).

As of Oct. 2022 (approximate values ending 9/30/2022), total reported analytical and qualified values consisted of 11,730 NTN samples, 3,850 MDN samples, and 3,240 AMON samples. Additionally, we also made 88 qualified mercury litterfall samples. Each NTN samples has ten separate analytes. All analytical results undergo an extensive quality assurance procedure prior to release to the public via the NADP website.

As of today, the 2021 calendar year data are complete, final, and online, and the 2022 data are posted generally through July, with final QA to be completed in the next few months (final data QA is completed after the full calendar year).

The NADP provides full technical support to data users and site operators. All program participants (supervisors, operators, funders) have direct access to technical experts at NADP via the web, email, and our toll free number (1-800-952-7353). Through this, we can address site operator's questions, offer technical expertise on data interpretation, and repair inoperable equipment. Hundreds of inquiries are answered each year.

Map Summary: The 2020 annual map series of atmospheric concentrations, wet deposition fluxes, and report was developed during fall of 2021 after all of the data and quality assurance checks were completed (https://nadp.slh.wisc.edu/pubs/Annual-Data-Summaries/). These individual maps are used widely and are one of the major network products. Individual maps are filed by network, year, and constituent, and can be downloaded individually (NTN, for example, https://nadp.slh.wisc.edu/maps-data/ntn-gradient-maps/). NADP printed 1500 copies of the Annual Summary (Oct 21), and has distributed many of these already, including to site operators and supporters, at scientific meetings and conferences, and for education and outreach activities. The 2022 Map Summary development will begin after the completion of the calendar year and all quality assurance of the data (approximately July 1, 2023).

Fall Scientific Symposium and Operational Meeting: The NADP hosted its second virtual Fall Meeting and Scientific Symposium over two separate weeks, beginning October 25-29 (science committees, Symposium), and then on November 1-2, 2021 (Technical committees). Meeting specifics, including agenda, proceedings, participants, etc. are all available (https://nadp.slh.wisc.edu/nadp2021/). During the multiple days, 266 attendees went to at least one session, and the majority of people attended the entire meeting. The meeting also included one keynote speaker (Dr. Delphine Farmer, Colorado State University - Masters of their fate: Revisiting atmospheric particle dry deposition and lifetime). The meeting was originally planned for Knoxville, TN (for a second year), but the live meeting was suspended due to COVID concerns.

The Spring 2022 NADP Business Meeting (Technical Committee, subcommittees, Executive Committee) was held in Madison, WI, on May 18-22, 2022, with limited live attendance (about 35), and most as a hybrid virtual meeting (another 40 or so). The basic committee meetings were all held (Technical, Operations, Outreach, Executive, and joint sessions), and included scientific subcommittee meetings. Meeting minutes by committee and subcommittees can be found at the subcommittee webpages, as approved (https://nadp.slh.wisc.edu/spring2022/).

The Summer Budget Meeting was hybrid meeting on Wednesday – Thursday Aug. 3-4, 2022. Approximately 25 members were in attendance, with several others attending digitally. Standard budget review occurred of the 2021 and to-date 2022 expenses, and current year incoming spending and expenses/budget.

The NADP supported 183 journal and report publications during the 2022 calendar year (our research support role and goals). The full list of publications can be found here (https://nadp.slh.wisc.edu/pubs/nadp-bibliography/), and a few examples of more agriculturally-related publications from both 2021 and 2022 in the publications section.

Additional Notable Outcomes include the ongoing testing of total nitrogen and total phosphorus in NTN samples. Also, the NADP is working with a WSLH laboratory to measure Per- and Polyfluoroalkyl Substances (PFAS) compounds in precipitation. PFAS is also of interest to agricultural scientists, given that at least one paper has shown uptake of PFAS compounds in cover crops and vegetables (Ghisi et al, 2019 Environmental Research 169: 326-341).

Part 3: Briefly describe how your target audience benefited from your project's activities.

