



**2011 Annual Meeting and Scientific Symposium
NADP at the Nexus: Cross System Connections**

**October 25-28, 2011
Providence, RI**



National Atmospheric Deposition Program

Schedule at a Glance					
	Monday October 24	Tuesday October 25	Wednesday October 26	Thursday October 27	Friday October 28
7:30	Registration	Registration	Registration	Registration	
7:45	AMNet Training	Joint Subcommittee meeting	Registration	Registration	Total Deposition (TDEP) Science Committee Meeting (AM only)/ Field Trip (all day)
8:00			Conference Opening	Opening Remarks	
8:15			Annual State of NADP	Keynote Speaker (8:40)	
8:30		Break	Keynote Speaker (9:10)	Session 4 (6 Speakers)	
8:45		Subcommittee Meetings (4)	Break		
9:00			Session 1 (6 Speakers)	Break	
9:15				Session 5 (4 Speakers)	
9:30					
9:45					
10:00					
10:15					
10:30					
10:45					
11:00					
11:15					
11:30					
11:45					
12:00	Lunch on your own	Lunch on your own	Lunch on your own	Lunch on your own	
12:15					
12:30					
12:45					
1:00			Session 2 (4 Speakers)		
1:15					
1:30	AMNet Training	Joint Subcommittee meeting	Break	Session 5 (4 Speakers)	
1:45					
2:00			Session 3 (6 Speakers)		
2:15					
2:30				Session 6 (2 Speakers)	
2:45					
3:00					
3:15					
3:30		Break		Break	
3:45		Executive Committee Meeting		Session 6 (4 Speakers)	
4:00			Break		
4:15					
4:30					
4:45					
5:00					
5:15					
5:30			Poster Session and Reception		
5:45					
6:00					
6:15					
6:30					
7:00					
7:15					
7:30					
7:45					

NADP Proceedings 2011-12

**NADP 2011
Technical Committee Meeting**

October 25-28, 2011
Providence, RI

Scientific Symposium Chair
Kathleen C. Weathers
Cary Institute of Ecosystem Studies

PROCEEDINGS

Prepared by

**Lisa A. Volk
NADP Program Office
Illinois State Water Survey
Prairie Research Institute
University of Illinois
2204 Griffith Drive
Champaign, IL 61820**

October 2011

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NADP Scientific Symposium Agenda

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**NADP Annual Meeting and Scientific Symposium
Providence, RI
October 25-28, 2011**

Tuesday, October 25, 2011

Room Location

Open All Day	Registration Desk	Registration/Office
8:00 a.m. – 9:15 a.m.	Joint Subcommittee Meeting	Symphony A
9:15 a.m. – 9:30 a.m.	Break	
9:30 a.m. – 12:00 noon	Subcommittee Meetings Network Operations Data Management & Analysis Ecological Response and Outreach Critical Loads	Symphony A Beethoven Room Handel Room Mozart Room
12:00 noon - 1:30 p.m.	Lunch - On your own	
1:30 p.m. - 3:30 p.m.	Joint Subcommittee Meeting	Symphony A
3:30 p.m. - 3:45 p.m.	Break	
3:45 p.m. - 6:00 p.m.	Executive Committee Meeting	Symphony A

Wednesday, October 26, 2011

Room Location

Open All Day	Registration/Office	Registration/Office
8:30 a.m. - 9:10 a.m.	Welcome, Program Office Report, Awards and Announcements	Symphony Ballroom
	Kathleen Weathers: NADP Vice Chair, Symposium Chair Cary Institute of Ecosystem Studies	
	David Gay: NADP Coordinator	
	Pam Padgett: NADP Chair U.S. Forest Service	

Wednesday, October 26, 2011

Room Location

Symphony Ballroom

Keynote Address

9:10 a.m. – 9:40 a.m.	The Interactive Effects of Climate and Nitrogen on Ecosystems, Human, Health and Climate Jill Baron, U.S. Geological Survey/Colorado State University
9:40 a.m. – 10:00 a.m.	Break
Technical Session 1:	Linking Atmosphere to Biosphere Session Chair: Tom Butler Cornell University
10:00 a.m. – 10:15 a.m.	Estimates of Wet Deposition across North America: The Challenges and Opportunities of Merging Data across Nations Alexandra G. Ponette-Gonzalez, University of North Texas
10:15 a.m. – 10:30 a.m.	Deposition, Retention, and Loading of Nitrogen to Adirondack Lakes Charlie Canham, Cary Institute of Ecosystem Studies
10:30 a.m. – 10:45 a.m.	From Top to Bottom: Fluxes of Nitrogen from the Atmosphere to the Forest Floor in a Redwood Forest Pamela Templer, Boston University
10:45 a.m. – 11:00 a.m.	New Insights about the Influence of Reactive Nitrogen Deposition on Ecosystem Processes Emily Elliott, University of Pittsburgh
11:00 a.m. – 11:15 a.m.	Implications of Alpine Warming on Biogeochemical Cycling in Green Lakes Valley, Colorado Front Range, USA Rebecca T. Barnes, Bard Center for Environmental Policy
11:15 a.m. – 11:30 a.m.	The 2011 National Acid Precipitation Assessment Program Report to Congress Douglas A. Burns, U.S. Geological Survey
11:30 a.m. – 11:45 a.m.	Discussion
11:45 a.m. - 1:00 p.m.	Lunch – On your own

Wednesday, October 26, 2011

Room Location

Symphony Ballroom

Technical Session 2:	Those Other Compounds Session Chair: Pam Templer Boston University
1:00 p.m. – 1:15 p.m.	Elemental Composition of Washout Particulates in NADP Samples by Instrumental Neutron Activation Analysis Gregory A. Wetherbee, U.S. Geological Survey
1:15 p.m. – 1:30 p.m.	Collection and Characterization of Organic Matter in NADP Wet and Dry Deposition Natasha R. Goss, University of Colorado at Boulder
1:30 p.m. – 1:45 p.m.	Evaluations of Methods for Measuring Carbonaceous Aerosol in Rainwater Alexander Torres, University of Illinois
1:45 p.m. – 2:00 p.m.	Determination of Bromide in NADP/NTN Wet Deposition Samples and its Spatial and Temporal Correlation with North American Mercury Wet Deposition Christopher Lehmann, National Atmospheric Deposition Program
2:00 p.m. – 2:15 p.m.	Break
Technical Session 3:	Critical Loading of Ecosystems Session Chair: Tamara Blett National Park Service
2:15 p.m. – 2:30 p.m.	National Critical Load Database: An Assessment of Atmospheric Deposition across the U.S. Jason Lynch, Environmental Protection Agency
2:30 p.m. – 2:45 p.m.	A National Application of Critical Loads by the U.S. Forest Service to Assess Atmospheric Deposition Effects on Watershed Condition Linda Geiser, USDA Forest Service
2:45 p.m. – 3:00 p.m.	Developing the Critical Loads and Target Loads for Watersheds of the Great Smoky Mountain National Park Qingtao Zhou, Syracuse University

Wednesday, October 26, 2011

Room Location

Symphony Ballroom

Technical Session 3:	Critical Loading of Ecosystems (continued) Session Chair: Tamara Blett National Park Service
3:00 p.m. – 3:15 p.m.	An Overview of Recent Developments in Estimating Critical Loads of Atmospheric Deposition for Terrestrial Ecosystems Salim Belyazid, Belyazid Consulting and Communication
3:15 p.m. – 3:30 p.m.	Empirical Critical Loads for Nitrogen for Ecoregions of the United States: Current and Future Linda H. Pardo, USDA Forest Service
3:30 p.m. – 3:45 p.m.	Mapping Critical Loads of Nitrogen Deposition for Aquatic Ecosystems in the Rocky Mountains, USA David W. Clow, U.S. Geological Survey
3:45 p.m. – 5:30 p.m.	Break
5:30 p.m. – 8:00 p.m.	Poster Session and Reception

Symphony B

Thursday, October 27, 2011

Room Location

Open All Day	Registration/Office	Registration/Office
8:30 a.m. – 8:40 a.m.	Opening remarks, announcements and overview of Day 2 Kathleen Weathers, NADP Vice Chair, Cary Institute of Ecosystem Studies	Symphony Ballroom
Keynote Day 2		
8:40 a.m. – 9:10 a.m.	Evolution of a network: How NADP Stays Reliable and Relevant after Nearly 40 Years. Pam Padgett U.S. Forest Service	

Thursday, October 27, 2011

Room Location

Symphony Ballroom

Technical Session 4: How Much Deposition?

Session Chair: Donna Schwede
U.S. EPA

9:10 a.m. – 9:25 a.m. **Impact of Updates to the Community Multiscale Air Quality (CMAQ) Model on Predicted Deposition**
Donna Schwede, U.S. EPA

9:25 a.m. – 9:40 a.m. **Sources of Atmospheric Nitrogen to the Upper Susquehanna River/Chesapeake Bay Watershed with Special Reference to Ammonia**
Tom Butler, Cornell University

9:40 a.m. – 9:55 a.m. **Total Deposition at Clingmans Dome, Tennessee, in the Great Smoky Mountains National Park**
Selma Isil, AMEC E&I Inc.

9:55 a.m. – 10:10 a.m. **An Exploration of Nitrogen Total Deposition Budget Uncertainty at the Regional Scale**
Robin L. Dennis, U.S. EPA

10:10 a.m. – 10:25 a.m. **Developing the Aquatic Acidification Index (AAI) for a Combined Oxides of Sulfur and Nitrogen Secondary Air Quality Standard**
Richard Scheffe, U.S. EPA

10:25 a.m. – 10:40 a.m. **Urban Atmospheric Environments**
Richard Pouyat, USDA Forest Service

10:40 a.m. – 11:00 a.m. Break

11:00 a.m. – 11:15 a.m. Discussion

Thursday, October 27, 2011

Room Location

Symphony Ballroom

Technical Session 5: Spatial and Temporal Patterns in Deposition

Session Chair: Richard Pouyat
USDA Forest Service

11:15 a.m. – 11:30 a.m. **Temporal and Spatial Variability in Atmospheric Ammonia Concentrations in the Western United States**
Jeff L. Collett, Colorado State University

11:30 a.m. – 11:45 a.m. **Back Trajectory Analysis of Reactive Nitrogen Measured Continuously at Rocky Mountain National Park, Colorado**
Kristi A. Gebhart, National Park Service, CSU/CIRA

11:45 a.m. – 12:00 p.m. **Seasonal Nitrogen Deposition Budgets at Rocky Mountain National Park**
Bret A. Schichtel, National Park Service, CSU/CIRA

12:00 p.m. – 12:15 p.m. **An Assessment of the Performance of the Monitor for Aerosols and Gases in the Ambient Air (MARGA): a Semi-Continuous Method for Soluble Compounds**
Ian C. Rumsey, U.S. Environmental Protection Agency

12:15 p.m. – 1:45 p.m. Lunch - On your own

Technical Session 5: Spatial and Temporal Patterns in Deposition (continued)

Session Chair: Richard Pouyat
USDA Forest Service

1:45 p.m. – 2:00 p.m. **Preliminary Results from the CASTNET Ammonia Special Study**
Christopher Rogers, AMEC E&I, Inc.

