National Research Support Project Summary

Project Number: NRSP_TEMP003

Title: The National Atmospheric Deposition Program (NADP)

Duration: October 2014 to September 30, 2019

Administrative Advisor(s): [Douglas Buhler (main) NC] [Larry Curtis W] [George M Hopper S] [Jon Wraith NE]

NIFA Reps:

Statement of Issues and Justification

Prerequisite Criteria

How is the NRSP consistent with the mission?
The mission of NRSP-3 (NADP) is to provide quality-assured data and information in support of research on the exposure of managed and natural ecosystems and cultural resources to acidic compounds, nutrients, mercury, and base cations in atmospheric deposition while seeking improvement to its measurement systems and the addition of other chemical and biological species.

NRSP-3 provides a collaborative framework for participating scientists from State Agricultural Experiment Stations (SAES); universities; federal, state, local, and tribal government agencies; national forests and laboratories; environmental institutes; private companies; and other research organizations to cooperate in sponsoring NADP measurement networks. The NADP provides the only regional and national-scale data and information on the amounts, geographic distribution, and trends in chemical deposition by precipitation in the United States. The NRSP-3 has demonstrated flexibility and response to the current and future needs of the research community for information on the effects of atmospheric deposition on terrestrial and aquatic ecosystems, biogeochemical cycling, climate change, and human health. NRSP-3 data support informed decisions on air quality issues related to precipitation chemistry and atmospheric deposition. Such information has been invaluable in:

* Documenting the presence and removal of inorganic pollutant gases and aerosols in the atmosphere (i.e., the United States' " chemical climate" ;

* Documenting how atmospheric chemicals are changing in amount and composition over time;

* Understanding the effects of atmospherically deposited chemicals on agricultural crops, forests, rangelands, surface and ground waters, estuaries, aquatic impoundments, and other natural resources;

* Assessing the accelerated weathering of material and cultural resources resulting from atmospheric chemical deposition;

* Discerning pollutant sources and source distributions and their relationships to deposition (i.e., source-receptor relationships); and

* Evaluating the effectiveness of current Clean Air Act (CAA) legislation and subsequent rules promulgated under the Act, and the impact of atmospheric deposition on water quality requirements set by the Clean Water Act.

How does this NRSP pertain as a national issue?
Since its founding as NC-141 in October 1977 by the SAES North Central Region, NRSP-3 has offered a unique opportunity for cooperation among scientists from land-grant and other universities, government agencies, and non-governmental organizations. It provides a framework for leveraging the resources of over 100 different sponsoring agencies to address contemporary and emerging issues of national importance. Figure 1 shows the locations of the 48 NADP sites either sponsored or operated by Agricultural Experiment Stations or located on Agricultural or Forestry Experiment Station properties. Sites are located in all four SAES Regions, with 55% having 30+ year operating records, representing the longest-running record of precipitation chemistry in the world.

This section provides a historical record of NRSP-3 and its continued evolution over time, demonstrating its continued national and international relevance. In October 1977, the SAES North Central Region established NC-141 to address "Chemical Changes in Atmospheric Deposition and Effects on Agricultural and Forested Land and Surface Waters in the United States " (1) Objectives of this project were to a) "establish an atmospheric deposition network for measuring beneficial nutrients and potentially injurious substances in precipitation and dry particulate matter," and to b) " organize and coordinate research on atmospheric deposition effects. "

The NC-141 initiated collection of one-week integrated wet-only deposition in 1978, and by 1979 sites represented all four SAES regions. Organizing the efforts were SAES scientists, federal and state agencies, universities, non-governmental organizations, and Canada. Justification for NC-141 was the increasing recognition of the potential for human activities to affect atmospheric chemistry and in turn the nutrient status of terrestrial and aquatic systems. Studies in Europe in the mid-1960s had documented the acidification of the atmosphere (2), and similar adverse effects were expected in the U.S. (3). Formation of the NC-141/NADP was in response to the call by a National Academy of Sciences panel to establish a U.S. network for measuring the spatial extent and intensity of acidic precipitation (4).

By 1982, the NADP had grown to 110 sites. Measurements revealed the spatial extent, intensity, and frequency of acidic precipitation, as well as the relationships between free acidity and its root causes, namely un-neutralized sulfate and nitrate species largely originating from fossil fuel combustion. SAES Directors in all four regions approved Interregional Project 7 (IR-7, 1982-1987), extending the project nationwide.

In 1980, a 10-year program entitled the National Acid Precipitation Assessment Program (NAPAP) was launched "to identify the sources, causes, and processes involved in acid precipitation and to evaluate the effects of acid precipitation" (5). A principal goal was to establish a long-term acid deposition monitoring network (the National Trends Network, NTN), later merged with the existing NADP under IR-7 as NADP/NTN. Eight federal agencies, led by the USGS, supported growth of the NADP/NTN to 203 sites by 1987. New sites were added to represent regional ecological properties (6) and lead one panel to conclude: "The monitoring program and resultant data that is being constructed is perhaps the most significant, long-term, continuous, and comprehensive sampling and analysis program to be undertaken in the environmental sciences" (7).

SAES Directors renewed IR-7 through 1992 and IR-7 scientists participated in NAPAP-funded studies of acidic deposition and its effects on crops, forests, soils, and surface waters. An overarching conclusion of NAPAP research was that chronic chemical loading from atmospheric deposition can result in long-term changes, finding:

* acidic sulfate and nitrate decreased at more than 75% of NADP sites (1979 to 1987) (8);

* there is no evidence to show that acidic precipitation at ambient U.S. levels is responsible for regional crop yield reductions (9);

* ambient deposition in high-elevation eastern-U.S. forests is thought to alter nutrient status leading to growth reduction, frost intolerance, or decline of these ecosystems (9);

* acidic deposition is expected to cause long-term chemical changes in some soils (9);

* atmospheric sulfate deposition results in some poorly buffered surface waters becoming more toxic (10); and

* acidic deposition increases the corrosion of metals and alloys (11).

During the early 1990s the SAES Directors changed the governance and identified a new class of projects called national research support projects (NRSPs), designed to support, rather than conduct, research. Specifically NRSP s were to collect data that researchers could use to study issues of national significance. The SAES Directors recognized NADP as consistent with the mission of NRSPs, and approved the project as NRSP-3 for the period 1992-1997. SAES support for NADP has continued uninterrupted through 2014.

NRSP-3 expanded in 1995 with the addition of the Atmospheric Integrated Research Monitoring Network (AIRMoN), primarily sponsored by NOAA. AIRMoN measurements are similar NTN, but are on a daily time scale, providing greater resolution for the validation of atmospheric models.

The NADP 's Technical Committee approved the Mercury Deposition Network (MDN) in 1996 to address concerns of mercury in precipitation. Research suggested that mercury had entered many of the affected lakes and streams with wet deposition (13). A 13-site pilot network has

grown to approximately 110 MDN sites as of 11/2013. Funding support for MDN is predominately from state, local, and tribal governments. The MDN (and its complimentary Atmospheric Mercury Network, AMNet) provide data to quantify ambient mercury, now identified as a health concern in every U.S. state and in many countries.

The AMNet was formed in 2009 to measure continuous gaseous ambient mercury concentrations and their speciation (e.g., elemental, particulate, and oxidized). Such information is crucial for quantifying the total deposition of mercury (wet plus dry deposition) to ecosystems. The AMNet data set allows for source-receptor modeling and assessment of short-term temporal trends. Integrating the MDN and AMNet data sets provides a better understanding of the entire atmospheric mercury cycle. Such information is crucial for understanding mercury inputs to agriculture systems (e.g., forests, crops, aquaculture), sensitive ecosystems, and the human food chain.

The Ammonia Monitoring Network (AMoN) was established in 2007 as a special study to measure ambient gaseous ammonia concentrations which are emitted primarily from agricultural sources (e.g., crop fertilization and animal operations). Data from AMoN are useful to agricultural scientists to better understand the emission and impact and dry deposition of ammonia. The AMoN represents the first consistent, long-term regional/national measurements of gaseous ammonia. Should regulations be promulgated to address ammonia emissions from agricultural operations, AMoN measurements will provide a baseline for evaluating subsequent reductions.