NADP samples are collected to support research of atmospheric transport, ecosystem impacts, spatial and temporal trends, any air pollution mitigation, development of computer simulations, and for community/educational outreach. With NADP's NRSP designation, publications that use our data are the best example that our target audience (researchers) is benefiting from our project.

NADP tracks the number of publications for each calendar year that use NADP data. During CY2021, we found 223 publications (almost all refereed articles) that used NADP data in some important way (our objective). During CY2022, we found 183 publications. The complete list of articles using NADP data is here: https://nadp.slh.wisc.edu/pubs/nadp-bibliography/.

The following are a subset of 2021 and 2022 journal articles using NADP data that should be of particular interest to agricultural researchers.

1. Hu, C., Griffis, Frie, Baker, Wood, Millet, ... & Czarnetzki, 2021. A multiyear constraint on ammonia emissions and deposition within the US corn belt. Geophysical Research Letters 48(6): e2020GL090865.

Ammonia in the atmosphere and its impact on air quality and the environment have become areas for intensive research, and this is particularly true in the US Midwest. These authors used ground-based ammonia observations in the Corn Belt to determine the accuracy of current atmospheric models (WRF-Chem) and the National Emissions Inventory, and to determine methods to make model improvements. They concluded that peak NH3 emission (May to July) were much higher than emissions were thought, that the emissions were consistent year to year, and that much of the ammonia from the region was dry deposited in the region.

USDA ARS scientists and SAES scientists used the NADP's AMON network bi-weekly data from 6 regional sites over 3 project years for comparison to the model.

2. Mississippi State University Extension, 2021. "Sulfur Nutrition for Mississippi Crops and Soils". Publication Number: P3669, http://extension.msstate.edu/publications/sulfur-nutrition-for-mississippi-crops-and-soils.

This extension publication is addressed to farmers to convey new information about lower sulfur content in agricultural soils, due to a number of factors including the reduction of atmospheric sulfur deposition between 1998 and 2018. The article discusses the loss rates of Sulfur from soils annually for nine specific crops, briefly discusses basic soil chemistry of sulfur, provides signs of plant sulfur stress, recommends soils testing, and also discusses soil amendment options for crops.

Although not a research grade article, the MSU Extension used NADP sulfur maps from 1998 and 2018 as references to the significant reduction in atmospheric sulfur to the US.

3. Ren, D., Engel, Mercado, Guo, Liu, & Huang, 2021. Modeling and assessing water and nutrient balances in a tile-drained agricultural watershed in the US Corn Belt. Water Res. 210: 117976.

The authors are interested in the addition of nitrogen compounds from tile drainage systems in the U.S. Corn Belt, one of the leading sources of N and P to nutrient loading in the Gulf of Mexico. They use the SWAT (Soil and Water Assessment Tool) model to simulate N movement from surface corn/soybean rotation through tile drainage into a St. Joseph River Watershed (IN, MI, OH). SWAT was improved to consider additional N and P loss paths from the soil, was calibrated to monthly flow, and simulated a number of chemical and physical constituents from 2011 to 2019. The model performed fairly well for stream flow, suspended solids and evaporation, but only acceptably for nutrient loads and crop yields. Fertilizer was the main source of N and P. Tile drainage and surface runoff each contributed about 30% of total N lost to water. Phosphorus losses were mainly through surface runoff. These results suggest a strong agricultural impact to water quality in the Corn Belt.

The authors used the weekly NADP/NTN observations for both Nitrogen (nitrate, ammonium) and Phosphorus for the 11 years of the study for a nearby site, and the model could be used with all Midwest NADP sites.

4. Yang, Y., Liu, Zhang, Zhang, Xu, Liu, ... & Xie, 2021. Soil Nitrous Oxide Emissions by Atmospheric Nitrogen Deposition over Global Agricultural Systems. Env. Sci. & Tech. 55(8): 4420-4429.