2:00 p.m. – 2:15 p.m. **Special Patterns and Temporal Trends in Mercury Wet Deposition in the Great Lakes**
Martin R. Risch, U.S. Geological Survey

2:15 p.m. – 2:30 p.m. **Isoscapes of Atmospheric Nitrate: What Do They Tell Us?**
Greg Michlski, Purdue University

2:30 p.m. – 2:45 p.m. **From Air to Water: Hg Deposition and Biogeochemistry in Sunapee, NH Watersheds**
Holly Ewing, Bates College

Thursday, October 27, 2011

Room Location

Symphony Ballroom

- Technical Session 5: Spatial and Temporal Patterns in Deposition (continued)**
Session Chair: Richard Pouyat
USDA Forest Service
- 2:45 p.m. – 3:00 p.m. **Discussion**
- Technical Session 6: Global Issues and Atmospheric Deposition**
Session Chair: Holly Ewing
Bates College
- 3:00 p.m. – 3:15 p.m. **Radioactivity in Precipitation – Methods & Observations from Savannah River Site**
Dennis G. Jackson, Savannah River National Laboratory
- 3:15 p.m. – 3:30 p.m. **Reactor Fission Product Fallout in North American Wet-Deposition Samples, from the March 11, 2011 Fukushima Dai-ichi Incident**
Gregory A. Wetherbee, U. S. Geological Survey
- 3:30 p.m. – 3:45 p.m. **Break**
- 3:45 p.m. – 4:00 p.m. **Deposition Can Be Biological, Too**
M. Elias Dueker, Columbia University
- 4:00 p.m. – 4:15 p.m. **Free Tropospheric Export of East Asian Atmospheric Mercury Observed at Lulin Atmospheric Background Station in Taiwan**
Guey-Rong Sheu, National Central University
- 4:15 p.m. – 4:30 p.m. **Solar Dimming & Brightening as Related to Airborne Particulate Matter**
Victoria Kelly, Cary Institute of Ecosystem Studies
- 4:30 p.m. – 4:45 p.m. **Modeling Of Global Source Contributions to Atmospheric Mercury Deposition in the United States**
Krish Vijayaraghavan, ENVIRON International Corporation
- 4:45 p.m. – 5:00 p.m. **Discussion/Closing Comments**

Friday, October 28, 2011

Scientific Tour - <http://www.nbrrierr.org/index.html>



- 7:15 a.m. Depart from hotel
- 8:00 a.m. Ferry Departs for Prudence Island
- Lunch at Narragansett Estuary (box lunch provided)
- 4:00 p.m. Ferry departs from Prudence Island
- 5:00 p.m. Return to hotel

2011 NADP SITE OPERATOR AWARDS

11

12

NATIONAL ATMOSPHERIC DEPOSITION PROGRAM OPERATOR AWARDS

5 YEAR AWARDS

Site	Operator Name	Site Name	Start	Agency
AK01 – NTN	Brian Charlton	Caribou-Poker Creek	12/29/92	U.S. Forest Service
CO93 – NTN	Nicolai Bencke	Buffalo Pass – Dry Lake	10/14/86	U.S. Forest Service
CO97 – NTN	Nicolai Bencke	Buffalo Pass – Summit Lake	02/07/84	U.S. Forest Service
MDN		Buffalo Pass – Summit Lake	09/29/98	
OK01 – NTN	Bryan Sims	McGee Creek	10/31/06	Oklahoma DEQ

10 Year Awards

Site	Operator Name	Site Name	Start	Agency
CAN5- NTN	Serge D'Amour	Frelighsburg	10/02/01	U.S. Geological Survey
CT15 - NTN	George Askew	Abington	01/26/99	U.S. EPA-Clean Air Markets
GA09 - NTN	Ronald Phernetton	Okefenokee National Wildlife Refuge	06/03/97	U.S. FWS-Air Quality Branch
NY22 - NTN	Angela Benedict-Dunn	Akwesasne Mohawk-Fort Covington	08/18/99	U.S. EPA-Clean Air Markets

15 Year Awards

Site	Operator Name	Site Name	Start	Agency
CA99 - NTN	Katy Warner	Yosemite National Park-Hodgdon Meadow	12/08/81	National Park Service-ARD
KS32 - NTN	Curt Sauer	Lake Scott State Park	03/27/84	U.S. Geological Survey
KY35 - NTN	Jeff Stamper	Clark State Fish Hatchery	08/30/83	U.S. Geological Survey
MN23 - MDN	Mary McGuire	Camp Ripley	07/02/96	Minnesota Pollution Control Agency
TX10 - NTN	Terry Rossignol	Attwater Prairie Chicken National Wildlife Refuge	07/03/84	U.S. Geological Survey
WA24 - NTN	Robert Barry	Palouse Conservation Farm	08/20/85	U.S. Geological Survey
WI08 - MDN	Ron Perala	Brule River	03/05/96	Wisconsin DNR
WI09 - MDN	Cathy McLain	Popple River	03/05/96	Wisconsin DNR
WI37 - NTN	Mark Sundeen	Spooner	06/03/80	Wisconsin DNR

20 Year Awards

Site	Operator Name	Site Name	Start	Agency
C022 - NTN	Mark Lindquist	Pawnee	05/22/79	National Science Foundation Shortgrass Steppe LTER
CO91 - NTN	Todd Pitcher	Wolf Creek Pass	05/26/92	U.S. Forest Service
ND11 - NTN	Gayle Cook	Woodworth	11/29/83	U.S. Geological Survey
NY98 - NTN	Douglas Wolfe	Whiteface Mountain	07/03/84	U.S. Geological Survey
OH49 - NTN	Mike Franko	Caldwell	09/26/78	U.S. Geological Survey
WI28 - NTN	Barry Benson	Lake Dubay	06/29/82	Wisconsin DNR
WI98 - NTN	Karen Teed	Wildcat Mountain	08/01/89	Wisconsin DNR

25 Year Awards

Site	Operator Name	Site Name	Wet Start	Agency
KS07 - NTN	Dan Mosier	Farlington Fish Hatchery	03/27/84	U.S. Geological Survey
MI99 - NTN	David Toczydlowski	Chassell	02/15/83	National Park Service-ARD
NE99 - NTN	Jim Goeke	No. Platte Agricultural Experiment Stn	09/24/85	U.S. Geological Survey
VT01 - NTN	Dan Taylor	Bennington	04/28/81	U.S. Geological Survey
WI09 - NTN	Cathy McLain	Popple River	12/30/86	Wisconsin DNR
WV18 - NTN	John Pearce	Parsons	07/05/78	U.S. Forest Service

30 Year Awards

Site	Operator Name	Site Name	Wet Start	Agency
MI09-NTN	Robert Vande Kopple	Douglas Lake	07/03/79	SAES-Michigan State Univ

KEYNOTE SPEAKER:

JILL BARON, SENIOR RESEARCH ECOLOGIST, COLORADO
STATE UNIVERSITY

Jill S. Baron

Dr. Jill S. Baron is an ecosystem ecologist with the U.S. Geological Survey, and a Senior Research Ecologist with the Natural Resource Ecology Laboratory at Colorado State University. Her interests include applying ecosystem concepts to management of human-dominated regions, and understanding the biogeochemical and ecological effects of climate change and atmospheric nitrogen deposition to mountain ecosystems. She is co-director of the John Wesley Powell Center for Earth System Science Analysis and Synthesis. Baron was Lead Author of the U.S. Climate Change Science Program report on Climate Change Adaptation Options for National Parks, has given testimony to Congress on western acid rain and climate change issues, and is Editor-in-Chief of *Issues in Ecology*, an Ecological Society of America publication for non-scientists. She is founder and Principal Investigator of the Loch Vale Watershed long-term monitoring and research program in Rocky Mountain National Park, an instrumented catchment with 30 years of continuous records. Dr. Baron received her Ph.D. from Colorado State University in 1991, and has undergraduate and master's degrees from Cornell University and the University of Wisconsin.

TECHNICAL SESSION 1:
LINKING ATMOSPHERE TO BIOSPHERE

*Session Chair: Tom Butler,
Cornell University*

Estimates of Wet Deposition across North America: the Challenges and Opportunities of Merging Data across Nations

Alexandra G. Ponette-González¹ and Kathleen C. Weathers²

The absence of a national atmospheric deposition network in Mexico represents a significant monitoring gap for North America. Although air quality measurements have been conducted in major cities throughout the country since the 1980s, the Red de Depósito Atmosférico (REDDA) in the Metropolitan Area of the Valley of Mexico is currently the only formal set of sites used to assess bulk wet and dry deposition. For other parts of Mexico, data on atmospheric deposition are scarce and limited to relatively few published studies. Many of these are restricted to a handful of sites and are short in duration. As a result, it is not possible to extrapolate findings to surrounding areas. Notwithstanding the paucity of atmospheric deposition research in Mexico, it is clear that this rapidly urbanizing and industrializing nation needs a national-scale deposition monitoring network. First, SO₂ and NO_x emissions to the atmosphere are either stable or increasing. Second, evidence from central and eastern Mexico indicates that deposition rates to natural and managed ecosystems may also be rising, with potentially acidifying effects on terrestrial and aquatic ecosystems. Third, more than half of Mexico's territory is >1000 m elevation. Deposition rates to montane landscapes are generally elevated compared to lowland areas, while deposition patterns are also more heterogeneous due to climatic, vegetational and topographic diversity. Finally, cross-boundary transport of atmospheric pollutants and the cascading ecological effects of enhanced deposition affect shared airsheds and watersheds between Mexico and its North American neighbors. For these reasons, a spatially-extensive and well distributed network of sites is necessary to identify levels of exposure to nutrients and pollutants across Mexico, and to assess and predict deposition effects on species diversity, sensitive ecosystems, watersheds, and climate.

¹Alexandra G. Ponette-González
Department of Geography
University of North Texas
1155 Union Circle #305279
Denton, Texas 76203, USA
Tel: (940)-565-2091
E-mail: alexandra@unt.edu

²Kathleen C. Weathers
Cary Institute of Ecosystem Studies
2801 Sharon Turnpike
P.O. Box AB
Millbrook NY 12545-0129, USA
Tel: (845) 677-7600 Ext. 137 (Direct)
E-mail: weathersk@ecostudies.org

Deposition, Retention, and Loading of Nitrogen to Adirondack Lakes

Charles D. Canham¹, Michael L. Pace², and Kathleen C. Weathers³

Loading of nutrients from terrestrial ecosystems strongly influences the productivity and biogeochemistry of aquatic ecosystems. Human activities can supplement and even dominate nutrient loading to many lakes, particularly in agricultural and urbanized settings. For lakes in more remote regions such as the Adirondack Mountains of New York, N deposition represents the primary potential anthropogenic nutrient source. We have combined a detailed spatial model of N deposition with data on lake N concentrations and detailed spatial data on watershed configuration to identify the sources of watershed N loading for over 200 lakes in the Adirondacks. The analysis indicates that while wetlands would be a stronger source of N loading per unit area than forests in the absence of inorganic N deposition, wetlands retain essentially all of the inorganic N deposition, while forests retained ~ 87% of N deposition. Since forests represent close to 90% of the watersheds, on average, upland forests are the single largest source of N loading to these lakes. Direct deposition of N to the surface of the lake accounted for as large a fraction of total loading as loading from wetlands in the watersheds. We found no evidence that presence of wetlands along upland flowpaths to lakes reduced loading from upland forests. Moreover, there was no evidence that net loading to lakes declined with increasing distance from a source area to the lake. Both of these lines of evidence suggest that N may be transported through these forested watersheds primarily in organic forms.

