### Basic Information

- **Project No. and Title:** NRSP_OLD_3 : The National Atmospheric Deposition Program (NADP)
- **Period Covered:** 03/16/2018 to 09/30/2018
- **Date of Report:** 01/04/2019
- **Annual Meeting Dates:** 11/05/2018 to 11/09/2018

### Participants

An attendee listing for our Fall Meeting and Science Symposium (FY18) is available at our meetings page (http://nadp.slh.wisc.edu/conf/). The fall meeting had 151 registered participants.

### Brief Summary of Minutes of Annual Meeting

# Meeting Minutes

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, ecological response and outreach, and data management. All approved meeting minutes from our FY18 Spring and FY2018 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, with some subcommittee minutes delayed for approval.

### Accomplishments

# Accomplishments

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 that support the National Atmospheric Deposition Program (NADP). The NADP 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 and through dry deposition of several of these compounds. NADP data support informed decisions on air quality and ecosystem impacts related to precipitation chemistry and wet and dry deposition.

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. These research activities address the mission of the NRSPs of “development of … support activities (e.g., collect, assemble, store, and distribute materials, resources and information)… to

accomplish high priority research". Researchers also use NADP Mercury networks and data to examine the effect of atmospheric deposition on the mercury content of fish, and to better understand the link between environmental and dietary mercury and human health. This fits with an agriculture research priority of food safety.

**Figure SAES particpating in NADP research activites.**

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). This report is specifically for the 48 NTN sites operated at the miscellaneous SAESs, and in part supported by this agreement. But, this report covers all of the accomplishments and impacts from all NADP networks.

The NTN provides the only long-term nationwide record of base ion wet deposition in the United States. Sample analysis includes free acidity ($H^+$ as pH), specific conductance, and concentration and deposition measurements for calcium, magnesium, sodium, potassium, sulfate, nitrate, chloride, bromide, and ammonium. NADP also measures orthophosphate ions ($PO_4^{3-}$, the inorganic form), but only for quality assurance as an indicator of sample contamination. At the end of September 2018, 264 NTN stations were collecting one-week precipitation samples in 48 states, Puerto Rico, the Virgin Islands, and Canada, and include the SAES sites shown in the map

above. Additionally, there are multiple quality assurance and testing sites located in Illinois, Colorado, and Wisconsin. Complementing the NTN is the 4-site AIRMoN, which are essentially NTN sites, operated on a daily basis (i.e., single precipitation events). Samples are collected to support continued research of atmospheric transport and removal of air pollutants and development of computer simulations of these processes.

The 99-site MDN offers the only long-term and routine measurements of mercury in North American precipitation. Measurements of total mercury concentration and deposition (and optional methyl-mercury) are used to quantify mercury deposition to water bodies, some of which have fish and wildlife mercury consumption advisories. Since 2008, every state and 10 Canadian provinces listed advisories warning people to limit fish consumption due to high mercury levels. Coastal advisories are also in place for Atlantic waters from Maine to Rhode Island, from North Carolina to Florida, for the entire U.S. Gulf Coast, and for coastal Hawaii and Alaska.

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. In many cases, dry deposition of the gas could far exceed the wet deposition of the same compound, thus, these are key parameters to understand ecosystem impacts.

At the end of September 2018, eighteen AMNet sites were collecting five-minute estimates of gaseous elemental mercury and (for a subset of sites) two-hourly average concentrations of gaseous oxidized mercury and particulate bound mercury. The AMNet provides the only long-term region-wide record of basic atmospheric mercury concentrations in the United States. The AMoN has 101 operating sites, where two-week averages of atmospheric ammonia gas are collected with passive gaseous sample cartridges. This low-cost network is designed to provide long-running estimates of ammonia in the atmosphere. These data are particularly important to agriculture, since many sources of ammonia are agricultural. In addition, gaseous ammonia deposition contributes to the total nitrogen deposition, an important parameter for understanding agricultural systems. Data from both gaseous networks support continued research of atmospheric transport and removal through dry deposition, and development of computer models of these processes.

Within this NRSP, there are three stated goals: 1) management and coordination of the five NADP monitoring networks; 2) site support, chemical analysis, data validation, and data reporting for network sites directly supported by this agreement; and 3) quality assurance and quality control activities to ensure consistent operation and standard operational procedures. During this annual period, all three of our goals were met.

The major accomplishment of the NADP is the operation of the five monitoring networks. Operation, maintenance, management, quality assurance, and data distribution from these networks is the major outcome of this grant and project. Network specifics are listed below.