The long-term high quality measurements provided by NRSP-3 have addressed national needs to evaluate atmospheric deposition trends and the effectiveness of mandated pollutant emissions reductions. The Clean Air Act Amendments of 1990 (CAAA-90) sought "to reduce the adverse effects of acid deposition through reductions in annual emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x)." The Act required monitoring and reporting the effect of these emissions reductions on deposition (12). NTN measurements provided the only basis for evaluating regional scale trends in the sulfate ($SO_4^{=}$) wet deposition, and as early as 1996 NRSP-3 scientists were able to report that large SO_2 emission reductions had decreased sulfate deposition by as much as 25% in portions of the East (14). These trends have been consistent over time and space (15, 16). Trends in nitrogen species have not demonstrated the same consistency as sulfate wet deposition. Although nitrate (NO_3^-) concentrations have decreased in Mid-Atlantic and New England states since the mid-1980s, significant increases have occurred in Great Plains and Rocky Mountain states (17-20). Increases in ammonium (NH_4^+) ion over the same period have been nearly as widespread as sulfate decreases (18). These trends are illustrated in NADP year-to-year map animations, available online at http://nadp.isws.illinois.edu/data/animaps.aspx). The increases in nitrate and ammonium, especially in the West, were unexpected. These ammonia trends have continued (20, 21), emphasizing the importance of agriculture participation in national-level studies with the predominant source of ammonia originating from agricultural sources.

Below is a brief summary of other contributions of NRSP-3 to the scientific community, demonstrating ongoing national relevance.

* Studies have connected atmospheric nitrogen (N) deposition, primarily from nitrate and ammonium, to estuarine eutrophication and related low dissolved oxygen concentrations and losses of aquatic vegetation (22, 23). Other studies have reported alterations of species richness and diversity of soil flora (24). Increasing N deposition trends in the West have heightened concerns over the potential effects of nutrient additions in alpine and subalpine areas in the Rockies and Cascades. (21).

* *Phakopsora pachyrhizi*, commonly called Asian Soybean Rust (ASR, or Soybean Rust, SBR), was first reported in the continental U.S. in November 2004. ASR is an obligate fungal parasite thought to rely on a living host (e.g., legumes such as soybean) for survival (25). ASR spreads through aerial dispersal and deposition of urediniospores, which can be transported hundreds of kilometers before being deposited by precipitation. Under the right conditions, deposited spores can germinate and spread the infection (26). With supplemental support from the Agricultural Research Service (ARS), NADP staff collected and prepared filters containing rain sample residue from eastern U.S. NTN samples over 5 years through 2010 (nadp.isws.illinois.edu/educ/asr/). The filters were sent to the ARS Cereal Disease Laboratory, where they were tested for ASR using Polymerase chain reaction (PCR). Results of these samples have been documented in many studies (26-29) and on the USDA Soybean Rust site (http://sbr.ipmpipe.org/cgi-bin/sbr/public.cgi, see 2007 spore deposition). These studies demonstrate the application of this NRSP in tracking ASR spores to the Midwest (30), and the potential for using NADP to assist in tracking many different airborne pathogens in U.S. agricultural crops.

* The U.S. EPA requested information from the NADP to assess the impact of the April 2010 Deepwater Horizon oil fire in Gulf of Mexico. The NADP was able to assess the potential impact of the fires, including concentrations of sulfur and nitrogen species, base cations, and mercury. Final reports are pending.

* NRSP-3 demonstrated its flexibility in responding to new issues following the Fukushima nuclear disaster in March, 2011. The NADP and USGS assessed the wet deposition of radionuclides in NTN and MDN samples to provide information on the geographic extent of radioactive fallout from the incident. Such information was crucial to assess the potential impact on the agriculture and human food chains (31, 32).

Rationale

Priority Established by ESCOP/ESS
This section summarizes how NRSP-3 supports objectives in five of the Grand Challenges listed in "A Science Roadmap for Food and Agriculture-2010 " (http://escop.ncsu.edu/docs/scienceroadmap.pdf).

Challenge I: We must enhance the sustainability, competitiveness, and profitability of U. S. food and agricultural systems.

The NADP networks support this challenge by measuring the deposition flux of three major agricultural compounds of interest: nitrogen (N), phosphorous (P), and sulfur (S). NADP provides research support by:

* measuring precipitation quality and quantity as it enters an agriculture system;

* providing data for fertilizer balance studies (N, P, and S) to crops, soils and water sources;

* providing data for the chemical balance of soils and crops;

* measuring the impact of compounds emitted from agriculture. systems to deposition in other regions; and

* providing data for energy and fertilizer efficiency studies of agricultural systems by allowing for full mass balance calculations that include atmospheric flux.

Specific examples which support this challenge include:

* Success in detecting ASR in precipitation samples by demonstrating aerial dispersal and deposition of plant pathogens and the spread of disease. The NADP s combined wet deposition networks represent more than 300 individual sites across the U.S. and select stations in Canada. Sites in Puerto Rico and the Virgin Islands stand as sentinels for detecting pathogens borne in trans-oceanic dust plumes from Africa or South America. Measurements at continental U.S. sites could be used to monitor the seasonal re-entry of pathogens from winter refugia or the spread of diseases to new areas. (See publications 27-29 for recent examples of reports using NADP measurements.) Measurements of plant pathogens in NADP samples provide a decision-support system for **risk-based farm management, informing cropping practices and pesticide application.**

* Recent studies have estimated that mercury emissions from fires may represent ~30% of the EPA s national mercury emissions inventory. Emissions from forests dominate agricultural fires on an annual basis, representing one of the largest sources of mercury to the atmosphere (33). Much of the mercury released during fires results from volatilization of legacy mercury held in the organic soil layer. Emissions are highly variable, depending on the temperature and mercury content of these soils. Airborne mercury measurements from the AMNet will help researchers identify mercury from smoke plumes and evaluate mercury emissions and emission factors from fires. **These data provide a decision-support system for risk-based management of forests, informing prescribed-burning practices.**

* Ammonia has been identified as a priority national research need in the agricultural air quality community (34). Ammonia is a nutrient, and atmospheric deposition of ammonia and ammonium to ecosystems can alter the structure and diversity of native plant communities and contribute to acidification (35). Domestic animals, fertilizers, and crops are important sources of atmospheric ammonia. Their source strength depends on a matrix of physical, chemical, and biological factors; consequently, ammonia emissions are highly variable and have large uncertainties. This has led to a call for a National Air Emissions Monitoring Study to quantify agricultural

emissions through mechanistic process-based modeling (36), (http://cobweb.ecn.purdue.edu/~odor/NAEMS/). **The NTN and AMoN provide critical data to assess the overall effectiveness of innovative technologies for reducing the impact of agriculture operations on the environment.**

Challenge II: We must adapt to and mitigate the impacts of climate change on food, feed, fiber and fuel systems in the U.S.

The NADP networks directly measure climate variables, including precipitation amount and intensity, and the chemical climatology of the atmosphere. This quantifies climate change and chemical deposition fluxes to agriculture systems. Specifically, NADP:

* measures trends and chemical changes in precipitation, which respond to changes in temperature (affecting atmospheric chemical reactions) and precipitation patterns;

* monitors the deposition of carbonates, which respond to carbon dioxide increases in the atmosphere;

* assesses the impact of agriculture operations on physical environment as changes in chemical use (e.g., ammonia, nitrate) affect mass deposition flux in precipitation;

* provides crucial baseline data for agricultural modelers evaluating changes to agriculture in response to a changing climate; and

* provides data for adaption strategies (e.g., water and nitrogen needs) in response to climate variation.

Challenge III: We must support energy security and the development of the bio-economy from renewable natural resources in the U.S. The NADP networks measure the chemical climatology of the atmosphere, which impacts the growth of corn and other energy crops. The NADP supports energy security and bio-economy development by:

* quantifying fertilizing chemical components (e.g., N, S, and P)

* identifying infectious agents (e.g., SBR) in precipitation, and measure vector movement to energy crops;

* providing data for the determination of chemical emissions from energy crop farms and energy technology installations (through fertilization efficiency);

* providing data for model studies designed to maximize efficiency in new crop growth strategies; and,

* measuring chemical inputs that limit or enhance biofuel crop yields.

Challenge IV: We must play a global leadership role to ensure a safe, secure and abundant food supply for the U.S. and the world.

The NADP networks measure the flux of chemical compounds to agriculture systems. By knowing what is flowing into these systems, agriculture scientists can ensure the safety and maximize the abundance of American agriculture production. Specifically, NADP:

* provides precipitation chemistry data to enhance prediction for crop yield, energy efficiency, and the chemical needs of crops;

* provides an organized, centrally-managed standing monitoring program that has demonstrated its flexibility in tracking multiple food safety hazards, pathogens, invasive species, chemical and physical contaminants including national threats (37) such as ASR (27-29); radioactive fallout (31, 32); and other species; and

* can be used effectively for the tracking of agriculture fertilizer emissions, leading to less use and less need for these compounds;

In 1996 when MDN was established, 39 states had advisories warning people to limit consumption of fish taken from certain water bodies because of mercury contamination. Today, advisories exist in essentially all states and coastal regions (www.epa.gov/ost/fish). State and federal agencies have issued these advisories because of high levels of methyl-mercury in fish tissue, and research has shown the leading pathway of mercury entering many of the affected lakes and streams is precipitation (13). MDN data quantify direct mercury inputs to surface water bodies, including fish farms. Combined with AMNet, NADP quantifies total mercury deposition. The NADP dataset has become an invaluable resource for developing regional and national models and trends studies for changes over time (24, 38-40). Continued measurements will support assessments of mercury emissions reductions.