¹ Cary Institute of Ecosystem Studies, Millbrook, NY 12545; phone: (845) 677-5343; e-mail: canhamc@caryinstitute.org

² Department of Environmental Sciences, University of Virginia, Charlottesville, VA 22904. phone: (434) 924-6541; e-mail: mlp5fy@virginia.edu

³ Cary Institute of Ecosystem Studies, Millbrook, NY; phone: (845) 677-5343; e-mail: weathersk@caryinstitute.org

From top to bottom: fluxes of nitrogen from the atmosphere to the forest floor in a redwood forest

Pamela Templer¹, Holly Ewing², Kathleen Weathers³, Todd Dawson⁴, and Mary Firestone⁵

Fog water contains a range of important nutrients and ions that can potentially influence terrestrial forest ecosystems. Nitrogen is present in fog, sometimes in high concentrations and often in much higher concentrations than normally found in rainwater. A defining feature of the redwood forest in coastal California is the presence of fog in the summer months. In this Mediterranean climate region, the fog provides water in a time when there is typically no rainfall. However, it is not known whether redwood trees can access nitrogen directly from fog. The goal of this project is to better understand the links between the water and nitrogen cycles of coastal forest ecosystems.

In this project, we hypothesize that fog water provides redwood trees with nitrogen during the summer months when they would otherwise not be taking up nutrients. We are using natural abundance techniques to determine the source of nutrients for redwood trees throughout the year. Our results show that inorganic nitrogen entering the forest floor via fog is greatest at the forest edge closest to the ocean ($p < 0.05$) where the redwood canopy has the greatest potential for interception, compared to the interior of the forest. Similarly, we found that rain water nitrogen inputs to the forest floor are greatest at the forest edge ($p < 0.05$), but the magnitude of this difference is not as strong. While $\delta^{15}\text{NO}_3$ values were not significantly different between rain and fog water samples, $\delta^{15}\text{NH}_4$ values were significantly greater in fog compared to rain water and throughfall. $\delta^{15}\text{N}$ values of foliage from forest edge trees were significantly greater compared to interior trees ($p < 0.05$), suggesting that the forest edge trees may be obtaining a greater proportion of their nitrogen directly from fog compared to the interior trees.

¹Boston University, Boston, MA, 02215; ptempler@bu.edu; 617-353-6978

²Environmental Studies, Bates College, 111 Bardwell Street, Lewiston, Maine 04240

³Cary Institute of Ecosystem Studies, Millbrook, NY, 12545

⁴Department of Integrative Biology, University of California Berkeley 94720

⁵Environmental Science, Policy and Management, University of California Berkeley 94720

New insights about the influence of reactive nitrogen deposition on ecosystem processes

Emily M. Elliott^{1*}, Lucy Rose¹, and J. David Felix¹

¹University of Pittsburgh

*Corresponding author: eelliott@pitt.edu

The family of NADP and CASTNET monitoring networks are the foundation for our understanding of atmospheric wet and dry nitrogen (N) deposition to landscapes. As such, empirical deposition measurements from these networks are commonly used in watershed N budget models and ecosystem studies. However, isotopic, remote sensing, and modeling studies indicate a more spatially heterogeneous pattern of reactive N deposition than is currently captured by these networks. In this presentation, we document variable rates of atmospheric deposition of reactive N across spatial scales using several approaches. We then examine the potential implications of such deposition patterns on ecosystem processes using examples from near-road environments, agricultural systems, and forested watersheds.

Implications of alpine warming on biogeochemical cycling in Green Lakes Valley, Colorado Front Range, USA

Rebecca T. Barnes¹, Jordan N. Parman² and Mark W. Williams³

Alpine ecosystems are particularly susceptible to disturbance due to their short growing seasons, sparse vegetation and thin soils. Atmospheric nitrogen deposition and warming temperatures currently affect Green Lakes Valley (GLV) within the Colorado Front Range. Research conducted within the alpine links chronic nitrogen inputs to a suite of ecological impacts, resulting in increased nitrate export. According to NADP records at the site, the atmospheric flux of nitrogen has decreased by 0.56 kg ha⁻¹ yr⁻¹ since 2000, due to a decrease in precipitation. Concurrent with this decrease, alpine nitrate yields have continued to increase; by 32% relative to the previous decade (1990-1999). In order to determine the source(s) of the sustained nitrate increases we utilized long term datasets to construct a mass balance model for four stream segments (glacier to subalpine) for nitrogen and weathering product constituents. We also compared geochemical fingerprints of various solute sources (glacial meltwater, thawing permafrost, snow, and stream water) to alpine stream water to determine if sources had changed over time. Long term trends indicate that in addition to increases in nitrate; sulfate, calcium, and silica have also increased over the same period. The geochemical composition of thawing permafrost (as indicated by rock glacial meltwater) suggests it is the source of these weathering products. Mass balance results indicate the high ammonium loads within glacial meltwater are rapidly nitrified, contributing approximately 0.45 kg yr⁻¹ to the NO₃⁻ flux within the upper reaches of the watershed. The sustained export of these solutes during dry, summer months is likely facilitated by thawing cryosphere providing hydraulic connectivity late into the growing season. In a neighboring catchment, lacking permafrost and glacial features, there were no long term weathering or nitrogen solute trends; providing further evidence that the changes in alpine chemistry in GLV are likely due to cryospheric thaw exposing soils to biological and geochemical processes. These findings suggest that efforts to reduce nitrogen deposition loads may not improve water quality, as melting cryosphere associated with climate change may affect alpine nitrate concentrations as much, or more than atmospheric deposition trends.

¹Bard Center for Environmental Policy, Annandale-on-Hudson, NY 12504, 845-758-7321, becca.barnes@gmail.com

²Institute of Arctic & Alpine Research, University of Colorado, Boulder, CO 80309, jordan.parlman@colorado.edu

³Institute of Arctic & Alpine Research, University of Colorado, Boulder, CO 80309, markw@culter.colorado.edu

The 2011 National Acid Precipitation Assessment Program Report to Congress

Douglas A. Burns¹, Jason A. Lynch², Bernard J. Cosby³, Mark E. Fenn⁴, Jill S. Baron⁵

The National Acid Precipitation Assessment Program (NAPAP) was established by the Acid Precipitation Act of 1980 to lead a multi-million dollar research program to determine the causes and environmental consequences of acid rain and to report these results to Congress. NAPAP has continued since completion of that first major task in 1991 (as enabled by the Clean Air Act Amendments of 1990) by providing a quadrennial report to Congress that: (1) summarizes the costs and benefits of the Acid Rain Control Program, (2) documents trends in acid deposition, (3) summarizes the state-of-science regarding the effects of acid precipitation on ecosystems, and (4) reports on reductions in SO₂ and NO_x emissions needed to protect ecosystems from acidification. The current report provides updated trends in the emissions, atmospheric deposition, and surface water chemistry of S and N air pollutants and related chemical constituents. This report also provides for the first time, an assessment of critical loads and exceedances for acid-sensitive regions of the eastern US, and a synthesis of current scientific understanding regarding the interactions of S and N air pollutants with changes in climate and the carbon cycle. The report documents large decreases in SO₂ and NO_x emissions and in wet and dry deposition of S and N since the early 1990s across much of the US. Parallel trends of lower magnitude than those of deposition have been observed in acid-neutralizing capacity (ANC) values of surface waters in regions sensitive to acidification. Soil acidification from decades of acid deposition has been identified as a key reason why surface water recovery has been sluggish to date. Despite some improvement in surface water chemistry in many sensitive regions of the US, widespread biological recovery in aquatic ecosystems is not yet evident, and the steady-state critical load is exceeded by current deposition rates in about 30% of surface waters in the Adirondacks and Central Appalachians. Model results for three different scenarios with progressively greater decreases of SO₂ and NO_x emissions by 2020 to levels below those required by air quality laws in place as of 2005 indicate progressively fewer surface waters with ANC values in the ranges of <50 µeq/L by the year 2050 in the Adirondacks, Northeast, and Southeast, but also that more than half the surface waters with ANC <50 µeq/L would remain below this level of elevated concern.

¹ U.S. Geological Survey, 425 Jordan Rd., Troy, NY 12180, 518-285-5662, daburns@usgs.gov

² U.S. Environmental Protection Agency, Washington, DC

³ Univ. of Virginia, Charlottesville, VA

⁴ U.S. Forest Service, Riverside, CA

⁵ U.S. Geological Survey, Fort Collins, CO

**TECHNICAL SESSION 2:
THOSE OTHER COMPOUNDS**

*Session Chair: Pam Templar,
Boston University*

Elemental Composition of Washout Particulates in NADP Samples by Instrumental Neutron Activation Analysis

Gregory A. Wetherbee¹, Timothy M. Debey², and Christopher M.B. Lehmann³

Washout particulates were analyzed from weekly wetfall samples collected by the National Atmospheric Deposition Program (NADP) at four sites in the Rocky Mountains and three sites in the Great Lakes region during December from 2010 – May 2011. The NADP Central Analytical Laboratory collected filters (0.45 microns) used to process weekly wetfall samples. The U.S. Geological Survey (USGS) composited the filters by month and site in polyethylene capsules for Instrumental Neutron Activation Analysis (INAA). USGS irradiated the filters with neutrons in the TRIGA¹ research reactor, and then analyzed them by gamma spectrometry to estimate mass of identified elements after blank correction.

Results indicate washout elemental relative abundances are generally consistent with relative crustal abundance with subtle regional differences. Elements of atomic number less than Na are not measurable, and Ca and S, are not easily measured by INAA.

Region & NADP Sites	Elements Identified and Relative Abundance	Sampling Period Flux Range (grams/m ²)
<i>Rocky Mountains</i>	K>Na>Cl>Cr>Mn	10 ⁻¹ - 37
CO92, CO93, CO96, WY95	Ba>Xe>Fe>As>Br>Cu>Zn>V>W>Sb>Ce>La Cs>Co>Zr>Mo>Hg>Sc>Ru>Ag>Eu>Au>Sr	10 ⁻³ - 10 ⁻² 10 ⁻⁶ - 10 ⁻⁵
<i>Great Lakes</i>	K	1.5 - 31
IN34, MI09, MI99	Na>Mn>Cl>Cd>Ba>Cr>Al Fe>As>Zn>Br>W>Zn>Cu>Ce>V>Sb Ru>Cs>La>Sc>Hg>Mo>Eu>Se>Ag>Au	10 ⁻² - 1.5 10 ⁻³ - 10 ⁻² 10 ⁻⁶ - 10 ⁻⁵

Elemental enrichment factors indicate potential anthropogenic sources. (EF) were calculated for most elements as: $EF = \frac{(X/C)_{atmospheric}}{(X/C)_{crustal}}$

where *X* and *C* are relative abundances of elements of interest and a reference element, in this case Na (EF:Na)², respectively. EF:Na values ranged from 2 to 8,874 for selected elements. EF:Na values for As (10 samples), Cr (9 samples), Cu (1 sample), Mn (3 samples), Fe and V (1 sample each). The highest EF:Na values for As, Cl, Cu, and Mn were observed during December 2010 for IN34, which is located downwind of industrial centers in Chicago, IL and Gary, IN.

Measurement of particulate Hg on NTN filters using INAA offers a practical and inexpensive method to augment Hg speciation data at NTN sites co-located with Mercury Deposition Network and Atmospheric Mercury Network sites. Hg-associated particulates in washout are of interest because this phase of Hg speciation is not well characterized. Monthly particulate Hg deposition ranged from 0.04 to 7.5 mg/m².

¹Use of trade of firm names is for identification only and does not constitute endorsement by U.S. government.

²Landsberger S., Jarvis, R. E., and Monaro, S., 1985, Trace analysis of wet atmospheric deposition by nuclear methods, in J.F. Lawrence, ed., Trace Analysis, vol. 4, Academic Press, Inc., Orlando, FL.