Nitrous Oxide (N2O) is an important gas in the atmosphere (warming, ozone depletion), and soil emissions are an important atmospheric source of this gas. The authors modeled the effect of N deposition and climate change on soil N2O emissions. They concluded that N deposition is responsible for 25% of global cropland soil emission, and these emissions are increasing slowly over time.

The authors used NADP measurements of both nitrate and ammonium wet deposition in sites from both the US and Canada for 18 years as input to the model.

5. Zhang, J., Cao, & Lu, 2021. Half-Century History of Crop Nitrogen Budget in the Conterminous United States: Variations Over Time, Space and Crop Types. Global Biogeo. Cycles 35(10): e2020GB006876.

Crop nitrogen budgets are important to many aspects of agricultural research, and these authors used multiple datasets to examine N budgets for 8 major crops in the U.S. at county scale between 1970 and 2019. The authors concluded that N use efficiency has increased from 0.55 kg N/kg N in the 1970s to 0.65 kg N/kg N in the 2010s. Corn, rice, cotton, and sorghum have increased in effeciency, while barley, durum wheat, spring wheat, and winter wheat have decreased. The national N surplus was approximately 41%, and this value has declined in the last 10 years. The largest N surpluses are in corn and rice producing counties.

Iowa State University researchers used 16 years of national NTN nitrogen deposition data (maps in our total deposition form, all sites) to estimate total N deposition for every county in the US.

6. Bhattarai, A., Steinbeck, Grant, Kalcic, King, Smith, Xu, Deng, and Khanal, 2022. Development of a calibration approach using DNDC and PEST for improving estimates of management impacts on water and nutrient dynamics in an agricultural system. Env. Mod. & Software 157: 105494.

The authors (Ohio State, ARS) focused on a modeling study of the biogeochemical DeNitrification DeComposition (DNDC) model in an agriculture situation in Ohio. The goal was to test three model calibration approaches to determine which was best suited for agricultural use. They also tested the effectiveness of the PEST parameter estimation software. Manual calibration by experts performed the best during calibration period, but "sequential calibration had the best model performance during the validation period". Several model parameters were shown to be very influential, while corn yield was most sensitive to accumulative temperature and grain carbon to nitrogen ratio. The automated calibration procedure proved to produce a more efficient and robust approach to better management practices.

The researchers used repeated years (2014-2020) of NADP's weekly data from a NE Ohio site (IN41).

7. Waiker, P., Ulus, Tsui, and Rueppell, 2022. Mercury accumulation in honey bees trends upward with urbanization in the USA. Ag. & Env. Letters 7(2): e20083.

With this very interesting idea, the authors theorized and found that honeybee (Apis mellifera) mercury concentrations, in part, were explained by the urbanization of the landscape. In their small sample, they did find that honeybee concentrations tend to increase with urbanization, although the low sample numbers but without any statistical power. Suburban areas were between high urban and low rural areas. Methyl mercury (organic Hg form) was undetectable in the samples. The authors conclude that "urbanization may play a role in increasing Hg exposure to these pollinators", and honeybees could be a useful biomonitor for pollutants.

The authors used 7 NADP Mercury Deposition Network sites to associated mercury deposition to the concentrations in bees.

Part 4: Briefly describe how the broader public benefited from your project's activities.

Primarily, the public benefits from the scientific research that is conducted in part using our data. Our data is used in many different research projects primarily for environmental impacts. As these environmental issues are identified and understood through research, the changes made to alleviate these problems are a direct benefit to the broader public. A brief review of our publications list shows that our data is used towards many different research ends. Two examples are the impact of agricultural chemical/fertilizer use on the surrounding areas, and the impact upon agriculture lands from pollution deposition. These are typical types of data uses show examples of a direct impact upon the broader public.