The principal output or deliverable from the NADP's five networks is the database of precipitation chemistry and deposition rates, along with atmospheric gaseous concentrations intended for the development of dry deposition fluxes (AMoN, AMNet). The wet deposition database has nearly 550,000 NTN, MDN, and AIRMoN observations available for download.

**Short-term Outcomes and Outputs**

***Samples Collected:*** NADP's principal objective and accomplishment/outcome is the collection, analysis quality assurance review, and reporting of precipitation chemistry for sites located throughout North America. In 2018, there were 13,525 precipitation samples collected and analyzed in the NTN (not including QA samples), for the 264 network sites. Analyses included, quantification of free acidity ($H^+$ as pH), specific conductance, calcium ($Ca^{2+}$), magnesium ($Mg^{2+}$), sodium ($Na^+$), potassium ($K^+$), sulfate ($SO_4^{=}$), nitrate ($NO_3^-$), chloride ($Cl^-$), bromide ($Br^-$), ammonium ($NH_4^+$) and inorganic orthophosphate ($PO_4^{3-}$ for quality assurance purposes) ion concentrations and precipitation volume. Results are reported as mass concentrations and wet deposition flux for each analyte. A total of 829 precipitation samples from the AIRMoN were analyzed for the same analytes. The AMoN quantified 2,682 gaseous ammonia samples and the MDN quantified 5,042 total mercury samples. The AMNet measured approximately 68,044 hourly and two-hourly ambient mercury fraction concentrations. All data are available on the NADP website, and were summarized in annual maps and figures.

***Major Activity:*** Our principal output is the collection and analysis of precipitation chemistry and atmospheric chemistry samples obtained from network operations. In 2018, total reported analytical values consisted of 135,250 NTN analytes, over 5050 MDN analytes, 8290 AIRMoN analytes, 2682 AMoN analytes, and 68,044 AMNet measurements.

The NADP offers a full technical support to data users and site operators. The program has direct access to technical experts, via the web and toll free numbers) to address site operators questions and offer technical expertise on data interpretation and the outreach materials. Through the NADP Program Office (PO) thousands of inquiries are answered each year. The NADP experts also contribute to the broader scientific community though dissemination of program information at external conferences, meetings, and in peer reviewed publications.

***NADP Database****:* Facilitating data access and availability is a key accomplishment/outcome of NADP, allowing support of continued research and outreach. Scientists, policymakers, educators, students, and others are encouraged to access data at no charge from the NADP website (nadp.slh.wisc.edu). This website 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. The NTN database is now populated by 450,000 observations of precipitation chemistry for all sites and all years. As of today, the 2017 calendar year data are complete and online, and the 2018 data are posted through July, with final

QA to be completed in the next few months (final data QA is completed after the full year of data is available).

Internet disbursement of precipitation chemistry and atmospheric data is the primary route of dissemination for the NADP project. Website usage statistics provide evidence that our data are being actively being used. During the 2018 year, NADP estimated 23,000 comma-delineated data sets were downloaded, including 14,000 from the NTN database. In addition, approximately 57,000 PDF map images and 100,000 map data sets (grid and kmz) were downloaded.

***Map Summary:*** The 2017 annual map series of atmospheric concentrations, wet deposition fluxes, and report was developed during Fall of 2018 and finalized and printed in October 2018. For each summary and calendar year, the NADP produces a series of 23 national maps of wet deposition concentration and flux maps for all of our analytes, and summary figures for each of the gaseous networks. These 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 in several formats (http://nadp.slh.wisc.edu/data/annualmaps.aspx). Individual maps are compiled into Annual Map Summary reports, and the summaries are available for download (nadp.slh.wisc.edu/lib/dataReports.aspx). We printed 2000 copies of the 2017 Annual Summary, and distribution has begun. The previous NADP PO at University of Illinois printed 2000 copies of the 2016 Map Summary (Sept 2017) and all have been distributed.

***Fall Scientific Meeting (FY2017 & 18):*** At the end of each federal year, a combined business and scientific meeting is held to showcase some of the latest deposition research that occurred during the year. Additionally, during each spring, a 3 day business meeting is conducted.

FY17 Fall Scientific Meeting: This meeting was held in in San Diego, CA between October 30 - November 3, 2017 (the meeting is not part of the reporting period, however due to the PO transition during this time it is briefly covered here). Information about it is available here (http://nadp.slh.wisc.edu/conf/2017/). The meeting included 130 attendees, eight oral sessions, 34 oral presentations, and 25 posters. The meeting was highlighted by a presentation from Dr. Lynn Russell, Professor of Climate, Atmospheric Science and Physical Oceanography – Scripps Institute of Oceanography, UC San Diego. The meeting included discussions of both wet and dry deposition measurement, and agricultural emissions, critical loads estimates, model development, and nitrogen transport.