³U.S. Geological Survey (USGS), Branch of Quality Systems, ²USGS, Energy, Minerals, and Environmental Health, National Reactor Facility; ³University of Illinois, Prairie Research Institute

Collection and Characterization of Organic Matter in NADP Wet and Dry Deposition

N. R. Goss¹, N. Mladenov¹, E. M. Boor¹, C. Seibold¹, K. Chowanski¹, S. K. Schmidt² and M. W. Williams^{1,3}

Organic matter in the atmosphere significantly affects visibility, human respiratory health, and climate change. Dissolved organic matter (DOM) is predominantly organic carbon and, among other functions, supplies energy to support the food web. Recent findings suggest that atmospheric deposition influences the quality of DOM in alpine lakes on a global scale. Here, we evaluate the quantity and quality of DOM in wet and dry deposition and of total particulate matter (PM) in dry deposition at the Niwot Ridge Long Term Ecological Research Station (Colorado, USA), and nearby alpine and subalpine ecosystems. Atmospheric wet deposition collectors located at NADP CO02 (3520 m a.s.l.), CO90 (3022 m a.s.l.), and CO94 (2524 m a.s.l.) were analyzed, as were wet and dry collectors at the Soddie site (3345 m a.s.l.).

Wet deposition was found to be a seasonally variable source of dissolved organic carbon (DOC), depositing on average 6 kg C/ha/yr or roughly 1500 kg C to the Green Lake 4 watershed at Niwot Ridge. This wet deposition of DOC was equivalent to over 80% of the carbon yield from the watershed. For dry deposition, which is often subject to sample loss in windy alpine environments, we developed a new marble insert procedure. In tests with known dust loading, we found that PM recovery was comparable to controls with no insert. Current efforts are aimed at quantifying the total PM deposition and its organic fraction. Thus far, our measurements of PM loading in dry deposition from collectors with inserts have shown that PM loading is highly variable, ranging from 100 to >230 g/ha/d in June and July, 2011. Estimates of particle numbers (> 4 µm) using a FlowCAM echoed this variability, showing that 104 to 105 particles/d were found in summer dry and wet deposition, and identified large numbers of pollen and other bioaerosols. Characterization of DOM in wet and dry deposition by fluorescence and absorbance spectroscopy showed that DOM chemical character and optical properties varied widely. In summer months, high concentrations of amino acid-like fluorescence suggest the deposition of bioaerosols and more biologically labile organic compounds. High spectral slope ratios (>2) further suggest that DOM in atmospheric deposition undergoes intense photobleaching, which may enhance bioavailability.

¹ Institute of Arctic and Alpine Research, University of Colorado at Boulder, UCB 450, Boulder, CO 80309, USA (natasha.goss@colorado.edu, natalie.mladenov@colorado.edu, ethan.boor@colorado.edu, christine.seibold@colorado.edu, kurt.chowanski@colorado.edu)

² Department of Ecology and Evolutionary Biology, University of Colorado Boulder, Campus Box 334, Boulder, CO 80301 (steve.schmidt@colorado.edu)

³ Department of Geography, University of Colorado at Boulder, UCB 360, Boulder, CO 80309, USA (markw@snobear.colorado.edu)

Evaluation of Methods for Measuring Carbonaceous Aerosol in Rainwater

Alexander Torres*, Tami Bond, and Christopher Lehmann
University of Illinois at Urbana-Champaign

Fuel combustion and other activities produce organic carbon (OC) and black carbon (BC) aerosols that are transported in the atmosphere and have adverse effects on visibility, climate change, and human health. Wet deposition is the main removal mechanism of carbon aerosols; hence, it dictates the atmospheric cycle and the lifetime, and the extent of the undesirable impacts. The study of wet removal of organic carbon and black carbon aerosols has been very limited. Challenges in this endeavor include the lack of a widely accepted method for their measurement, low levels of BC, and the susceptibility the samples to OC contamination and degradation. The goal of this research is to develop a sound analytical procedure to measure OC and BC in rain that can be incorporated into the NADP Monitoring. Different analytical techniques were tested to measure BC in precipitation, including: Thermal/Optical Analysis, Single Particle Soot Photometer (SP2), and UV/VIS Spectrophotometer. Water soluble OC was measured by Total Organic Carbon (TOC) Analysis and water insoluble OC was measured by Thermal/Optical Analysis. The evaluation was performed using laboratory standard solutions made by burning pine wood and aging with ozone, and rain samples collected by the National Atmospheric Deposition Program at Bondville (Champaign County), Illinois. Results indicated that filtration followed by thermal/optical analysis is only efficient (~90%) when a coagulant aid is added to the sample to increase particulate size and the collection efficiency of the quartz fiber filters. The UV/VIS spectrophotometer has proved to respond linearly at 550 nm-wavelength to BC particles in water; nevertheless, further evaluation of the interference of non BC particles is required. The SP2 analysis showed good reproducibility and sensitivity, despite its inherent losses (~33%) during the sample nebulizing. TOC Analysis is able to measure more than 95% of the total carbon (OC and BC).

*Corresponding author: (787) 515-7225; 337 Paddock DR W, Savoy IL 61874;
aturnesa1@uiillinois.edu

Determination of Bromide in NADP/NTN Wet Deposition Samples and its Spatial and Temporal Correlation with North American Mercury Wet Deposition

Christopher Lehmann, Lee Green, Tracy Dombek, and David Gay

National Atmospheric Deposition Program
Illinois State Water Survey, Prairie Research Institute
University of Illinois at Urbana-Champaign
Phone: 217-265-8512
Email: clehmann@illinois.edu

Bromide is released into the environment via natural and anthropogenic processes. Brominated flame retardants are used widely in a wide variety of products, while methyl bromide is a fumigant applied before and after harvest for a variety of fruits and vegetables. Methyl bromide is classified as an ozone-depleting substance, and its use is strictly regulated and monitored by the U.S. EPA. Research has linked gaseous bromide to oxidation of elemental mercury in the atmosphere; this could lead to enhanced deposition of mercury to the terrestrial environment. Therefore it is of interest to determine if there is any correlation in time and space between oxidized forms of bromine and mercury wet deposition.

The NADP is evaluating bromide as an additional analyte for its 244-site National Trends Network (NTN) and 7-site Atmospheric Integrated Research Monitoring Network (AIRMoN). Bromide concentrations have been measured in all NTN and AIRMoN samples since June of 2009. Additional funding was provided by the U.S. Geological Survey to evaluate bromide concentrations in NTN archive samples. Archive samples from 2001 and 2002 were selected based upon geographical locations and agricultural activities in those areas. Spatial and temporal trends are evaluated and presented from the data obtained for 2001-2002 and 2009-2010. Initial spatial trends indicate that the highest wet concentrations of bromides are in the Rocky Mountains and along the Gulf and East Coast of North America.

Data from the National Atmospheric Deposition Program/Mercury Deposition Network (NADP/MDN) indicate significant trends have occurred in the deposition of mercury in certain regions of the United States (U.S.). Collocated bromide wet deposition samples are studied to determine spatial or temporal relationships between mercury and bromide concentrations.

TECHNICAL SESSION 3:
CRITICAL LOADING OF ECOSYSTEMS

*Session Chair: Tamara Blett,
National Park Service*

National Critical Load Database: an assessment of atmospheric deposition effects across the U.S.

Jason Lynch, Jack Cosby, Linda Pardo, Tamara Blett, Richard Haeuber, Richard Pouyat and Cindy Huber

In the United States, critical loads are emerging as an important assessment and policy tool for protecting ecosystems from atmospheric deposition of pollutants. Critical loads simplify complex scientific information on exposure to air pollutants, making them an effective tool for informing policy and land management decisions. However, only limited national assessment of critical loads and exceedances have been undertaken in the United States because of a lack of a repository for critical load data and coordination between scientists and federal managers. Beginning in 2006, the primary forum for critical loads research and development coordination in the United States has been the Critical Loads of Atmospheric Deposition Science Committee (CLAD) of the National Atmospheric Deposition Program. In 2010, the “FOCUS Pilot Study” project began a national effort to synthesize empirical and calculated critical loads and to submit data unofficially to the UNECE Coordinating Center on Effects in the interests of international cooperation and exchange of information on the effects of atmospheric deposition on ecosystems. The goals include developing methods to characterize CLs in a standardized reproducible fashion, characterize uncertainty in CLs, identify gaps in available data, and advance efforts to use CLs as an air quality management tool for policy and land management assessment. This national database for sulfur (S) and nitrogen (N) compounds is comprised of three major critical load sources: 1) empirical N critical loads for fungi, lichens, herbaceous, forests (Pardo et al. 2011; Geiser et al. 2010); 2) steady-state soil critical load for acidity (McNulty et al. 2007); and 3) steady-state surface water CLs of acidity. We present two analyses that use the CL database to examine the reliability and uncertainty of CL values and assess national CL exceedances with respect to current deposition loading of NO_x and SO_x. We found that different surface water CL models for acidity produced comparable values. In addition, emission control programs, such as the Acid Rain Program, NO_x Budget Trading Program and Clean Air Interstate Rule, together with other controls, have increased ecosystem protection from acidic deposition across the US.

Affiliations:

Jason Lynch – Environmental Protection Agency, 202-343-9257, lynch.jason@epa.gov
Jack Cosby – University of Virginia, 434-924-7761, B.J.Cosby@virginia.edu
Linda Pardo – USDA Forest Service, 802-951-6771, lpardo@fs.fed.us
Tamara Blett – National Park Service, 303-969-2011, tamara_blett@nps.gov
Richard Haeuber – Environmental Protection Agency, 202-343-9250, haeuber.richard@epa.gov
Richard Pouyat – USDA Forest Service, 703-605-5286, rpouyat@fs.fed.us
Cindy Huber – USDA Forest Service, 540-265-5156, chuber@fs.fed.us

A national application of critical loads by the US Forest Service to assess atmospheric deposition effects on watershed condition.

Cindy Huber¹, Linda Geiser², Erika Cohen³, William Jackson⁴, Linda Pardo⁵, Rick Graw⁶

The critical load (CL), or atmospheric deposition loading below which no harmful effect can be detected to an ecosystem component according to current knowledge, is a science-based tool of growing interest to land managers to understand existing conditions in relationship to natural resource protection goals. In a first national scale application by a federal land management agency, the Forest Service used terrestrial critical loads of acidification and nutrient nitrogen to assess air pollution effects to watershed condition throughout the national forest system. Here we report on the methods and decision-making processes that were used to calculate CLs, apply them to the 6th level HUC, and then classify watershed condition based on CL exceedances. Three ratings were used; good (functioning properly), fair (functioning at risk), or poor (impaired function); based on the maximum CL exceedance that occurred within the watershed. Forest managers then used these rankings, along with 22 additional attributes of watershed condition, to evaluate local conditions on individual national forests. Their responses regarding the utility of the CL-based component of the watershed condition assessment are discussed.