The NADP measured nuclear fallout after the 1986 Chernobyl (37) and 2011 Fukushima radioactive releases (31, 32). This same system can readily respond to future threats to the agriculture system of the U.S.

These results demonstrate NRSP-3 support of research to mitigate losses from invasive (plant pathogen) species and contamination of the human food chain. With over 35 years of experience, geographically dispersed monitoring stations, a centrally-organized communications network, and a management infrastructure, the NRSP-3/NADP stands ready to help, if called on to assist in homeland security efforts.

Challenge VI: We must heighten environmental stewardship through the development of sustainable management practices.

The NADP networks track regional movement of chemical species into and out of agricultural farms and installations; measure the atmospheric transport of chemicals in crop-growing regions; and provide data for crop studies, soils, and other research. Specific measurements include:

* Quantifying the water cycle (both quality and quantity) through the NADP wet deposition networks;

* Measuring fluxes of chemical compounds to agriculture systems and soils;

* Evaluating threats of other agents, including parasites and agriculture diseases;

* Supporting science-based policy decisions by evaluating the interaction between agricultural production practices and their regional and global environmental impacts; and

* Measuring nitrogen deposition, complemented by AMoN s ambient gas-phase ammonia measurements. Such data provide quantification of agricultural ammonia emissions, evaluation of emissions reduction practices in farm fields (e.g., cropping systems, fertilizer applications) and facilities (animal feeding operations, waste management), and estimation of total ammonia/ammonium deposition.

Relevance to stakeholders
NRSP-3 provides a collaborative environment to leverage the fiscal, material, human, and intellectual resources of scientists, educators, and policy-makers from SAES, universities, government agencies, and non-governmental organizations. Stakeholders include:

* sponsors that pay for NADP site costs, site operations, and/or other program activities;

* site operators contributing efforts in sample collection;

* cooperators that provide land access, electricity, laboratory/office space, and/or shipping;

* scientists who use and present NADP data;

* educators who use NADP data in their classrooms or textbooks; and

* students who use NADP data in the classroom, science fair projects, or graduate studies.

NADP will initiate an outreach and communications plan during the project period, with the goal of increasing participation of all stakeholders. This is described in detail under the Outreach and Communications section.

All program participants are invited to attend twice yearly committee/subcommittee meetings in the spring and fall, typically representing 50 to 75 individuals. Subcommittees receive status and progress reports on network activities, review network operations and documents, consider procedures and equipment changes, propose actions to correct deficiencies and improve operations, and propose and review initiatives for new measurements. The NADP *Quality Management Plan* calls for triennial reviews of each network laboratory and NADP management procedures. Review team members are drawn from subcommittee membership. Other committee roles are discussed in Management, Budget, and Business Plan.

The Executive Committee seeks to engage stakeholders in NADP activities. Recent interest has led to investigation of critical loads to inform policy (41). Recognizing this need, the Critical Loads AD hoc (CLAD) committee was formed in 2006. This committee has grown to over 100 individuals, many of whom are new participants in NADP. In 2010, the Total Deposition Committee (TDEP) was formed to focus on new methods to estimate dry deposition of components (i.e., measurements from AMON and AMNet). The Total Deposition Science (TDEP) was also established, hosting workshops of 50+ individuals to assess new methods to measure total (wet + dry) deposition.

Stakeholders in the research community include those using archived NADP samples and subsamples to augment routine analyses. Researchers are encouraged to submit simple proposals to an NADP review panel. Since adoption, virtually every archival sample has been delivered to an outside researcher, at minimal or no cost. Researchers are encouraged to attend NADP meetings and present their findings. This has sparked new discussion topics, new research, and potential new NADP measurements. Recent research studies include:

* applying O^{18} and H^{2} measurements to examine the relationship between precipitation and surface and ground water sources (42-44);

* using N^{15} measurements to infer atmospheric NO_x sources (45);

* testing for the presence of potentially hazardous chemicals (31, 32, 46-47).

Stakeholder use of NADP data is assessed by recording website activity, requesting program participants to report their activities annually, and performing regular literature searches. This information is summarized annually in SAES-422 reports, Current Research Information System AD-421 reports, and other federal agency reports. The number of registered NADP website users has increased over the past five years, with well over 37,000 individuals. The users represent: universities (33%), federal and state agencies (27%), K to 12 students (20%), and private research groups (20%). Registrants represent more than 150 nations and every continent, except Antarctica.

Each year, NADP summarizes research that develops in whole or in part from NADP data. This is done by requesting copies of journal articles and reports from all participants, and by searching digital repositories. During 2012, the NADP s information and data were used in over 160 publications. Publications are compiled on the NADP website. These reports are detailed in SAES 422 annual reports.

NADP data are frequently used to inform and evaluate environmental policies and agreements. NADP maps are utilized in materials prepared by the EPA, including nitrogen deposition maps (e.g., EPA Clear Skies). NADP wet deposition values are compiled in map form to estimate total deposition of S and N at the EPA s CASTNET site). In its evaluations of CAAA-90, the EPA Clean Air Markets Division utilized NADP data in its annual reports (48). Similarly, NAPAP reports to Congress used NADP data in assessing the effects of emissions changes on deposition and deposition changes on aquatic and terrestrial systems (49). The International Joint Commission uses NADP data in its periodic evaluations of the U.S.-Canada Air Quality

Agreement (50) and the Canadian government in its independent evaluation of the agreement and acidic deposition assessments (51). Additional regional and state policy assessments, environmental impact statements, and numerous other reports utilizing NADP data are detailed in annual NADP reference lists.

Each year, articles with particular agriculture impacts are detailed in the NADP s SAES 422 report. Here is a short synopsis of 3 articles from 2012:

* Qi et al. (52, USDA-ARS scientists) developed a carbon-nitrogen cycle module for use in the Great Plains Framework for Agriculture Resource Management model (GPFARM-Range, simulations of forage growth and cow calf production). This module predicts crop carbon and soil carbon and nitrogen over time. The model was developed to be used directly with NADP data: observations of ammonium and nitrate are N inputs to the module and system.

* Moore et al. (53, SAES and extension scientists) quantified the change in recharge rates in semiarid rangelands with brush management of the surface. The authors conclude that with removal of brush, modest but significant reductions in evapotranspiration and increases in groundwater recharge are realized. The researchers used nine Texas NADP sites and chloride observations as an environmental tracer to determine accurate recharge rates.

* Lawrence et al. (54, including USDA and SAES scientists) report early indications of soil recovery from reduced acidic deposition in Northeast forests. Their results suggest the initiation of pH increase in soils, an ending of calcium loss, and decreasing mobilization of aluminum into the B soil horizon. The authors used NADP sulfate and pH observations from five NADP sites from 1985 through 2004.

Special Relevance to SAES Participation Of special note is the particularly important role that SAES and off-the-top funding plays in NADP. The SAES funding provides three very important advantages: (1) it enhances the ability of the SAES to address pressing needs of agriculture, (2) it controls NADP site loss due to lower costs for SAES participation, and (3) SAES funding is heavily leveraged by allowing participation of other federal and state agencies. More specifically:

1. Addressing Pressing Needs of Agriculture. The NADP is addressing highly relevant issues related to nitrogen, ammonia, transport of plant pathogens, and provides a scientific forum for communication about agriculture research. At many locations we have a 30-year record of this deposition, and these show trends at many sites (decreasing $SO_4^{=}$, regional increasing and decreasing NO_3^- and increasing NH_4^+).

2. SAES Monitoring Site Losses. All NADP sites pay a management fee for operations. The SAES funding pays all or some of this fee for the SAES sites. Currently, 19 SAESs have these fees paid in full, and all other sites have reduced fees relative to average federal site expenses. The remaining costs are borne by the individual SAES. With a loss of NRSP status, the operational costs at all sites would increase significantly and many sites located in the agricultural production areas could shut down. This loss would greatly affect the ability to follow

national trends in deposition since many of these SAES sites are the oldest sites in the network: 10 sites have precipitation chemistry records originating in 1978.

3. Federal and State Leveraging. The continued active status of NRSP-3 allows funding contributions from many federal agencies, totaling $1.8 million dollars annually, to flow through the NIFA to the University of Illinois and NADP by cooperative agreement. Without this mechanism, funding to NADP will be permanently disrupted and potentially all funding lost due to significant increases in indirect cost recoveries by other mechanisms.