After FY17, and after this project period (November 2018), the Fall Meeting and Symposium was held in Albany, NY and will appear in the FY2019 activity report.

Every spring, NADP holds a 3-day business meeting (Technical Committee, subcommittees, Executive Committee). All final committee meeting minutes are available here (nadp.slh.wisc.edu/committees/minutes.aspx). The NADP Spring Business Meeting (FY2018) was held in Milwaukee, WI, and the Spring 2019 meeting will be held in Madison, WI in May. Attendance in Milwaukee was over 60 members.

These basic activities fulfilled the project objectives: (1) coordination of these networks; (2) quality assurance to ensure consistency; and (3) analytical, site support, and data validation

services for the sites financed directly through this agreement. Again, this report is for the 48 SAES sites, but the network results are equivalent for all sites. Over the year, 48 SAES sites operated, including a relatively new SAES site operating at North Carolina Agricultural and Technology University (NCA&T). It became an active NTN site on Jan 30, 2015. NCA&T is a historically black university and is an 1890 Land-Grant University. This site is operated with cooperation of the U.S. Dept. of Energy. At the end of the FY2017 period, funding support for the NCA&T has become questionable. NADP will continue efforts to support the activities at this SAES site.

***Additional notable outcomes during the project period are as follows:*** A major change occurred with the CAL and PO during the reporting period. Beginning in late 2017 and completed in mid-2018, the NADP Program Office (PO) and Central Analytical Laboratory (CAL) moved from their longtime home at the University of Illinois Urbana–Champaign, Illinois State Water Survey (UI ISWS) to the University of Wisconsin–Madison, Wisconsin, State Laboratory of Hygiene (WSLH). The transition was seamless, with no data gaps occurring during the transition period and data quality continuing to meet the high standards established by NADP. The transition included transferring PO and Network Equipment Depot (NED) records, supplies, and equipment from Champaign, IL to Madison, WI. In addition, a comprehensive Laboratory Readiness Verification Plan was executed and the Wisconsin CAL performed quite well, meeting all performance metrics.

During the past year, several other important results have occurred beyond our basic mission and goals, these include:

- FY 2017, the NADP supported 213 publications through data support and PO and CAL outreach. These publications included (http://nadp.slh.wisc.edu/lib/bibliography.aspx):
    - 25 Doctoral Dissertations
    - 7 agency reports
    - 1 article in the journal Science, and
    - 1 article in the journal Nature.
- FY 2018, the NADP supported 208 publications through data support and PO and CAL outreach.
    - 14 Doctoral Dissertations
    - 7 agency reports, and
    - 1 article in the journal Science,

- The Mercury Litterfall Initiative with U.S. Geological Survey (USGS) scientists completed its fifth year of operation. Twenty-six sites collected litterfall (e.g., leaves, twigs, etc.) for subsequent mercury measurements. These important results have garnered the support for making Litterfall a permanent network.
- The Total Deposition Science Subcommittee (TDEP) continued its work with U.S. Environmental Protection Agency (USEPA) scientists to estimate dry deposition of nitrogen, sulfur, and other analytes.

- NADP collaborated with Utah State University to monitor dry deposition as part of a pilot study.
- NADP continued to work with the Council of State and Territorial Epidemiologists (CSTE) on a possible monitoring network for airborne allergen tracking. Airborne allergens are important as they contribute to allergic rhinitis (i.e., hay fever) and asthma. Other participants in this work include the National Oceanic and Atmospheric Administration (NOAA), USEPA, and the Centers for Disease Control and Prevention.
- NADP continued working with the National Park Service, USGS, USEPA, Colorado Department of Public Health and Environment, Colorado State University, and the Longmont and Boulder Valley Conservation Districts to address the effects and trends of nitrogen deposition and related air quality issues at Rocky Mountain National Park (RMNP). The Rocky Mountain National Park Initiative works to address nitrogen deposition concerns and the 2017 data generated from this collaboration was used to develop the draft 2017 Monitoring and Tracking Wet Nitrogen Deposition at Rocky Mountain National Park report.

***Continued Quality Assurance Audits:*** NADP contract laboratories and the Program Office are typically reviewed annually in rotation to identify problems, improve performance, and provide external checks to the program. These audit team members are a mix of external and NADP member scientists. The CAL and PO were audited July 16-18, 2018 as part of the NADP transition. The finding were summarized in "National Atmospheric Deposition Program Office and Central Analytical Laboratory DRAFT 2018 Readiness Review Report" by the Quality Assurance Advisory Group on August 27, 2018. In general, the review was positive, and the few findings have been address by the PO and CAL since the review was completed.