¹ USFS Southern Region Air Program, 540-265-5156, 5162 Valleypointe Parkway, Roanoke, VA 24019, chuber@fs.fed.us

² USFS Pacific Northwest Region Air Program, 541-231-9452, P.O. Box 1148, Corvallis, OR 97330, lgeiser@fs.fed.us

³ USFS Southern Research Station, 919-513-3189, 3041 Cornwallis Rd., Research Triangle Park, NC 27709, ecohen@fs.fed.us

⁴ USFS Southern Region Air Program, 828-257-2815, 160A Zillicoa Street, Asheville, NC 28801-1082, bjackson02@fs.fed.us

⁵ USFS Northern Research Station, 802-951-6771 x1330, 705 Spear St S., Burlington, VT 05403, lpardo@fs.fed.us

⁶ USFS Pacific Northwest Region Air Program, 503-808-2918, P.O. Box 3623 Portland, OR 97208-3623, rgraw@fs.fed.us

Developing the critical loads and target loads for watersheds of the Great Smoky Mountain National Park

Qingtao Zhou¹, Charles T Driscoll^{1*}, Steve E Moore², John S. Schwartz³

Critical loads and target loads were calculated for 12 watersheds in the Great Smoky Mountain National Park, Tennessee using the hydrochemical model PnET-BGC. The 12 sites were chosen based on a block design and have different watershed characteristics with acid neutralizing capacity (ANC) values ranging from to $-14 \mu\text{eq/L}$ to $60 \mu\text{eq/L}$. Some of the watersheds have no prior land disturbance history such as Left Prong Anthony and Walker Camp Prong, while others have been affected by the human settlement, diffuse disturbance, logging or exotic insect infestation. The model is run from 1000 year to 1850 as a spin-up period. 1850 to 2010 is a hindcast period in which stream chemistry is simulated based on reconstructions of historical changes in acidic deposition and land disturbance. From 2010 to 2200 year the model is run under a range of future scenarios of decreases in SO_4^{2-} , NH_4^+ and NO_3^- deposition to estimate target and critical loads. Our results show that the model simulations of long-term stream data match well with the observed data. We find that most of the SO_4^{2-} from atmospheric deposition is adsorbed by soil, and most of the stream output of Ca^{2+} is the result of desorption from the soil exchange complex. The results show that the historical acidification has a similar pattern across the watersheds in which the ANC was decreased significantly since the industry time-1850. The results also show that decreases in NO_3^- deposition are much more effective in achieving increases in stream ANC than decreases SO_4^{2-} deposition. These results are markedly different than the results of previous simulations conducted for northern forest sites. Decreases in NH_4^+ and SO_4^{2-} deposition had comparable and but small effects on increasing stream ANC.

*Corresponding author: Department of Civil and Environmental Engineering, Syracuse University, Syracuse NY 13244; (315)443-3434; cd104@atlas.syr.edu

¹ Department of Civil and Environmental Engineering, Syracuse University, Syracuse NY 13244,

² Great Smoky Mountains National Park, 107 Park Headquarters Road, Gatlinburg, TN 37738.

³ Department of Civil and Environmental Engineering, University of Tennessee, Knoxville, Tennessee 37996-2010

An overview of recent developments in estimating critical loads of atmospheric deposition for terrestrial ecosystems

Salim Belyazid^{*}, Harald Sverdrup, Jennifer Phelan, Timothy Sullivan

The hypothesis of steady state is the main underlying assumption of both empirical and dynamically modeled Critical Load (CL) estimates. Furthermore, while empirical CLs are derived from direct impacts of deposition on biological properties of ecosystems, classical dynamically modeled CLs use chemical criteria as substitutes for biological indicators.

In light of the ongoing changes in climate and land use, it has become necessary to use methods able to simultaneously account for and integrate multiple drivers when estimating critical loads (1,2). One such method uses the ForSAFE-Veg family of integrated ecosystem models, which provide a platform for dynamically estimating critical loads based on chemical as well as biological indicators. The models are able to simulate terrestrial biogeochemistry as well as plant community composition.

Within the Long-Range Transboundary Air Pollution (LRTAP) work in Europe, the model ForSAFE-Veg has been used to develop a method to use plant community composition as a criterion for setting deposition caps, as it is able to reconstruct plant species presence and abundance in response to climate, atmospheric deposition, land management and interactions with herbivores (2,3). This method has been used successfully to set preliminary CLs of deposition in parts of Europe and is being introduced into the reporting on effects by member states on the LRTAP convention, providing a necessary complement to the classical CL methods.

In the US, the models PROFILE and ForSAFE-Veg have been used in successful exploratory work (4,5,6), paving the ground to possible applications of the methods being developed in Europe.

Here we would like to give an overview of the latest developments mentioned above, the potentials they provide and the uncertainties related to them.

*Corresponding author: salim@belyazid.com

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Empirical critical loads for nitrogen for ecoregions of the United States: current and future

Pardo, L.H*, Geiser, L.H., Fenn, M.E., Lynch, J.,

Background/Questions/Methods

Human activity in the last century has led to an exponential increase in nitrogen (N) emissions and deposition. This N deposition has reached a level that has caused or is likely to cause alterations and damage in many ecosystems across the United States. The critical loads approach. The critical load, defined as the level of a pollutant below which no detrimental ecological effect occurs, is one approach for quantifying the level of pollution that would be harmful to ecosystems.

The objective of this project was to synthesize current research relating atmospheric N deposition to effects on terrestrial and aquatic ecosystems in the United States and to identify empirical critical loads for atmospheric N deposition where possible. The receptors that we evaluated included aquatic diatoms, mycorrhizal fungi and other soil microbes, lichens, herbaceous plants (forbs, graminoids), shrubs, and trees. The main responses reported fell into two categories: biogeochemical and soil microbial responses and individual, population, and community plant and lichen responses. Biogeochemical and soil microbial responses included increased N mineralization and nitrification, changes in microbial community structure (including shifts in the relative proportion of bacteria:fungi), increased gaseous N losses (ammonia volatilization, nitric and nitrous oxide from nitrification and denitrification), and increased N leaching. Plant and lichen responses included increased tissue N, physiological and nutrient imbalances, increased growth, altered root:shoot ratios, shifts in competitive interactions and community composition, increased susceptibility to secondary stresses, changes in species richness and other measures of biodiversity, increases in invasive species, and altered fire regime.

Results/Conclusions

The range of critical loads for nutrient N reported for U.S. ecoregions, inland surface waters, and wetlands is 1-39 kg N ha⁻¹ y⁻¹. This broad range spans the range of N deposition observed over most of the country. The empirical critical loads for N tend to increase in the following sequence for different life forms: diatoms, lichens and bryophytes, mycorrhizal fungi, herbaceous plants and shrubs, trees.

The critical loads approach is an ecosystem assessment tool with great potential to simplify complex scientific information and effectively communicate with the policy community and the public.

The objective of this on-going analysis is to refine existing critical loads for nutrient N based on finer scale resolution of the biotic and abiotic factors that influence the critical load.

*corresponding author:

US Forest Service

705 Spear St

S. Burlington, VT 05403 USA

ph: 1-802-951-6771 x1330 fax: 1-802-951-6368, e-mail: lpardo@fs.fed.us

Mapping Critical Loads of Nitrogen Deposition for Aquatic Ecosystems in the Rocky Mountains, USA

David W. Clow¹, Leora Nanus^{2*}, Jasmine Saros³ Donald H. Campbell¹

Aquatic ecosystems at high elevations in the Rocky Mountains are sensitive to adverse effects of inorganic nitrogen (N) deposition, including nutrient enrichment and acidification. The objective of this study was to develop spatially explicit estimates of critical loads of N deposition (CL_{Ndep}) for nutrient enrichment in aquatic ecosystems of the Rocky Mountains, USA. Surface water nitrate (NO₃) concentrations were statistically modeled based on observed surface water NO₃ concentrations, estimated inorganic N deposition, and basin characteristics (topography, landcover, and soil characteristics). The NO₃ model was used to map estimated surface water NO₃ concentrations for high-elevation basins in the study area. Threshold values of NO₃ at which nutrient enrichment causes ecological effects were identified and substituted for observed NO₃ in the model to estimate and map CL_{Ndep}. The CL_{Ndep} maps indicate that the lowest CL_{Ndep} values (< 1.5 kg N ha⁻¹ yr⁻¹) are located in high-elevation basins with steep slopes, sparse vegetation, and an abundance of exposed bedrock and talus. These areas often correspond with areas of high N deposition (> 3 kg N ha⁻¹ yr⁻¹), resulting in exceedances greater than 2 kg N ha⁻¹ yr⁻¹. Critical loads and exceedances exhibit substantial spatial variability related to basin characteristics, and are highly sensitive to estimates of the NO₃ threshold value at which ecological effects are thought to occur. Based on a NO₃ threshold of 0.4 μmol L⁻¹, N deposition exceeds the CL_{Ndep} in 29% of the high-elevation areas of the Rocky Mountains. Thus, broad areas of the Rocky Mountains may be impacted by excess N deposition, with greatest impacts likely at high elevations.

¹ U.S. Geological Survey, Federal Center, Denver, Colorado 80225

² San Francisco State University, 1600 Holloway Ave, San Francisco, CA 94132

³ University of Maine, 137 Sawyer Research Center, Orono, Maine 04469

KEYNOTE SPEAKER:

PAM PADGETT, RESEARCH PLANT PHYSIOLOGIST, USDA
FOREST SERVICE

Pamela Padgett, PhD

Research Plant Physiologist, US Forest Service, Riverside

BS from Virginia Tech in Agronomy

PhD in Plant Physiology from Univ. of California, Riverside

My original interest was plant nutrition of agronomic crops and how plant nutrients are metabolized into plant tissue. The PhD work was focused on identifying and characterizing the cell membrane carrier for nitrate. The turn off the track came with an offer to post-doc with Edie Allen who was investigating nitrogen deposition (mostly HNO_3) effects on the local vegetation. And plant assimilation of “nitrogen from the sky” became my passion from then on.

TECHNICAL SESSION 4:
HOW MUCH DEPOSITION?

*Session Chair: Donna Schwede,
U.S. Environmental Protection
Agency*

Impact of Updates to the Community Multiscale Air Quality (CMAQ) Model on Predicted Deposition

Donna Schwede, Jesse Bash, Ellen Cooter, Jon Pleim, and Robin Dennis
U.S. Environmental Protection Agency, National Exposure Research Laboratory,
Atmospheric Modeling and Analysis Division

The Community Multiscale Air Quality model (CMAQ) is a regional air quality model which provides estimates of concentration, dry deposition, and wet deposition. CMAQ uses a detailed emissions inventory and algorithms for accounting for transport and transformation to provide a representation of the spatial changes in concentration and deposition. The Weather Research and Forecasting (WRF) model is used to provide meteorological data to CMAQ. The Pleim-Xu land surface model in WRF calculates the moisture, heat, and momentum fluxes and this information is passed to CMAQ for use in the deposition calculations. Recent improvements have been made to CMAQ (v5.0) that impact deposition estimates including the addition of the capability to model the bidirectional exchange of NH_3 . New methods for estimating fertilizer application rates for agricultural areas and the resulting soil chemistry are a key component of this new capability. Additionally, speciation of dust emissions and inclusion of the dynamic interaction between fine and coarse modes allows for a better representation of base cations. Lightning NO_x is now included in the model which leads to a better characterization of the nitrogen budget. The capability to output land use specific deposition is also available in CMAQ v5.0 which will provide important information for ecological assessments. An overview of these modifications is provided as well as model results showing the impact of these changes.

Corresponding author: Donna Schwede, U.S. EPA, Tel: 919-541-3255,
Email: schwede.donna@epa.gov
NERL Atmospheric Modeling and Analysis Division, MD: E243-02, Research Triangle Park, NC
27711

Sources of atmospheric nitrogen to the Upper Susquehanna River/ Chesapeake Bay watershed with special reference to ammonia.