Consequently, if the NRSP-3 is lost, then all NADP sites would likely see a 50% increase in total monitoring costs for each year. Not only does the NRSP status leverage large amounts of federal and state funding, but the NRSP-3 also leverages a lower cost for all NADP site sponsors. **Therefore, even though the $50,000 is a relatively small part of the NRSP-3 total budget (1.4%), the SAES funding is extremely important to the NADP and to the United States.**

Objectives and Projected Outcomes:

The NADP has had three objectives during its existence (see below). To achieve these objectives, NADP provides timely deliverables free of charge. Scientists, educators, students, policy-makers, and others are encouraged to access data from the NADP website. This site offers on-line retrieval of individual data points, seasonal and annual averages, trend plots, concentration and deposition maps, reports, manuals, educational brochures, and other information about NRSP-3.

Quality-assured data and information from all networks are loaded quarterly into the on-line database system with a lag of ~180 days. Information available from this website and linked database management system constitute the deliverables that support the project objectives. NADP also addresses special request data products, answers scientific questions, and assists users to find related information.

Complementing the on-line data and information are publications such as annual data summaries, annual meeting proceedings and presentations, quality assurance documents (e.g., quality management plans), manuals, informational and educational brochures, and reports. All publications are available online.

Implementation

Objectives

1. The NADP has had three objectives during its existence: 1. to characterize geographic patterns and temporal trends in chemical or biological atmospheric (wet and dry) deposition
2. 2. to support research activities related to: (a) the productivity of managed and natural ecosystems
3. (b) the chemistry of surface and ground waters, including estuaries
4. (c) critical loads in terrestrial and aquatic ecosystems

5. (d) the health and safety of the nation s food supply
6. and (e) source-receptor relationships
7. and 3. to support education and outreach through the development of informational materials and programs aimed at people of all ages. To achieve these objectives, NADP provides timely deliverables free of charge. Scientists, educators, students, policy-makers, and others are encouraged to access data from the NADP website (http://nadp.isws.illinois.edu/). This site offers on-line retrieval of individual data points, seasonal and annual averages, trend plots, concentration and deposition maps, reports, manuals, educational brochures, and other information about NRSP-3. Quality-assured data and information from all networks are loaded quarterly into the on-line database system with a lag of ~180 days. Information available from this website and linked database management system constitute the deliverables that support the project objectives. NADP also addresses special request data products, answers scientific questions, and assists users to find related information. Complementing the on-line data and information are publications such as annual data summaries, annual meeting proceedings and presentations, quality assurance documents (e.g., quality management plans), manuals, informational and educational brochures, and reports. All publications are available online (nadp.isws.illinois.edu/lib/). Project Assessment and Revision of Objectives: In order to assess the type and amount of research activity supported by NRSP-3, participants are asked to report their program activities and publications that use NADP data annually. Additionally information is obtained from online literature repositories to locate all publications that reference or use NADP data, maps, and other information. These are summarized annual and provided on the NADP website (http://nadp.isws.illinois.edu/lib/bibliography.aspx). More than ~95% of these publications are peer-reviewed journal articles and reports, including theses and dissertations. The balance includes informational pieces, such as newspaper articles and other news reports. Over the last three complete years (2010-2012), publications listed have numbered 146, 172, and 170 publications, respectively. **This demonstrates that NRSP-3 is achieving the primary function of NRSPs, namely to support research (and NADP s Objective #2).** Objective (1) was changed during the 2002-06 funding period to chemical or biological atmospheric (wet and dry) deposition. This objective now explicitly mentions wet and dry deposition, including the (biological) deposition of plant pathogens, such as ASR spores. Current networks to measure air concentrations of ammonia and mercury make possible the estimation of dry deposition fluxes, building new research support capacity. Research activities under objective (2) were amended to address emerging interest in critical loads and the health and safety of the nation s food supply. Including the health of food supplies embraces the work being done to understand mercury sources that have led to advisories in 49 states to limit fish consumption, and also embraces the work being done to track SBR, a disease that can drastically reduce yields in unprotected soybean crops. Objective (3) articulates what is already being done (see summary in Integration and Documentation of Research Support). These points show that the NRSP-3 is adjusting to our current understanding and adapting to new needs (e.g., ambient ammonia monitoring, ASR pathogen transport, radioactive fallout from Fukushima, and related studies.).

Projected Outcomes

1. The NADP has had three objectives during its existence: 1. to characterize geographic patterns and temporal trends in chemical or biological atmospheric (wet and dry) deposition
2. 2. to support research activities related to: (a) the productivity of managed and natural ecosystems
3. (b) the chemistry of surface and ground waters, including estuaries
4. (c) critical loads in terrestrial and aquatic ecosystems
5. (d) the health and safety of the nation s food supply
6. and (e) source-receptor relationships
7. and 3. to support education and outreach through the development of informational materials and programs aimed at people of all ages. To achieve these objectives, NADP provides timely deliverables free of charge. Scientists, educators, students, policy-makers, and others are encouraged to access data from the NADP website (http://nadp.isws.illinois.edu/). This site offers on-line retrieval of individual data points, seasonal and annual averages, trend plots, concentration and deposition maps, reports, manuals, educational brochures, and other information about NRSP-3. Quality-assured data and information from all networks are loaded quarterly into the on-line database system with a lag of ~180 days. Information available from this website and linked database management system constitute the deliverables that support the project objectives. NADP also addresses special request data products, answers scientific questions, and assists users to find related information. Complementing the on-line data and information are publications such as annual data summaries, annual meeting proceedings and presentations, quality assurance documents (e.g., quality management plans), manuals, informational and educational brochures, and reports. All publications are available online (nadp.isws.illinois.edu/lib/). Project Assessment and Revision of Objectives: In order to assess the type and amount of research activity supported by NRSP-3, participants are asked to report their program activities and publications that use NADP data annually. Additionally information is obtained from online literature repositories to locate all publications that reference or use NADP data, maps, and other information. These are summarized annual and provided on the NADP website (http://nadp.isws.illinois.edu/lib/bibliography.aspx). More than ~95% of these publications are peer-reviewed journal articles and reports, including theses and dissertations. The balance includes informational pieces, such as newspaper articles and other news reports. Over the last three complete years (2010-2012), publications listed have numbered 146, 172, and 170 publications, respectively. **This demonstrates that NRSP-3 is achieving the primary function of NRSPs, namely to support research (and NADP s Objective #2).** Objective (1) was changed during the 2002-06 funding period to chemical or biological atmospheric (wet and dry) deposition. This objective now explicitly mentions wet and dry deposition, including the (biological) deposition of plant pathogens, such as ASR spores. Current networks to measure air concentrations of ammonia and mercury make possible the estimation of dry deposition fluxes, building new research support capacity. Research activities under objective (2) were amended to address emerging interest in critical loads and the health and safety of the nation s food supply. Including the health of food supplies embraces the work being done to understand mercury sources that have led to advisories in 49 states to limit fish consumption, and also embraces the work being done to track SBR, a disease that can drastically reduce

yields in unprotected soybean crops. Objective (3) articulates what is already being done (see summary in Integration and Documentation of Research Support). These points show that the NRSP-3 is adjusting to our current understanding and adapting to new needs (e.g., ambient ammonia monitoring, ASR pathogen transport, radioactive fallout from Fukushima, and related studies.).

Management, Budget, and Business Plan

Project management is described in the *National Atmospheric Deposition Program Governance Handbook*, available at http://nadp.isws.illinois.edu/lib/brochures/nadpGovernanceHandbook.pdf. This handbook describes the roles and responsibilities of the members of the Program Office, including areas of responsibility. It additionally describes the role of each committee, subcommittees, and membership. Each role is briefly summarized here: The NADP Program Office (NPO), located at the University of Illinois (UI), is responsible for promoting long-term NADP operations that comply with the operational procedures and quality-assurance standards set by the Executive Committee (EC), with guidance from its subcommittees. The NPO manages day-to-day operations. NPO responsibilities include: 1. Securing site support, chemical analytical, and data validation services for NADP measurement programs; 2. ensuring measurement programs produce consistent quality-assured data; 3. managing the NADP website and linked database; 4. publishing data reports and summaries; 5. providing support for committee and subcommittee meetings; and 6. coordinating special studies. The NADP Coordinator is the NPO Director and principal investigator of the cooperative agreements between NADP sponsors and the UI. At least two times a year, the Coordinator reports to the EC on the status and progress of NPO and NADP activities.

Budgeting is done on a federal fiscal year basis. The Coordinator reports on the fiscal status of the project to the Budget Advisory Committee (BAC), which is responsible for financial planning. The BAC reviews the Coordinator s report and the Coordinator s income and expenditure plans for the upcoming fiscal year. The BAC makes its budget recommendations to the EC, which has budget approval authority. BAC membership consists of elected and ex-officio members. Over the past 5 years, NRSP-3 has remained within projected budget (+/- 2%); demonstrating that all provided funds effectively support NRSP-3 s mission. The EC is responsible for making budgetary decisions and ensuring program continuity and balance. It provides technical and administrative guidance to the NPO. The EC receives input and recommendations from the BAC on budgetary matters and the Quality Assurance Advisory Group on quality assurance matters. It also receives input and recommendations from three technical subcommittees: " The Network Operations Subcommittee (NOS), which oversees field-siting criteria and laboratory and sample collection protocols, and evaluates equipment and recordkeeping methods; " The Data Management and Analysis Subcommittee (DMAS), which guides data collection, storage, QA/QC, and, most importantly, web-based data presentations in tables, maps, and graphs; and " The Ecological Responses and Outreach Subcommittee (EROS), which provides input on data user needs, and initiates and develops programs and products to promote the program and increase participation.