During the project period, in conjunction with the transition, all NADP SOPs and operation manuals are in review and subject to revision. This is an ongoing process, finalized document will be upload to the NADP website upon completion (http://nadp.slh.wisc.edu/lib/manualsSOPs.aspx). In addition, the PO worked with the NADP Executive Committee to revise the NADP Governance Document. These revisions were approved during the 2018 Fall Meeting.

**Impacts**

As a National Research Support Project (NRSP-3), NADP's main mission is to support research, and in particular, to provide data for research journal articles and reports.

Each calendar year, the NADP compiles a list of research articles, reports and theses/dissertations that used NADP data in some fashion, or compared their results to NADP data. In 2017 and 2018, 213 and 208 articles and reports utilized NADP data and resources, respectively. The journal articles that follow are example journal articles from the project period with a strong connection to agriculture. The annual bibliography of articles and reports can be found here: nadp.slh.wisc.edu/lib/bibliography.aspx.

These example publications, which are more agricultural-related publications, were published during the year in 2018. The publications may extend before and beyond the project period of March 2018 - September 2018, this allow coverage for the project activity that was not covered due to the transition from UI to UW-Madison.

*Asao, S., Parton, W. J., Chen, M., & Gao, W., 2018. Photodegradation accelerates ecosystem N cycling in a simulated California grassland. Ecosphere, 9(8), e02370*

The authors used NADP nitrogen deposition data to support the model of litter decay in arid grasslands. The photodegradation in the DayCent-UV model accelerated was shown to decrease C and N cycling and residence times. The acceleration made a greater fraction of system N available for plants, increasing net N mineralization and plant production.

*Averill, C., Dietze, M. C., & Bhatnagar, J. M., 2018. Continental‐scale nitrogen pollution is shifting forest mycorrhizal associations and soil carbon stocks. Global change biology, 24(10), 4544-4553.*

The authors combined nitrogen deposition data with continental- scale US forest data, and showed nitrogen pollution is spatially associated with a decline in ectomycorrhizal vs. arbuscular mycorrhizal trees. The results imply changes in nitrogen deposition may alter the capacity of forests to sequester carbon and offset climate change.

*Horn, K. J., Thomas, R. Q., Clark, C. M., Pardo, L. H., Fenn, M. E., Lawrence, G. B., ... & Nordin, A., 2018. Growth and survival relationships of 71 tree species with nitrogen and sulfur deposition across the conterminous US. PloS one, 13(10), e0205296.*

The authors apply reported TDEP data to analyze how tree growth and survival for 71 species vary with N and S deposition across the conterminous U.S. The study reveals that the growth and/or survival of the vast majority of species in the analysis were significantly affected by atmospheric deposition. The study's findings can help ecosystem management and policy makers to understand deposition impacts to temperate forests and suggest that N and S deposition have likely altered forest demographics in the U.S.

*Jeong, H., & Bhattarai, R., 2018. Exploring the effects of nitrogen fertilization management alternatives on nitrate loss and crop yields in tile-drained fields in Illinois. Journal of environmental management, 213, 341-352.*

The authors explored the effects of N fertilization alternatives on nitrate loss and crop yields using the Root Zone Water Quality Model (RZWQM) in tile-drained fields in central Illinois. The model indicated an adaptive N fertilizer management method is needed due to the heterogeneity in agricultural systems, and showed the importance of timing and placement of N fertilizer.

*Kosiba, A. M., Schaberg, P. G., Rayback, S. A., & Hawley, G. J., 2018. The surprising recovery of red spruce growth shows links to decreased acid deposition and elevated temperature. Science of The Total Environment, 637, 1480-1491.*

The authors explore the recovery of red spruce in the northeastern United State after acid rain linked declines. Since 2001, the study found that more than 75% of red spruce trees and 90% of the plots examined in the study showed increased growth. Nitrogen deposition was associated with lower growth, but in recent year the association has become less evident, in particular, due to observed longer growing seasons and increased temperatures related growth.

*Mathias, J. M., & Thomas, R. B., 2018. Disentangling the effects of acidic air pollution, atmospheric CO 2, and climate change on recent growth of red spruce trees in the Central Appalachian Mountains. Global change biology 24: 3938–3953.*

The authors investigate the recovery of red spruce in the Appalachian Mountains. The results indicated the two most important factors driving increased tree growth are reductions in acidic sulfur pollution and increases in atmospheric $CO_2$. The study showed reductions in pollutant emissions of NOx and warmer springs also played an important role.