Tom Butler^{1,2,*}, Roxanne Marino¹, Robert Howarth¹

Control of nitrogen loading to reduce eutrophication in Chesapeake Bay has been an issue for several decades. A major input of nitrogen to the Bay is from the Susquehanna River, and oxidized atmospheric inputs represent 20% to 25% of the estimated net anthropogenic nitrogen input to the watershed, which is strongly correlated to the nitrogen discharge of the Susquehanna to Chesapeake Bay. While many of the atmospheric inputs (NO_3^- and NH_4^+ from wet deposition, particulate NO_3^- and NH_4^+ and gaseous HNO_3 from dry deposition) are reasonably well-understood, other atmospheric nitrogen sources (wet organic nitrogen and dry deposition of NO_x and NH_3) are not empirically well quantified. Gaseous ammonia deposition may be a significant component of total N deposition particularly in and near areas of agricultural activity.

Using passive samplers we have measured concentrations of NH_3 and NO_2 in a number of landscapes representing land use areas found in the upper Susquehanna Watershed such as agricultural farmland, animal production facilities, forests, roadsides and urban areas. Using representative deposition velocities we have estimated the contribution of NO_2 and NH_3 to total deposition. Our results show that for most landscapes NH_3 deposition can account for a significant percentage of the total nitrogen deposition to the upper Susquehanna watershed. NO_2 deposition is less important, except near roadsides where NO_2 and NH_3 deposition are comparable. We will present data on concentration and deposition of these species and their relative importance compared to other nitrogen deposition species. These deposition results will be compared with estimates of deposition generated by the EPA CMAQ model for this region.

Control of both NO_x (mainly from vehicle and utility emissions) and NH_3 (mainly from agriculture and livestock production) will further reduce nitrogen loading from the upper Susquehanna watershed to the Chesapeake Bay ecosystem.

¹Cornell University, Ecology and Evolutionary Biology Dept., Corson Hall, Ithaca, NY 14853

²Cary Institute of Ecosystem Studies, Millbrook, NY 12545

*Corresponding author: tbl2@cornell.edu, 607 255 3580

TOTAL DEPOSITION AT CLINGMANS DOME, TENNESSEE IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

Selma Isil¹, Christopher Rogers², Thomas Lavery³

The CASTNET Mountain Acid Deposition Program (MADPRO) has been monitoring cloud water and its chemical constituents at Clingmans Dome, TN (CLD303) in the Great Smoky Mountains National Park since 1994. High-elevation (typically higher than 800 m) ecosystems are subject to substantial levels of acid deposition from clouds that originate in polluted areas and contain high concentrations of acidic dissolved ions. High levels of acid deposition result from frequent cloud immersion, orographically enhanced precipitation, high wind speeds, and the large leaf areas typical of mountain tree species. Cloud chemistry data from such ecologically sensitive regions with complex terrain are sparse and have been collected from less than twenty mountains in the United States. Total deposition estimates are either lacking or calculated from dry, wet and cloud collection sites that are not collocated due to the constraints imposed by access and lack of power typical of mountaintop research station locations. The station at CLD303 is no exception and total deposition for this site has been estimated from precipitation collected at the NADP/NTN site (TN11) at Elkmont, TN, and filter pack measurements conducted at the GRS420 CASTNET site at Look Rock, TN. These sites are not only separated by distance from the CLD303 site but differ substantially in elevation as well. For example, the elevation difference between the CLD303 site and GRS420 site is 1,221 meters. Even with distance and elevation differences between the three sites, estimation of total deposition for the CLD303 site shows some very interesting results. Cloud deposition is by far the most significant source of deposition at this site and most likely at other high elevation ecosystems as well. The impact of cloud deposition on complex high-elevation terrain should be investigated further, especially considering the model used for estimating cloud deposition at CLD303 assumes a 10-m tall, intact, homogeneous conifer canopy. Dry deposition model estimates are known to be reasonably accurate for flat terrain and also assume a homogeneous canopy, but are not so accurate for forests and are mostly untested in uneven terrain. This paper will investigate other methods of estimating total deposition than the current methodology and compare/contrast the results obtained by the various methods.

¹ AMEC E&I, Inc., 404 SW 140th Terr., Newberry, FL 32669, 352-333-6607, ssisil@mactec.com

² AMEC E&I, Inc., 3901 Carmichael Ave., Jacksonville, FL 32207, 904.391.3744, cmrogers@mactec.com

³ Fuss and O'Neil, Inc., 317 Iron Horse Way, Suite 204, Providence, RI 02908, 401-861-3070, tlavery@fardo.com

An Exploration of Nitrogen Total Deposition Budget Uncertainty at the Regional Scale

Robin L. Dennis, Donna Schwede, Jesse Bash, and Jon Pleim
U.S. Environmental Protection Agency, National Exposure Research Laboratory,
Atmospheric Modeling and Analysis Division

Deposition loss processes cleanse the atmosphere resulting in loading of nitrogen to the Earth's surface and its ecosystems. Excess nitrogen above critical loads leads to ecosystem impacts. Models are used to estimate nitrogen deposition in support of critical load and other impact assessments. Dry deposition is not easily measured and the models can provide fields for both wet and dry deposition. Typically, dry deposition parameterizations follow the resistance conceptual model, with resistances in parallel and in series to represent the different pathways along which gases and particles are exchanged with the Earth's surface. We have examined several sources of uncertainty in the model parameterizations of dry deposition in the Community Multiscale Air Quality model (CMAQ) and the impact of these uncertainties on the total nitrogen budget. For oxidized nitrogen the uncertainty in stomatal, cuticular and aerodynamic resistances are most important. For reduced nitrogen, a major "uncertainty" in regional models we have examined is the switch from a unidirectional to a bi-directional formulation of surface ammonia flux. In the bi-directional formulation, uncertainties in the soil and stomatal compensation points are most important. For ammonia we show that there is compensation between wet and dry deposition pathways, resulting in a smaller change in the total budget than one would expect, but that in general the bi-directional formulation results in more ammonia being advected off the North American continent. Across both oxidized and reduced nitrogen species, we also show that the uncertainty analyses need to be conducted with the full chemical transport model, not stand-alone models of deposition velocity. The quantification of the changes in deposition velocity via a stand-alone model do not match the budget changes from the full model due to dynamic chemical interactions and the effects of transport.

Corresponding author: Robin L. Dennis, U.S. EPA Tel: 919-541-2870;
Email: dennis.robin@epa.gov, NERL Atmospheric Modeling and Analysis Division,
MD: E243-02, Research Triangle Park, NC 27711

Developing the Aquatic Acidification Index (AAI) for a combined oxides of sulfur and nitrogen secondary air quality standard.

Richard Scheffe, Jason Lynch, Tara Greaver, Bryan Hubbell, Adam Reff and Karen Martin

From 2006 through 2011 the U.S. Environmental Protection Agency explored development of a new multiple pollutant secondary National Ambient Air Quality Standard (NAAQS) that combined two criteria pollutant groups – oxides of nitrogen and sulfur. This effort proceeded through EPA's integrated science assessment (ISA), risk and exposure assessment (REA) and culminated in a policy assessment (PA) which included development of an aquatic acidification index (AAI). The AAI reflects the potential that atmospheric concentrations of oxides of S and N have in sustaining a target acid neutralizing capacity (ANC) across a representative suite of water bodies in a given area. Steady state critical load modeling is used to link deposition of N and S and ANC, and air quality modeling through the Community Multiscale Air Quality (CMAQ) platform is used to translate target deposition rates to allowable ambient air concentrations. This presentation walks through the derivation of the AAI equation and explains how the concept would be applied using results from the PA in a standard setting context compatible with other NAAQS.

Urban Atmospheric Environments

Richard V. Pouyat¹ and Kathleen Weathers²
¹USDA Forest Service, Washington, DC & ²Cary
Institute of Ecosystem Studies, Millbrook, NY

Urban environments usually have higher concentrations and depositional fluxes of atmospheric chemicals than rural environments. Most atmospheric pollutants originate from the combustion of fossil fuels and industrial emissions, which are often associated with urban areas. These include nitrogen oxides, sulfur oxides, heavy metals, and various organic chemicals. These pollutants are emitted locally into a restricted geographic area, particularly relative to the area from which the resources were derived, resulting in high atmospheric concentrations and depositional flux rates. Since the capacity of ecosystems to assimilate atmospheric chemicals is correlated with the amount of living biomass and soil biological activity, highly altered urban ecosystems may have greatly diminished capacities to assimilate chemicals, especially when inputs are high. We will discuss 1) the complexity of the spatial and temporal dimension of depositional flux rates occurring in urban landscapes, 2) how these elevated fluxes potentially impact ecosystem structure and function and human health, and 3) the importance of measuring urban atmospheric environments and their relationship to sensitive ecosystems.

TECHNICAL SESSION 5:
SPATIAL AND TEMPORAL PATTERNS IN
DEPOSITION

Session Chair: Rich Pouyat
USDA Forest Service

TEMPORAL AND SPATIAL VARIABILITY IN ATMOSPHERIC AMMONIA CONCENTRATIONS IN THE WESTERN UNITED STATES

J. L. Collett, Jr.^{1*}, Y. Li¹, T. Lee¹, D. Chen¹, K. Benedict¹, D. Day⁴, S. Raja^{1,2}, F. M. Schwandner^{1,3}, C. M. Carrico¹, S. M. Kreidenweis¹, W. C. Malm⁴, B. A. Schichtel⁵, J. Ray⁶, M. Tigges⁷, S. Holcomb⁷, C. Archuleta⁷, L. Sherman⁷, J. Molenaar⁷, H. J. Sewell⁸, J. Mojica⁹, and C. McDade⁹

In the western United States ammonia is a key ingredient in aerosol formation and is contributing to growing levels of nitrogen deposition in high elevation ecosystems. Despite its importance, ammonia concentrations are not regulated and seldom measured. Data from a series of ambient monitoring studies are examined here to explore the temporal and spatial variability of ammonia concentrations in the western U.S. Study sites were located in the states of California, Arizona, Texas, Colorado, Wyoming, Utah, and Nebraska. Measurement campaigns at individual sites ranged from one month to 4 years in duration. Ammonia was measured through a combination of URG annular denuders and Radiello passive samplers. The ammonia denuders were included in a denuder/filter-pack sampling system that also provided measurements of other key aerosol and gas phase nitrogen and sulfur species. Radiello passive samplers were found to provide excellent precision and good accuracy (vs. a denuder reference) for ammonia concentration measurements on timescales of one to three weeks. Network observations reveal strong spatial gradients in ammonia concentrations, with the highest concentrations in agriculture and livestock regions. Strong seasonal variability was observed in ammonia concentrations, consistent with higher emissions during warmer times of the year. Changes in gas-particle partitioning were observed, with a shift away from particulate ammonium toward increased gas phase ammonia during warmer and drier seasons. Observations from these studies will be reviewed and recent implementation of pilot NH_x (gaseous ammonia plus $\text{PM}_{2.5}$ ammonium) measurements into the U.S. Interagency Monitoring of PROtected Visual Environments (IMPROVE) network will be discussed.