The EC acts on recommendations and sets program policies and procedures. EC membership consists of four elected officers, the elected chairs of each of the technical subcommittees, the BAC co-chair, and an SAES representative, all of whom have voting privileges. Membership also includes ex-officio non-voting members, such as the SAES Regional Administrative Advisors and the NIFA program manager. Membership in the technical subcommittees is open and the rosters range from 40 to 60 per committee. Summaries of EC minutes are provided on the web (http://nadp.isws.illinois.edu/committees/minutes.aspx), along with all subcommittee s minutes.

As mentioned in the Relevance to Stakeholders section, the EC has continued to look for ways to engage new participation in its technical subcommittees and annual meetings. In 2006 the Program Chair formed the CLAD as a new Science Committee to provide a venue for discussing current and emerging issues regarding the science and application of critical loads. This action has been rewarded with substantial new participation of agencies and individuals. CLAD membership now totals approximately 120.

Both the EC and EROS, which seeks ways to promote the program, have struggled to increase participation from land-grant university scientists. The AMON network along with the SBR project has had some success in stimulating new interest from this group. Specific sessions at recent annual NADP symposia have had sessions devoted to agricultural and ammonia issues. Full meeting records since 2007 can be found on the web (http://nadp.isws.illinois.edu/conf/) including abstracts and selected presentations).

Project Budget: NRSP-3 provides the authority and framework for combining the resources of many and diverse sponsors in support of NRSP-3. Project support is divided into monies administered by the UI and the monies and in-kind support for operating NADP sites. UI-administered funds provide the resources for the NPO to perform duties and obligations required to satisfy the six responsibilities listed above. Money and in-kind support for site operations cover the cost of sample collection, transportation and electricity to run the site, sample shipping, and land access and office space. Support for site operations is not administered by the UI but is provided through contractual arrangements between funders and operating agencies.

Three funding streams provide support for the NPO: (1) SAES off-the-top monies, (2) a cooperative agreement between the USDA-NIFA and UI, and (3) agreements between individual SAES, universities, government agencies, or non-governmental organizations and the UI. The USDA-NIFA/UI cooperative agreement combines the support of seven federal agencies (BLM, EPA, NOAA, NPS, TVA, USDA-Forest Service, USGS), along with USDA, each having an interagency agreement with the USDA-NIFA. Each individual (type 3) agreement funds one or more sites (103 currently).

Twelve NTN sites are sponsored by SAES through individual agreements between land-grant universities and the UI. Support for the 38 other NADP sites at SAES facilities come either from federal agencies through the NIFA/UI cooperative agreement or from state agencies through type 3 agreements. Hatch funds provide off-the-top support and the land-grant university support of SAES sites. Since these funds can pay only direct program costs and under the NRSP-3 are combined with funds from other sources, all NPO support, no matter the source, pays only direct

program costs. Indeed, the USDA-NIFA/UI cooperative agreement stipulates that monies be used only for direct costs and not for facilities and services. Total FY14 support from these three funding streams was $3.4M. From FY09 to FY14, off-the-top support remained constant at $50,000. Therefore, over the years SAES funds have been highly leveraged into an internationally successful NRSP.

NRSP-3 off-the-top monies provide partial support of the Program Coordinator. Since this position spearheads day-to-day outreach to new stakeholders and development of innovative data products that support new research interests, we propose a level NRSP-3 budget of $50,000 per year for the FY15-FY19 renewal period.

The NRSP-3 funding model has enabled project growth and diversification of funding sources (see previous section). With the addition of the MDN in 1996, the number of individual (type 3) agreements has more than doubled. MDN support comes largely from state, local, and tribal government agencies in states confronting a growing number of health advisories because of mercury-contaminated fish. NPO outreach efforts have been successful in enlisting new MDN support from these agencies. MDN is currently at 110 sites, most in the U.S., several in Canada (6 sites), and within Tribal Nations (12 sites). Plans are ongoing for 1 to 3 new sites in Mexico. The NTN is currently at its maximum number of sites, 265. This growth has been realized by containing costs and gaining efficiencies in network operations.

The NRSP-3 committees and NPO continue to look for ways the project can serve regional and national needs. Establishing the CLAD is an example of engaging new scientific participation. Partnering with USDA-ARS to use NADP samples for detecting ASR spores in precipitation opens new possibilities for supporting research in the transport and deposition of airborne plant pathogens. Initiating the AMON has demonstrated the viability of cost-efficient passive sampling methods for measuring ambient ammonia, and is responding to the national need to better understand ammonia sources, atmospheric cycling, and deposition. These and other efforts remain true to the vision that NRSP-3/NADP will remain one of the nation's premier research support projects, serving science and education and supporting informed decisions on air quality issues.

Subsection 3.3. Integration and Documentation of Research Support: (5,000 characters)

Academic Programs: Data and information on the NADP website have become an important resource for educators at virtually every level. Users indicate that 50% access the site for educational purposes and the balance for research from academic institutions, with significant growth since 1998 (38% education). In 2012, total data downloads were identified as follows: " 40% from federal and state agencies, " 36% from universities " 16% from K-to-12 schools, and " 6% from other individuals or organizations.

NADP data are typically used in 5 to 10 theses/dissertations each year. Over the last five years, authors have used NADP data, figures and maps in undergraduate textbooks in biology, chemistry, environmental sciences, and related areas (54, 55). The NADP willingly supplies high quality graphics and data free of charge for these efforts. Secondary-level students continue to access on-line brochures, data and maps for use in science fair projects and classroom exercises.

The NADP partnered with Dr. Robert Hudson and the UI College of Agricultural, Consumer and Environmental Sciences to develop a 2.5-hour installment of Natural Resources and Environmental Sciences Watersheds and Water Quality class and its video series for online education. The video was a description of the NADP, explanations of acid rain and its impacts.

NADP staff has been involved in extension work with Native American organizations concerning mercury, motivated by the high tribal fish consumption levels. NADP continues to contribute to the Institute of Tribal Environmental Professionals, National Tribal Air Association, and Tribal Air Monitoring Support Center.

Partnerships: The NADP partnership with the ARS Cereal Disease Laboratory at the University of Minnesota to quantify SBR in precipitation samples continued through 2011. This project was previously described in the National Relevance section.

During 2010 to 2012, the NADP has adopted a new method for developing maps by improving the precipitation data that goes into our wet deposition products. The NADP now uses the PRISM (Parameter-elevation Regressions on Independent Slopes Model) precipitation data to augment routine NADP measurements. PRISM incorporates point measurement data (from 7000 precipitation gages), a digital elevation model, and expert knowledge of complex climatic extremes to estimate precipitation, all on a 4x4 km grid spacing. PRISM data sets are recognized as being of very high-quality and are supported by the USDA Natural Resources Conservation Service, USDA Forest Service, and the NOAA Office of Global Programs. This new partnership has resulted in greater spatial resolution in NTN and MDN map products.

During the past 5 years, two new networks (AMON, AMNet) were developed at the request of stakeholders and to address the needs of the agriculture research community. In both cases, these new networks have brought in new site and funding partners, and new researchers. AMON is of particular interest to SAES scientists. Both networks have been discussed in other sections of this report.

Over the last 3 years, the NADP has brought in two new partner acid deposition networks: the New York Atmospheric Deposition Monitoring Network and the Pennsylvania Atmospheric Deposition Monitoring Network. In each case, the independent state networks determined that partnering with the national network was preferential to independent status. Both networks historically measured the same analytes as NTN and are now fully integrated into the NADP.

Support Nationwide Research: NADP has over 37,000 registered data users across the U.S., with 12 states having more than 1000 users. There are additional users in more than 150 countries. The NADP has sites in every state (except RI), and in Canada, Puerto Rico, and the Virgin Islands, and new sites in Argentina and in Taiwan. The AMON has 64 sites in 29 states and Canada (including all 4 SAES regions), with preliminary gaseous ammonia measurements extending back to 2007 and official network measurements beginning in 2010. The number of active data users and monitoring sites provide indications of the breadth of support and continued interest in NRSP-3, and recognition that NADP is responsive to emerging needs of researchers and policy-makers. The breadth of reports and journal articles using or citing NADP data demonstrates the nationwide, indeed international, use of NADP data.