*McDonnell, T. C., Belyazid, S., Sullivan, T. J., Bell, M., Clark, C., Blett, T., ... & Sverdrup, H., 2018. Vegetation dynamics associated with changes in atmospheric nitrogen deposition and climate in hardwood forests of Shenandoah and Great Smoky Mountains National Parks, USA. Environmental Pollution, 237, 662-674.*

The study modeled the ecological effect of atmospheric nitrogen (N) and sulfur (S) deposition on two hardwood forest sites in the eastern United States. The study indicates the primary driver of ecological effects was soil solution N concentration and suggests future climate change might compromise habitat suitability in forests.

*Rothstein, D., 2018. Effect of Fertilization on Growth and Mortality of Jack Pine Growing on Poor, Sandy Soils in Michigan, USA: Implications for Sustainable Management. Forests, 9(9), 549.*

The study reports on a factorial fertilization experiment to better understand nitrogen (N), phosphorus (P) and base cations nutrient limitations to jack pine growth on excessively drained sandy soils in northern Lower Michigan. The report showed increased N leads to an overall decline in growth rates, and an increase in mortality rates. The results suggest long-term whole tree harvesting may not be sustainable over multiple rotations.

***Future Work/Directions***

A significant portion of the transition from UI to UW-Madison has been completed. Work will continue to update policies and operating procedures in the PO and CAL. In addition, online training methods for operators will be implemented to increase the overall QA/QC management of NADP networks. The PO is supporting sites with data management tools to allow efficient data collection and reporting. The WSLH has developed a plan to implement strategic planning meeting during the NADP Spring meetings. The goal is to identify and address the needs of NADP stakeholders, supporters, and data users. Some suggested ideas to be discussed

include: future deployments of sensor technology, development of improved data products for users, identifying future analytes of concern, and identify the infrastructure and coordination needs of NADP to support and expand external research.

The PO is actively developing a NADP supersite on the UW-Madison campus. The site will support collaborations with NADP data users such as the College of Engineering, the College of Agricultural and Life Sciences, Department of Limnology, and the Department of Atmospheric and Oceanic Sciences. The goal is to expand the research opportunity and application for NADP data and infrastructure.

In addition, during the Fall 2018 meeting, (next reporting period) the NADP Executive Committee directed the PO to investigate and pursue the transfer of the mercury analytical lab from Eurofins/Frontier in Seattle, WA to the WSLH as a method of cost saving and increased QA oversite of MDN analytical results. The Executive Committee also approved a process to integrate the mercury litterfall network into the NADP. The PO and CAL will develop plans and capabilities to allow the litterfall next work to be housed at WSLH.

## Impacts

## Publications

### *Publications*

Includes 208 publications that used NADP data, made comparisons to NADP data, or resulted from NRSP-3 activities in 2018. A publically available listing of all citations using NADP data is accessible at: http://nadp.slh.wisc.edu/lib/bibliography.aspx. The list is for both before and after the reporting period as an attempt to cover activities that occurred during the UI and UW-Madison NADP transition.


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4. Asao, S., Parton, W. J., Chen, M., & Gao, W., 2018. Photodegradation accelerates ecosystem N cycling in a simulated California grassland. Ecosphere, 9(8), e02370.
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11. Battye, W. H., 2018. Satellite, Aircraft, and Ground Level Measurements to Characterize Ammonia Emissions from Agricultural Sources. Doctoral Dissertation, North Carolina State University.
12. Bela, M. M., Barth, M. C., Toon, O. B., Fried, A., Ziegler, C., Cummings, K. A., ... & Yang, Q., 2018. Effects of scavenging, entrainment, and aqueous chemistry on peroxides and formaldehyde in deep convective outflow over the central and Southeast United States. Journal of Geophysical Research: Atmospheres, 123(14), 7594-7614.
13. Benedetti, A., Reid, J. S., Knippertz, P., Marsham, J. H., Giuseppe, F. D., Rémy, S., ... & Mona, L., 2018. Status and future of numerical atmospheric aerosol prediction with a focus on data requirements. Atmospheric Chemistry and Physics, 18(14), 10615-10643.
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19. Brantley, S. L., White, T., West, N., Williams, J. Z., Forsythe, B., Shapich, D., ... & Herndon, E., 2018. Susquehanna Shale Hills Critical Zone Observatory: Shale Hills in the context of Shaver's Creek watershed. Vadose Zone Journal, 17(1).
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