* Presenting author (E-mail : collett@atmos.colostate.edu)

¹Atmospheric Science Department, Colorado State University, Fort Collins, CO 80523 USA

²currently at Providence Engineering and Environmental Group, Irving, TX USA 75063

³currently at Nanyang Tech. University, Earth Observing Laboratory, Singapore 639798

⁴Coop. Inst. for Res. in the Atmosphere, Colorado State Univ., Fort Collins, CO 80523 USA

⁵National Park Service/CIRA, Colorado State University, Fort Collins, CO 80523 USA

⁶National Park Service, Air Resources Division, Denver, CO 80225 USA

⁷Air Resource Specialists, Inc., Fort Collins, CO 80525 USA

⁸Shell Exploration and Production Company, Denver, CO 80237 USA

⁹University of California, Crocker Nuclear Laboratory, Davis, CA 95616 USA

Back Trajectory Analysis of Reactive Nitrogen Measured Continuously at Rocky Mountain National Park, Colorado

Kristi A. Gebhart, Bret A. Schichtel, Michael G. Barna¹
Marco A. Rodriguez, William C. Malm²
Jeffrey Collett Jr., Katherine Benedict³
Christian M. Carrico⁴

Increases in the wet and dry deposition of reactive nitrogen in ecologically sensitive areas of the Rocky Mountains have led to recent efforts to determine the source types and source regions that contribute to this problem. Analysis of data collected during a 2006 field study at Rocky Mountain National Park, Colorado, indicated that during April and July, approximately half of the deposited nitrogen was from sources within the state of Colorado. Potential contributing sources include agricultural activities, mobile sources, oil and gas extraction, fossil fuel combustion, and wildfires. During November 2008 through November 2009 a follow up study designed to examine data collected during a full year was conducted. Several methods were utilized to obtain continuous measurements of both oxidized and reduced nitrogen. These high time resolution data collected over a year provide a unique opportunity to examine source-receptor relationships both seasonally and by hour of day. As a first step, air mass back trajectories are examined to determine where they resided prior to arriving at RMNP under a variety of conditions including periods of high and low deposition, concentrations, and precipitation by month and by hour of day. Back trajectories were generated on a 4 km grid resolution using output from the Weather Research and Forecasting (wrf) mesoscale meteorological model with observational data assimilation including data from a nearby radar wind profiler installed for the study. Additionally, a receptor model, Trajectory Mass Balance, was used to estimate the relative attributions of several source areas to the measured concentrations.

¹National Park Service, CIRA Building, Colorado State University, Fort Collins, CO

²Cooperative Institute for Research in the Atmosphere, Colorado State University, Fort Collins, CO

³Atmospheric Sciences Department, Colorado State University, Fort Collins, CO

⁴AECOM, Fort Collins, CO

Seasonal Nitrogen Deposition Budgets at Rocky Mountain National Park

Bret A. Schichtel¹, Katie Beam², Christian M. Carrico², Jr.², Ezra Levin², Derek Day, William C. Malm³, Jeffrey L. Collett², Sonia M. Kreidenweis²

Excess nitrogen (N) deposition is occurring in Rocky Mountain National Park (RMNP) that is altering its ecosystems. The Rocky Mountain Atmospheric Nitrogen and Sulfur (RoMANS) study was conducted to improve our understanding of the origins of N species in RMNP as well as the complex chemistry occurring during transport from sources to receptor. This study measured N deposition during a spring and summer period in 2006 and found that about a third of the N deposition was due to wet-deposited organic N and ammonia dry deposition. Neither of these N deposition pathways is measured in routine monitoring programs. Missing from these budgets was the contribution of dry-deposited organic N. In addition, there were questions about the representativeness of the RoMANS results to other years and seasons. To address these issues, a year of detailed measurements of ambient concentrations and wet deposition of N compounds was conducted at RMNP during 2009. These measurements included indirect estimates of ambient organic N concentrations. It was found that large contributions of wet-deposited organic N and dry-deposited ammonia occurred during all four seasons, with average spring and summer N deposition budgets similar to those from the RoMANS study. In addition, the measurements indicate that large ambient concentrations of organic N compounds were also present that could significantly contribute to the total N deposition at RMNP.

¹National Park Service, CSU/CIRA, Fort Collins, Colorado 80523-1375

²Department of Atmospheric Science, Colorado State University, Fort Collins, Colorado 80523-1371

³Cooperative Institute for Research in the Atmosphere (CIRA), Colorado State University, Fort Collins, Colorado 80523-1375

An assessment of the performance of the Monitor for Aerosols and Gases in ambient air (MARGA): a semi-continuous method for soluble compounds

Ian. C. Rumsey^{a*}, Ken Cowen^b, Tom Kelly^b, Elizabeth Hanft^b, Kevin Mishoe^c, Chris Rogers^c, Rob Proost^d, Gary Lear^e, Timmer Frelink^d, John.T. Walker^a

Ambient air monitoring as part of the U.S. Environmental Protection Agency's (U.S. EPA) Clean Air Status and Trends Network (CASTNet) currently uses filter packs to measure weekly integrated concentrations. The U.S. EPA is interested in supplementing CASTNet with semi-continuous monitoring systems at select sites to examine ecosystem exposure to nitrogen and sulfur compounds at higher time resolution and with greater accuracy than the filter pack. The Monitor for Aerosols and Gases in ambient air (MARGA) measures water-soluble gases and aerosols at hourly temporal resolution. The performance of the MARGA was assessed under the U.S. EPA Environmental Technology Verification (ETV) program. The assessment was conducted in Research Triangle Park, NC from September 8th-October 8th, 2010. Precision of the MARGA was evaluated by comparing duplicate units and accuracy was evaluated by comparing duplicate MARGAs to duplicate reference denuder/filter packs. The MARGA utilizes a Wet Rotating Denuder (WRD) to collect gases, while aerosols are collected by a Steam Jet Aerosol Collector (SJAC). Both the WRD and the SJAC produce aqueous sample streams, which are analyzed by online ion chromatography for anions and cations. The reference denuder/filter pack consisted of sodium carbonate (Na₂CO₃) and phosphorous acid (H₃PO₃) coated denuders followed by a Teflon filter, a nylon filter, and a citric acid coated cellulose filter. The assessment of the MARGA units focused on gaseous SO₂, HNO₃ and NH₃ and aerosol SO₄⁻, NO₃⁻ and NH₄⁺. The MARGA units performed well for SO₂, SO₄⁻, NH₃ and NH₄⁺, with these compounds meeting the accuracy and precision goals. The MARGA units did not perform as well for HNO₃ and NO₃⁻, with both species linear regression slopes not achieving the accuracy target of having a slope between 0.8-1.2. Furthermore, for NO₃⁻, the median absolute relative percent difference between both MARGA units and the reference filter pack was greater than the performance goal of 40%. Comparison of total nitrate (HNO₃ + NO₃⁻) suggests that the lesser performance of the MARGA units for these compounds likely results from aerosol volatility in the MARGA inlet/tubing or the reference filter pack and exchange of HNO₃ with tubing walls. In addition, the NO₃⁻ concentrations were low (<0.5 μg m⁻³) for significant periods of the ETV assessment. Details of the comparison will be examined and suggested instrument improvements will be discussed.

^a Office of Research and Development, U.S. Environmental Protection Agency,

^c AMEC, Jacksonville, FL, 32669, U.S.A
Research Triangle Park, NC 27711, U.S.A

^b Battelle, Columbus, OH, 43201, U.S.A

^d Metrohm Applikon B.V., Schiedam, The Netherlands

^e Clean Air Markets Division, U.S. Environmental Protection Agency, Washington, DC 20460

* Corresponding author

Email: ian.rumsey@epa.gov Telephone: (919) 541-4746 Fax: (919) 541-7885

Preliminary Results from the CASTNET Ammonia Special Study

Christopher Rogers¹, Kevin Mishoe², Marcus Stewart², Michael Smith², Garry Price², H. Kemp Howell²

As part of the CASTNET monitoring program, AMEC is conducting a special study for the U. S. Environmental Protection Agency that compares methods for collecting sulfur and nitrogen containing compounds at five CASTNET sites for one year. The CASTNET 3-stage filter pack captures particulate sulfate (SO_4^{2-}), ammonium (NH_4^+), and nitrate (NO_3^-) on the first (Teflon) filter; gaseous nitric acid (HNO_3) and part of the gaseous sulfur dioxide (SO_2) on the second (nylon) filter; and the remainder of the SO_2 on the final (potassium carbonate-impregnated cellulose) filters. Regarding nitrogen, CASTNET measurements represent only part of the nitrogen budget with gaseous ammonia (NH_3) being a key missing species. The goals of the study are to: assess the precision, accuracy, and bias of Radiello passive ammonia samplers, used for the NADP Ammonia Monitoring Network (AMoN); characterize Met One SuperSASS mini parallel plate denuders for NH_3 collection; and compare SuperSASS ion module collection, used for the Chemical Speciation Network (CSN), with CASTNET 3-stage filter pack collection.

Duplicate annular denuder systems (ADS) are deployed as the reference method. Site selection was based on proximity to ammonia emissions sources, operator capability, and collocation with AMoN. Sampling began in August 2010 and will continue through September 2011, a total of ten 2-week sampling periods. Preliminary review of the data collected during the first half of the study shows good agreement between the ADS and the CASTNET filter pack, SuperSASS ion module, and AMoN passive NH_3 sampler. The SuperSASS NH_3 module produced concentrations lower than the ADS.

¹ AMEC E&I, Inc., 3901 Carmichael Ave., Jacksonville, FL 32207, 904.391.3744, cmrogers@amec.com

² AMEC E&I, Inc., 404 SW 140th Terr., Newberry, FL 32669, 352.332.3318, kmishoe@amec.com, mstewart@amec.com, msmith@amec.com, gprice@amec.com, and hkhowell@amec.com

Spatial Patterns and Temporal Trends in Mercury Wet Deposition in the Great Lakes Region

Martin R. Risch¹, David A. Gay², and Kathleen K. Fowler³, Gerard J. Keeler⁴, Sean M. Backus⁵, Pierrette Blanchard⁶, James A. Barres⁷, and J. Timothy Dvonch⁸

Data from three mercury wet-deposition-monitoring networks and two precipitation-monitoring networks in the USA and Canada, for 2002-2008, were combined to assess spatial patterns and temporal trends in 8 states and 2 provinces in the Great Lakes Region. Spatial patterns of annual mercury wet deposition were examined by generating high resolution maps based on precipitation-weighted annual mean mercury concentrations at 37 sites and annual precipitation depths at 1,541 sites. Temporal trends in weekly data were determined with the Seasonal Kendall Trends Test and the Seasonal Kendall Slope Estimator.

Year-to-year variations in spatial patterns of mercury wet deposition were observed throughout the region. Generally, mean annual mercury wet deposition was highest in the southern part of the study region and lowest in the north and followed patterns of mean annual precipitation depths. Localized areas with high annual mercury wet deposition (15 to 20 micrograms per square meter) were mapped in 6 of 7 years and typically corresponded with sites having high precipitation-weighted annual mean mercury concentrations.

Seven-year temporal trends in mercury wet deposition or mercury concentration were observed in data for weekly samples from 20 monitoring sites. For sites with significant trends, the median annual decrease or increase in weekly mercury concentration was less than a nanogram per liter. For a group of monitoring sites near southern Lake Michigan, trends of decreased mercury concentrations coincided with trends of increased precipitation depths. Significant 7-year trends in weekly mercury wet deposition were not coincident with trends in weekly mercury concentration.

During the 2002-2008 study period, mercury wet deposition was unchanged in the Great Lakes region or its sub-regions. Any small decreases in mercury concentration apparently were offset by increases in precipitation. Continued monitoring could detect whether these observations are consistent over a longer time period.