Researchers continue to value data that addresses acidic deposition issues in eastern states. There is emerging interest in the Rockies, Cascades, Sierras, and other sensitive high-elevation ecosystems in the West, driven partially by CLAD representatives. Researchers continue to utilize NTN s nutrient deposition data in nitrogen-limited montane ecosystems as well as estuaries and coastal watersheds. Researchers value MDN s mercury deposition data to investigate the cause of widespread mercury contamination of fish and piscivores. Finally, researchers need ambient gaseous ammonia data from AMoN to understand atmospheric nitrogen deposition and the relationship of ammonia emissions to air quality. The NRSP-3/NADP has effectively supported these and other research activities and proposes to continue this support.

Integration

Academic Programs: Data and information on the NADP website have become an important resource for educators at virtually every level. Users indicate that 50% access the site for educational purposes and the balance for research from academic institutions, with significant growth since 1998 (38% education). In 2012, total data downloads were identified as follows:

* 40% from federal and state agencies,

* 36% from universities

* 16% from K-to-12 schools, and

* 6% from other individuals or organizations.

NADP data are typically used in 5 to 10 theses/dissertations each year. Over the last five years, authors have used NADP data, figures and maps in undergraduate textbooks in biology, chemistry, environmental sciences, and related areas (54, 55). The NADP willingly supplies high quality graphics and data free of charge for these efforts. Secondary-level students continue to access on-line brochures, data and maps for use in science fair projects and classroom exercises.

The NADP partnered with Dr. Robert Hudson and the UI College of Agricultural, Consumer and Environmental Sciences to develop a 2.5-hour installment of Natural Resources and Environmental Sciences Watersheds and Water Quality class and its video series for online education. The video was a description of the NADP, explanations of acid rain and its impacts.

NADP staff has been involved in extension work with Native American organizations concerning mercury, motivated by the high tribal fish consumption levels. NADP continues to contribute to the Institute of Tribal Environmental Professionals, National Tribal Air Association, and Tribal Air Monitoring Support Center.

Partnerships: The NADP partnership with the ARS Cereal Disease Laboratory at the University of Minnesota to quantify SBR in precipitation samples continued through 2011. This project was previously described in the National Relevance section.

During 2010 to 2012, the NADP has adopted a new method for developing maps by improving the precipitation data that goes into our wet deposition products. The NADP now uses the PRISM (Parameter-elevation Regressions on Independent Slopes Model) precipitation data to augment routine NADP measurements. PRISM incorporates point measurement data (from 7000 precipitation gages), a digital elevation model, and expert knowledge of complex climatic extremes to estimate precipitation, all on a 4x4 km grid spacing. PRISM data sets are recognized as being of very high-quality and are supported by the USDA Natural Resources Conservation Service, USDA Forest Service, and the NOAA Office of Global Programs. This new partnership has resulted in greater spatial resolution in NTN and MDN map products.

During the past 5 years, two new networks (AMON, AMNet) were developed at the request of stakeholders and to address the needs of the ag. research community. In both cases, these new networks have brought in new site and funding partners, and new researchers. AMON is of particular interest to SAES scientists. Both networks have been discussed in other sections of this report. Over the last 3 years, the NADP has brought in two new partner acid deposition networks: the New York Atmospheric Deposition Monitoring Network and the Pennsylvania Atmospheric Deposition Monitoring Network. In each case, the independent state networks determined that partnering with the national network was preferential to independent status. Both networks historically measured the same analytes as NTN and are now fully integrated into the NADP.

Support Nationwide Research: NADP has over 37,000 registered data users across the U.S., with 12 states having more than 1000 users. There are additional users in more than 150 countries. The NADP has sites in every state (except RI), and in Canada, Puerto Rico, and the Virgin Islands, and new sites in Argentina and in Taiwan. The AMON has 64 sites in 29 states and Canada (including all 4 SAES regions), with preliminary gaseous ammonia measurements extending back to 2007 and official network measurements beginning in 2010. The number of active data users and monitoring sites provide indications of the breadth of support and continued interest in NRSP-3, and recognition that NADP is responsive to emerging needs of researchers and policy-makers. The breadth of reports and journal articles using or citing NADP data demonstrates the nationwide, indeed international, use of NADP data.

Researchers continue to value data that addresses acidic deposition issues in eastern states. There is emerging interest in the Rockies, Cascades, Sierras, and other sensitive high-elevation ecosystems in the West, driven partially by CLAD representatives. Researchers continue to utilize NTN s nutrient deposition data in nitrogen-limited montane ecosystems as well as estuaries and coastal watersheds. Researchers value MDN s mercury deposition data to investigate the cause of widespread mercury contamination of fish and piscivores. Finally, researchers need ambient gaseous ammonia data from AMoN to understand atmospheric nitrogen deposition and the relationship of ammonia emissions to air quality. The NRSP-3/NADP has effectively supported these and other research activities and proposes to continue this support.

Outreach, Communications and Assessment

Audience: The NRSP-3 mission is to provide quality-assured data and information on atmospheric deposition for use by scientists, educators, students, policy-makers, and the public. The NRSP-3/NADP has effectively supported outreach, and routinely assesses the impact of these activities through quantifiable metrics.

The NADP website provides on-line access to virtually all project data and information, including educational and informational brochures. All data from all networks is freely available to all interested users through the website. Download web statistics have been presented previously. User statistics, described in Relevance to Stakeholders show the continual growth in the number of registered users and data downloads, two indicators of the importance and relevance of the data.

In its role of assessing project performance, the NRSP-3 EC charged the NPO with updating the website to improve the organizational layout, facilitate data and map accessibility, enhance communications, and modernize the look and feel. NADP has received beneficial feedback through its EROS subcommittee to best structure the materials to meet the needs of stakeholders. Over the past four years, a new website design has been put in place, including new sections featuring: " Education, with new materials for classrooms at the 4th to 6th grade and senior high level; " New Issues section that details some of the innovative measurements being done (e.g., Fukushima, new networks, and a new mercury litterfall partnership with USGS scientists); a " Committees section, where mission statements and topics of discussion, minutes, and related materials are located; a " Publications section, including all NADP standard operating procedures, minutes and presentations from meetings); and a " News section, where NADP can highlight new happenings with the network.

Engagement of Stakeholders: Stakeholder involvement in committee and subcommittee activities at twice yearly meetings is described in Relevance to Stakeholders. In addition, members participate in triennial laboratory and quality management reviews, where they provide recommendations for improvement. Committees and subcommittees identify emerging scientific needs and interests. For example, the AMoN and AMNet originated with committee discussions. As mentioned in Management, Budget, and Business Plan, the committees continually seek increase participation from land-grant university scientists, especially at annual technical meetings. Specific goals and tasks to increase communication, outreach, and participation from stakeholders (defined later in this section) were described in the Outreach and Communications section.

Measuring Accomplishments: Methods to measure program outputs, accomplishments, and impacts have been described in previous sections of the proposal and include: 1. An annual request to all program participants to send a list of accomplishments and publications utilizing NADP data to the NPO; 2. routine searches of scholarly repositories, journal articles and professional reports; 3. compilations of Web user statistics; 4. identification of NADP data use in policy-related documents and websites, e.g., NAPAP reports, NRC reviews, government agency reports and websites; 5. participation in NADP meetings; and 6. routine program reviews.

Many of these have been discussed in other parts of this proposal.

Communication Pieces: The NADP s principal data product is its annual map summary report, which provides a summary of annual highlights and map products. This summary is distributed at scientific meetings and is mailed to all program participants. An online version is available on the NADP website to students, educators and the general public. Additional publications are available on the NADP website and in print form: 1. Welcome to NADP, which describes the program to newcomers, encourages their involvement, and is regularly updated with upcoming meeting dates; 2. Monitoring Mercury Deposition, which describes the mercury problem and promotes the MDN; 3. Nitrogen in the Nation s Rain, which describes nutrient deposition and potential problems from excess nutrients (El Nitrogeno en la Lluvia Nacional, is provided as a Spanish translation); 4. Inside Rain, which describes atmospheric deposition and the NADP; 5. Ammonia Monitoring Network (AMoN) Fact Sheet, which describes issues related to gaseous ammonia, and provides an overview of methods and measurements in the AMoN,; 6. NADP s Governance Handbook, providing the structure and operation of NADP s officers, committees, and organization; and 7. Critical Loads - Evaluating the Effects of Airborne Pollutants on Terrestrial and Aquatic Ecosystems, which is a basic primer of the critical loads issue and the NADP s scientific role.

Recent articles in the general interest literature include: " The July, 2012 issue of Earth Magazine, feature the cover story Acid Rain: A Science Policy Success Story" describing the progress made over the past 30 years on the acidic precipitation problem. The 7-page article featured the network and results of the NADP, site pictures, laboratory pictures, and map products of the NADP. " The April 2013 issue of New York Conservationist, featured an article entitled Understanding Acid Rain , including an 8-page for kids pullout, the NADP and the work of NY State Department of Environmental Protection. The issue provided an ideal outreach/education tool for young scientists (4th to 6th grade).