NADP provides scientifically-sound measurements that many different government bodies (federal, state, local) can use to make more informed decisions. Many of our membership organizations (such as NOAA, National Park Service, Bureau of Land Management, etc.) use our data for their respective management practices on federal lands to help them make scientifically based policy decisions. For example, EPA's Office of Air uses our data to estimate the rate of sulfate removal from the atmosphere to help them track compliance with specific aspects of the Clean Air Act (acid rain issues). A second more recent example is that some agriculture extension services have begun to note that sulfate deposition has dropped so drastically over the past 40 years that some farmers need to consider adding sulfur as part of their fertilizer applications. Overall, better policy decisions by numerous agencies benefit the broader public.

Researchers use our samples and data to both identify environmental problems, and to track these issues for change over time. The public benefits from both the understanding of a problem and policy decisions meant to solve or alleviate the issue.

We provide our data, maps, trends and statistics to all users, beyond scientists and researchers. NADP provides data access and availability everyone at no charge from the NADP website, and all are welcome to use our data in any reasonable manner. The website offers online retrieval of all individual data points (weekly and biweekly), seasonal and annual averages, trend plots, concentration and deposition maps, reports, manuals, etc. Many different groups use our data (we track some information from downloads) including many different school districts for educational purpose, many college students and professors, environmentally related organizations, companies, and other organizations. One example is that educators often use our data for real-world scientific data for understanding environmental information and questions and for statistical applications.

Part 5: Comments (optional), Describe and explain any major changes or problems encountered in approach. Additionally, note opportunities for training and professional development provided, how results have been disseminated to communities of interest, and any new details regarding what the project or program plans to do during the next reporting period to accomplish the goals.

We have really had no major problems during the year with network operation, outside of the continuing issues presented by the pandemic, such as remote work, employee turnover, inflation, etc. However, during the COVID period, we only missed a few sample collections (about 6%) and this was mostly due to policies that did not allow people to enter federal lands/areas. Throughout, the NADP labs and Program Office continued to operate and had no work stoppage. Other than this, no major problems occurred out of the normal operational issues, so no major changes are planned in the next few years.

Distribution of data is free to all, and occurred normally. Distribution of the printed materials to other scientists and policy professionals that usually occurs at scientific meetings and talks was curtailed during the pandemic, but this is beginning to relent, as more post-COVID travel begins.

We are continually looking for new and valuable measurements that can be made with our samples, with little additional costs (efficiency of funding). The following areas continue to be tested.

a) NADP continued to collaborate with Utah State University scientists to develop methods to measure dry deposition accurately and correctly. This study continues to expand and will generate valuable dry deposition data, and perhaps expand the capabilities of the NADP to make dry deposition measurements directly (see Brahney, et al., 2020, A new sampler for the collection and retrieval of dry dust deposition, Aeolian Research, 45, 100600).

b) The NADP has begun a testing procedure to determine if we can accurately determine both total nitrogen and total phosphorus in our wet deposition samples from the NTN. With total N, our wet deposition nitrate and ammonium values will be subtracted, giving us a “measurement” of organic nitrogen compounds. The sampler will also be able to provide a total phosphorus deposition value, which is currently not reported (NTN measures orthophosphate only by request). With our past year’s progress, we have run into an issue with the TN measurement, due to low pH values in our samples.

During the next period, we hope to overcome this analytical limitation and bring a viable approach to the NADP for approval and use.

c) The NADP is working with a WSLH laboratory to evaluate whether Per- and Polyfluoroalkyl Substances (PFAS) compounds are found in precipitation. We are currently surveying precipitation at 12 sampling locations (increase of 4 since the last report) for these compounds, and find different compounds at detectible levels. This work will continue through the current year with expected publications coming soon. PFAS analysis is one option of future work identified within our Strategic Plan effort last year. PFAS is also of interest to agricultural scientist, given that one paper has shown uptake of PFAS compounds in cover crops and vegetables (Ghisi et al, 2019 Environmental Research V169 326-341).