Distribution of Results: As described in previous sections of this proposal, NADP data are distributed primarily via the NADP website, which offers easy-to-use on-line retrieval of data in multiple formats. This site receives ~1.4M hits per year, and in 2012 there were over 25,000 data downloads. These data were used in approximately 170 publications (reports and journal articles) in 2012.

Every year, a scientific symposium is held where presenters summarize the results of their scientific studies, using NADP data. Over the past five years, attendance at these meetings has averaged 140; the typical number of oral presentations is 40 and the number of poster presentations is 35. Attendance at the 2012 meeting was 150.

Future Plans for Outreach and Communication

To improve communication, outreach, and participation of stakeholders during the funding period, NADP will: a) develop an organized and sustained education and outreach program; and b) develop and implement an effective marketing plan to raise the awareness of the NADP data availability and to increase scientific participation and data use, particularly among agricultural scientists.

To achieve these goals, NADP will develop tools that support science education within agriculturally-oriented communities, K-8 schools, high school agriculture and environmental programs, and college-level research and education. To support these efforts, the NPO intends to hire a 0.25 0.50 FTE education and outreach staff person, whose responsibility will be to coordinate development and review of outreach materials.

Tasks specific to the development of outreach and communication materials are described below, many of which are in active discussion by the Technical Committee: " update Nitrogen in the Nation s Rain and Inside Rain educational materials (which incorporate online database use) for distribution within the agricultural education structure (e.g., extension agencies); " seek participation in the National Council for Agricultural Education s CASE Program (Curriculum for Agricultural Science Education) or similar efforts; " work with the 4-H program to develop STEM-focused curriculum of Agriculture Science and Environmental Science education resources; " work with other environmentally-focused organizations (e.g., Boy Scouts) on specific topics of nitrogen deposition and acid rain education; " participate in programs with the University of Illinois Extension Service and broader programs within the national extension system; " Prepare and distribute an agricultural-focused online education package for use by K-8 and high school teachers, tentatively titled Pollution s Influence on the Food Chain and incorporating the following sections: 1. Nitrogen deposition (featuring wet deposition data from NTN and dry deposition data from AMoN); 2. Mercury bioaccumulation in the food chain (featuring MDN and AMNet data); and 3. Hazardous Pollution, featuring plant pathogens (soybean rust deposition) and radioactive fallout (Fukushima observations). Materials provided will include a workbook with basic concepts (K-8 grade) and an introduction to data analysis in databases (high school level). Additional teacher resources and example lesson plans will be developed.

To implement our program marketing goals, the Technical Committee will seek to develop and implement an effective marketing plan to raise the awareness of the NADP data and to increase participation, particularly among agricultural scientists, in both attendance at meetings and data use. To measure the effectiveness of this plan, we will use established benchmarks of number of annual publications and subcommittee meeting participation.

To improve awareness of the NADP and its data products, the NPO proposes to: " Provide presentations and distribute outreach materials at agriculturally-oriented meetings (approximately 3 per year). This may include a supported booth which focuses on NADP data and materials that are of interest to agriculture scientists and educators; " Provide presentations and distribute outreach materials at water quality-focused meetings; " Develop and distribute an NADP Impacts brochure, describing impacts on agriculture; and " Distribution of the NADP Map Summary and Impacts sheet to SAES scientists, ARS scientists and offices, state extension programs, and to national agriculture education organizations, such as The National Council for Agricultural Education.

These expansive and achievable goals to improve outreach and communication continues NRSP-3/NADP s legacy to support education and outreach through the development of informational materials and programs aimed at people of all ages. The Technical Committee has demonstrated its commitment to continue in its support of these efforts.

Projected Participation

Budget Requests Summary

Literature Cited

1. Cowling, E.B., J. Fulkerson, K. Huston, and J.H. Gibson. 1977. Plan of Research for NC-141 North Central Regional Project on Atmospheric Deposition and Effects on Agricultural and Forested Land and Surface Waters in the United States. National Atmospheric Deposition Program (contact NADP Program Office, nadp@sws.uiuc.edu) 85 pp. 2. Oden, S.N.F. 1968. The Acidification of Air and Precipitation and Its Consequences in the Natural Environment. Swedish National Science Research Council, Ecology Committee Bulletin No. 1. Stockholm, Sweden. 68 pp. 3. Likens, G.E. 1976. Acid Precipitation. Chemical and Engineering News. 54(48):29-44. 4. National Academy of Science. 1975. Atmospheric Chemistry: Problems and Scope. National Academy f Sciences, Washington, D.C. 130 pp. 5. Interagency Task Force on Acid Precipitation. 1982. National Acid Precipitation Assessment Plan. Council on Environmental Quality, Washington, D.C. 100 pp. 6. Robertson, J.K. and J.W. Wilson. 1985. Design of the National Trends Network for Monitoring the Chemistry of Atmospheric Precipitation (U.S. Geological Survey Circular 964). U.S. Geological Survey, Alexandria, VA. 7. Jansen, J., K. Aspila, M. Hoffman, G. Ohlert, and J. Winchester. 1988. Session Summary Report, NAPAP Task Group IV, Wet Deposition Monitoring Peer Review. National Acid Precipitation Assessment Program, Washington, D.C. 8. National Acid Precipitation Assessment Program. 1991. Response of Vegetation to Atmospheric Deposition and Air Pollution, IN: Acidic Deposition: State of Science and Technology (Volume I Emissions, Atmospheric Processes, and Deposition). National Acid Precipitation Assessment Program, Washington, D.C. pp. 6-1 6-338. 9. National Acid Precipitation Assessment Program. 1991. Response of Vegetation to Atmospheric Deposition and Air Pollution, IN: Acidic Deposition: State of Science and Technology (Volume III Terrestrial, Materials, Health and Visibility Effects). National Acid Precipitation Assessment Program, Washington, D.C. pp. 18.1-206. 10. National Acid Precipitation Assessment Program. 1991. Watershed and Lake Processes Affecting Surface Water Acid-Base Chemistry, IN: Acidic Deposition: State of Science and Technology (Volume II Aquatic Processes and Effects). National Acid Precipitation Assessment Program, Washington, D.C. pp. 10-1 10-167. 11. National Acid Precipitation Assessment Program. 1991. Effects of Acidic Deposition on Materials, IN: Acidic Deposition: State of Science and Technology (Volume III Terrestrial, Materials, Health and Visibility Effects). National Acid Precipitation Assessment Program, Washington, D.C. pp. 19-1 19-280. 12. Public Law 101-549. November 15, 1990. The Clean Air Act Amendments of 1990. http://www.epa.gov/oar/caa/caaa.txt. 13. U.S. Environmental Protection Agency. 1997. Executive Summary, IN: Mercury Study Report to Congress (EPA-452/R-97-003). Office of Air Quality Planning and Standards and Office of Research and Development, Washington, D.C. 95 pp. 14. Lynch, J.A., V.C. Bowersox, and J.W. Grimm. 1996. Trends in

Precipitation Chemistry in the United States, 1983-94: An Analysis of the Effects in 1995 of Phase I of the Clean Air Act Amendments of 1990, Title IV (Open-File Report 96-0346). U.S. Geological Survey, Reston, VA. 100 pp. 15. Lynch, J.A., V.C. Bowersox, and J.W. Grimm. 2000. Changes in Sulfate Deposition in Eastern USA Following Implementation of Phase I of Title IV of the Clean Air Act Amendments of 1990. Atmospheric Environment. 34(11):1665-1680. 16. Waller, K., Driscoll, C., Lynch, J., Newcomb, D., & Roy, K. (2012). Long-term recovery of lakes in the Adirondack region of New York to decreases in acidic deposition. Atmospheric Environment, 46, 56-64. 17. Stephen, K., & Aneja, V. P. (2008). Trends in agricultural ammonia emissions and ammonium concentrations in precipitation over the Southeast and Midwest United States. Atmospheric Environment, 42(14), 3238-3252. 18. Lehmann, C.M.B., V. C. Bowersox, and S.M. Larson. 2005. Spatial and Temporal Trends of Precipitation Chemistry in the United States, 1985-2002. Environmental Pollution. 135:347-361. 19. Lehmann, Christopher MB, and David A. Gay. "Monitoring long-term trends of acidic wet deposition in US precipitation: Results from the National Atmospheric Deposition Program." Power Plant Chemistry 13.7 (2011): 378. 20. Lehmann, C.M.B. 2006. Atmospheric Deposition Monitoring to Assess Trends in Atmospheric Species. Ph.D. thesis. University of Illinois, Urbana-Champaign, IL. 404 pp. 21. Benedict, K. B., Day, D., Schwandner, F. M., Kreidenweis, S. M., Schichtel, B., Malm, W. C., & Collett Jr, J. L. (2012). Observations of atmospheric reactive nitrogen species in Rocky Mountain National Park and across northern Colorado. Atmospheric Environment. 64 (2013) 66-76. 22. Paerl, H.W. 2002. Connecting Atmospheric Nitrogen Deposition to Coastal Eutrophication. Environmental Science & Technology. August 1, 2002:323A-326A. 23. Hameedi, J., H. Paerl, M. Kennish, and D. Whitall. 2007. Nitrogen Deposition in U.S. Coastal Bays and Estuaries. EM. December 2007: 19-25. 24. Fenn, M.E., J.S. Baron, E.B. Allen, H.M. Rueth, K.R. Nydick, L. Geiser, W.D. Bowman, J.O. Sickman, T. Meixner, D.W. Johnson, and P. Neitlich. 2003. Ecological Effects of Nitrogen Deposition in the Western United States. BioScience. 53(4):404-420. 25. Pivonia, S., and X.B. Yang. 2004. Assessment of the Potential Year-Round Establishment of Soybean Rust Throughout the World. Plant Disease. 88:523-529. 26. Melching, J.S., W.M. Dowler, D.L. Koogle, and M.H. Royer. 1989. Effects of Duration, Frequency, and Temperature of Leaf Wetness Periods on Soybean Rust. Plant Disease. 73:117-122. 27. Barnes C. W., Szabo, L. J., and Bowersox, V. C., 2009. Identifying and Quantifying Phakopsora pachyrhizi Spores in Rain. Phytopathology 99 (4): 328-338. Web. 19 June 2011 28. Isard, S. A., Barnes, C. W., Hambleton, S., Ariatti, A., Russo, J. M., Tenuta, A., Gay, D. A., and Szabo, L. J., 2011. Predicting Soybean Rust Incursions into the North American Continental Interior Using Crop Monitoring, Spore Trapping, and Aerobiological Modeling. Plant Disease 95:1346-1357. 29. Ford, T., D. A. Gay, and C. M. B. Lehmann, Modeling Asian Soybean Rust Urediniospore Movement Into and Amid the Contiguous United States. In review at Atmospheric Environment, August, 2013. 30. Krupa, S., V. Bowersox, R. Claybrooke, C.W. Barnes, L. Szabo, K. Harlin, and J. Kurle. 1006. Introduction of Asian Soybean Rust Urediniospores into the Midwestern United States A Case Study. Plant Disease. 90(9): 11254-1259. 31. Wetherbee, G.A., Gay, D.A., Debey, T.M.,

Lehmann, C.M.B., and Nilles, M.A., 2012. Fission Products in National Atmospheric Deposition Program Wet Deposition Samples Following the Fukushima Dai-ichi Nuclear Power Station Incident, March 8 - April 5, 2011. Environmental Science and Technology 46 (5) 2574 2582, doi: 10.1021/es203217u. 32. Wetherbee, G.A., Gay, D.A., Debey, T.M., Lehmann, C.M.B., and Nilles, M.A., 2012. Fission Products in National Atmospheric Deposition Program Wet Deposition Samples Following The Fukushima Dai-ichi Nuclear Power Station Incident, March 8 - April 5, 2011. U.S. Geological Survey Open-File Report 2011-1277, 34pp. 33. Wiedinmyer, C. and H. Friedli. 2007. Mercury Emission Estimates from Fires: An Initial Inventory for the United States. Environmental Science & Technology. 41: 8092-8098. 34. Aneja, V.P., W.H. Schlesinger, D. Niyogi, G. Jennings, W. Gilliam, R.E. Knighton, C.S. Duke, J. Blunden, and S. Krishnan. 2006. Emerging National Research Needs for Agricultural Air Quality. EOS. 87(3): pp. 25, 29. 35. Krupa, S.V. 2003. Effects of Atmospheric Ammonia (NH3) on Terrestrial Vegetation: A Review. Environmental Pollution.124: 179-221. 36. National Research Council. 2003. Air Emissions from Animal Feeding Operations: Current Knowledge, Future Needs. p. 263. National Academy Press, Washington, D.C. 37. Lambert, K.F. and V. Bowersox. 2002. Environmental Monitoring and Nationa Security: Is There a Connection? EM. August 2002: 17-22. 38. Knightes, C., M. Meaburn, and R. Araujo. 2007. Atmospheric Deposition of Mercury. EM. December 2007: 26-30. 39. Butler, T. J., Cohen, M. D., Vermeylen, F. M., Likens, G. E., Schmeltz, D., & Artz, R. S. (2008). Regional precipitation mercury trends in the eastern USA, 1998 2005: Declines in the Northeast and Midwest, no trend in the Southeast.Atmospheric Environment, 42(7), 1582-1592. 40. Prestbo, E. M., and D. A. Gay, 2009. Wet Deposition of Mercury in the U.S. and Canada, 1996-2005: Results and Analysis of the NADP Mercury Deposition Network (MDN), Atmospheric Environment 43 (September): 4223 4233. 41. Porter, E., and S. Johnson. 2007. Translating Science into Policy: Using Ecosystem Thresholds to Protect Resources in Rocky Mountain National Park. Environmental Pollution. 149: 268-280. 42. Harvey, F.E. 2001. Use of NADP Archive Samples to Determine the Isotope Composition of Precipitation: Characterizing the Meteoric Input Function for Use in Ground Water Studies. Ground Water. 49(3):380-390. 43. Dutton, A., B.H. Wilkinson, J.M. Welker, G.J. Bowen and K.C. Lohmann. 2005. Spatial Distribution and Seasonal Variation in 18O/16O of Modern Precipitation and River Water Across the Conterminous USA. Hydrological Processes. 39:4121-4146. 44. Harvey, F.E. 2005. Stable Hydrogen and Oxygen Isotope Composition of Precipitation in Northeastern Colorado. Journal of American Water Resources Association. April 2005:447-459. 45. Elliott, E.M., C. Kendall, S.D. Wankel, D.A. Burns, E.W. Boyer, K. Harlin, D.J. Bain, and T.J. Butler. 2007. Nitrogen Isotopes as Indicators of NOx Source Contributions to Atmospheric Nitrate Deposition Across the Midwestern and Northeastern United States. Environmental Science & Technology. 41: 7661-7667. 46. Dasgupta, P.K., J.V. Dyke, A.B. Kirk, and W.A. Jackson. 2006. Perchlorate in the United States: Analysis of Relative Source Contributions to the Food Chain. Environmental Science & Technology. 40:6608-6614. 47. Scott, B.F., C. Spencer, S.A. Mabury, and D.G. Muir. 2006. Poly and Perfluorinated Carboxylates in North American Precipitation. Environmental Science &

Technology. 40:7167-7174. 48. U.S. Environmental Protection Agency. 2011. Acid Rain and Related Programs, 2011 Progress Report (EPA-430-R-07-011). U.S. Environmental Protection Agency Office of Air and Radiation, Clean Air Markets Division,. 54 pp. 49. Burns, D.A., Lynch, J.A., Cosby, B.J., Fenn, M.E., Baron, J.S., US EPA Clean Air Markets Div., 2011, National Acid Precipitation Assessment Program Report to Congress 2011: An Integrated Assessment, National Science and Technology Council, Washington, DC, 114 p. 50. Air Quality Committee. 2012. United States - Canada Air Quality Agreement, Progress Report 2012. International Joint Commission, Washington, D.C. 92pp. 51. Meteorological Service of Canada. 2005. 2004 Canadian Acid Deposition Science Assessment: Summary of Key Results. Environment Canada, Ontario, Canada. 32 pp. 52. Qi, Z., Bartling, P. N., Ahuja, L. R., Derner, J. D., Dunn, G. H., & Ma, L., 2012. Development and evaluation of the carbon nitrogen cycle module for the GPFARM-Range model. Computers & Electronics in Agriculture 83: 1 10. 53. Moore, G. W., Barre, D. A., & Owens, M. K., 2012. Does shrub removal increase groundwater recharge in southwestern Texas semiarid rangelands? Rangeland Ecology & Management 65(1): 1 10. 54. Lawrence, G. B., Shortle, W. C., David, M. B., Smith, K. T., Warby, R. A. F., & Lapenis, A. G., 2012. Early indications of soil recovery from acidic deposition in U.S. red spruce forests. Soil Science Society of America Journal 76(4): 1407 1417. 55. Withgott, Jay, Scott R. Brennan, and Barbara Winifred Murck. Environment: The science behind the stories. Pearson Benjamin Cummings, 2013. 56. Eubanks, Lucy Pryde, Catherine Middlecamp, and Wilmer J. Stratton.Chemistry in context: Applying chemistry to society. Boston: McGraw-Hill, 2011.