¹ U.S. Geological Survey, 5957 Lakeside Boulevard, Indianapolis, Indiana 46278, mrisch@usgs.gov (corresponding author, 317/290-3333 ext. 163)

² Illinois State Water Survey, University of Illinois, 2204 Griffith Drive, Champaign, Illinois 61820-7495, dgay@illinois.edu

³ U.S. Geological Survey, 5957 Lakeside Boulevard, Indianapolis, Indiana 46278, kkfowler@usgs.gov

⁴ University of Michigan, 6646 SPH Tower, 1415 Washington Heights, Ann Arbor, Michigan 48109-2029,

⁵ Environment Canada, 867 Lakeshore Road, Burlington, ON M3H 5T4, sean.backus.ec.gc@gmail.com

⁶ Environment Canada, 4905 Dufferin Street, Toronto, ON M3H 5T4, pierrette.blanchard@ec.gc.ca

⁷ University of Michigan, M6210 SPH II, 1420 Washington Heights, Ann Arbor, Michigan 48109-2029, jbarres@umich.edu

⁸ University of Michigan, 6642 SPH Tower, 1415 Washington Heights, Ann Arbor, Michigan 48109-2029, tdvonch@umich.edu

ISOSCAPES OF ATMOSPHERIC NITRATE: WHAT DO THEY TELL US?

Greg Michalski, Krystin Riha, David Mase, Lindsey Crawley, Helen Waldschmidt, and Michelle Kolanowski

Department of Earth and Atmospheric Sciences,
Purdue University,
West Lafayette, IN. 47907.
gmichals@purdue.edu

What drives the high degree of spatial and temporal variability in the amount and isotopic composition of atmospheric nitrate? Deposition of atmospheric nitrate can range from over 50 to less than 1 kg/ha yr and seasonally vary by an order of magnitude. These variations are largely a function of proximity to sources of nitrogen oxides (NO_x) such as power plants, cities, and agricultural centers. Does the isotopic composition of nitrate primarily reflect these different sources or is it mainly controlled by the kinetic and equilibrium isotope effects that occur during NO_x oxidation into nitrate? We have begun using archived samples from the National Atmospheric Deposition Program and US-EPA's aerosol monitoring program to analyze $\delta^{15}\text{N}$, $\delta^{18}\text{O}$, and $\Delta^{17}\text{O}$, and $\square^{17}\text{O}$ composition of atmospheric nitrate. We observe seasonal trends in all three isotope ratios, with $\delta^{18}\text{O}$ and $\Delta^{17}\text{O}$ values in the winter and lower values in the summer months. A similar trend is observed in the $\delta^{15}\text{N}$ values but with considerably more scatter in the data. Interpreting the observed spatial and temporal trends in atmospheric nitrate's isotopic composition requires incorporating isotopes into sophisticated computer models, which can work on local, regional, and global scales. New modeling approaches will be discussed including what roles aerosols, trace gas concentrations and atmospheric water play in the isotope composition of atmospheric nitrate. Preliminary results suggest isotopes can be used to understand how NO_x is converted to nitrate under different chemical conditions and the role aerosols play in heterogeneous reactions of NO_x. Current limitations and future directions will also be discussed.

From Air to Water: Hg deposition and biogeochemistry, Sunapee, NH watersheds

Weathers, K.C., *Ewing, H.A., Baer, N.A., Chen, C.Y., Roebuck, H.J., Maki, C.E., Richardson, D.R., Lindsey, A.M., Wilson, A., Chikering, J., Fiorillo, A.U., Cottingham, K.L.

The relationship between mercury (Hg) deposition and methyl mercury (MeHg) accumulation in aquatic biota is often indirect, at best. We suggest that both landscape and biogeochemical heterogeneity are the reasons. Mercury deposition is estimated to be approximately 7 $\mu\text{g Hg}/\text{m}^2$ per year to southeastern New Hampshire, based on Mercury Deposition Network monitoring sites. However, these estimates do not take into account variability in deposition at the spatial scale of hectares. In addition, the biogeochemical transformations and effects of this deposited Hg are likely to differ across the landscape.

We modeled Hg deposition and examined landscape characteristics and water chemistry across 12 tributary watersheds that drain into Lake Sunapee, NH, a large, recreational lake that is also a drinking water source. Using a landscape model that accounts for differences in watershed elevation and vegetation, across-watershed deposition was modeled to differ only by about 25% among watersheds, between 9.5 and 12.4 $\mu\text{g}/\text{m}^2$. In contrast, total Hg concentrations in streamwater ranged nearly eight-fold, from 322 to 2250 pg/L across watersheds. MeHg concentrations in streamwater were even more variable, ranging over an order of magnitude across streams (23-854 pg/L) and accounting for 7-42% of the total Hg. Streamwater dissolved organic carbon (DOC) and MeHg concentrations were strongly correlated. The amount of inorganic Hg was positively correlated with modeled Hg deposition and the percentage of the watershed that was coniferous forest. DOC concentrations were best predicted by the percentage of the watershed underlain by Histisols (peat soils), and the percentage of the watershed in wetlands was the best predictor of MeHg.

Weathers, Lindsey - Cary Institute of Ecosystem Studies
Ewing, Roebuck, Fiorillo - Bates College,
Baer, Wilson, Chikering - Colby-Sawyer College
Chen, Roebuck, Cottingham - Dartmouth College

**TECHNICAL SESSION 6:
GLOBAL ISSUES AND ATMOSPHERIC
DEPOSITION**

*Session Chair: Holly Ewing,
Bates College*

Radioactivity in Precipitation – Methods & Observations from Savannah River Site

Dennis G. Jackson, G. Timothy Jannik – Savannah River National Laboratory, Aiken, SC
Miranda LaBone – Clemson University, Clemson, SC
Rebecca Scheffler – University of South Carolina Aiken, SC

Background/Objectives: The Fukushima Daiichi disaster was a reminder of the global scale processes of atmospheric deposition. Monitoring of “fallout” from nuclear events has been a component of the nuclear age. The monitoring is central in determining exposure to the general population from anthropogenic events and nuclear operations. Numerous programs and ad-hoc networks have or currently monitor radioactivity as both dry and wet deposition. We present collection methods, analytical techniques, and observations from one network that is operated by the Savannah River Site (SRS).

Savannah River Site is one of several nuclear facilities in the U.S. Department of Energy complex. Nuclear facilities at SRS were constructed during the early 1950s to produce materials (primarily plutonium-239 and tritium) used in nuclear weapons. The site covers 800 square kilometers (310 square miles) in South Carolina and borders the Savannah River. Since the Spring of 1951 environmental radioactivity has been measured and reported as part of construction and nuclear operations. The objective of this monitoring is to characterize environmental radiation so that any increase due to operations could be readily determined. One aspect of the program is monitoring of radioactivity in precipitation.

Approach/Activities: Since 1954 SRS has reported radioactivity in precipitation. A network of rainwater sampling sites is maintained as part of the monitoring program. These stations are used to measure deposition of radioactive materials on-site, around the site-perimeter (approximately 15-miles in diameter), at off-site control locations, and at selected major population centers located at 40 and 161 kilometers (25 and 100 miles). In the early years collection and analytical methods were refined to current techniques. At each of the locations, two samples of precipitation are collected. Beginning in 1963 ion-exchange resin columns have been used for gamma-emitting radionuclides, gross alpha, gross beta and specific isotopes associated with facility operations. As precipitation passes through the column radioactive particles partition into the resin and are retained. Once in the laboratory the particles are extracted from the resin and assayed for specific isotopes. In 1971 the current tritium sampling methods were implemented. This involves direct capture of precipitation and analysis based upon scintillation counting. Generally the ion-exchange column sampling is performed monthly, while sampling of rainwater for tritium is performed biweekly. Results are compiled and reported annually in the *SRS Annual Environmental Report* as activity and deposition.

Results/Observations: Continuous observations from 1954 have allowed scientists to assess impacts of SRS nuclear operations on the surroundings. In addition SRS has observed fallout from weapons testing from around the world and the 1986 Chernobyl and 2011 Fukushima disasters. The observations record long-term trends of radioactivity and nuclides in precipitation from the southeastern United States. Analysis of precipitation samples from the National Trends Network (NTN) would be supportive in evaluating tritium distributions on a larger scale.

Reactor Fission Product Fallout in North American Wet-Deposition Samples, from the March 11, 2011 Fukushima Dai-ichi Incident

Gregory A. Wetherbee¹, David A. Gay², Timothy M. Debey³, Christopher M.B. Lehmann², and Mark A. Nilles⁴

The U.S. Geological Survey (USGS) and National Atmospheric Deposition Program (NADP) networks successfully responded to monitor radioactive fallout from the Fukushima Dai-ichi nuclear power facility release incident, March 11, 2011. In coordination with other federal agencies, USGS/NADP provided scientifically reasonable and cost effective observations of fission-product isotopes in wet deposition over North America from 170 NADP sites. These results are comparable to measurements from other networks in North America and Europe.

For the period March 8 – April 5, 2011, wet-only precipitation samples were collected by NADP and analyzed for radionuclides in whole-water and filterable solid samples (0.45 µm polysulfone filter) by the USGS using gamma spectrometry. Samples from two sites in Environment Canada’s Canadian Air and Precipitation Monitoring (CAPMoN) network were analyzed, but no fission-products were found in these samples.

Initially, filterable solids from National Trends Network (NTN) samples were analyzed. However, no fission products were detected on the filters. The USGS then analyzed whole-water precipitation samples provided by the NADP. NTN samples were acidified with 0.5% Ultrex nitric acid and placed in a warm bath to limit adsorption to the NADP bottles. Weekly Mercury Deposition Network (MDN) samples were also analyzed, and were acidified with 1% hydrochloric acid preservative at time of collection. Two-week precipitation-weighted composite samples were made from weekly NTN and daily CAPMoN samples, but MDN samples were not composited.

Detectable quantities of ¹³¹I, ¹³⁴Cs, or ¹³⁷Cs were observed at approximately 25% of sampled NADP locations. One-week and two-week deposition fluxes calculated from NADP/USGS data range from 11 - 1,000 Becquerels per square meter (Bq/m²) for ¹³¹I, 0.5 - 108 Bq/m² for ¹³⁴Cs, and 0.7 - 240 Bq/m² for ¹³⁷Cs. The spatial extent of measured deposition were consistent with the modeled position of the jet stream and air mass back trajectory (NOAA HYSPLIT) modeling results. Fission products were also detected in Alaska. Activities measured in wet deposition samples are comparable to bulk measurements by the USEPA RadNet network, University of California at Berkeley, and European entities. The highest ¹³¹I, ¹³⁴Cs, and ¹³⁷Cs activities (9.2, 1.2, and 1.5 Bq per liter, respectively) were observed at the CO90 site, located at 3,015 meters altitude in the Rocky Mountains near Nederland, CO.

¹U.S. Geological Survey (USGS), Branch of Quality Systems; ²University of Illinois, Prairie Research Institute; ³USGS, Energy, Minerals, and Environmental Health, National Reactor Facility; ⁴USGS, Office of Water Quality

Deposition can be biological, too

M. E. Dueker¹, G. D. O'Mullan^{1,2}, K. C. Weathers³

Globally, bacteria suspended in the atmosphere, or microbial aerosols, can range in concentration from 1×10^4 to 6×10^5 cells m^{-3} . They can be either attached to ambient aerosol particles or exist singly in the air. They affect climate through serving as ice, cloud and fog nucleators, and have the metabolic potential to alter atmospheric chemistry. Despite the ubiquity of these microbes and their global importance, little is known about their source, viability, and in-air metabolic activity. Even less is known about the ecological ramifications of the deposition of these microbes along with the nutrients and pollutants present in the atmosphere. Microbial aerosols are known to be diverse in identity and biogeochemical capacity, and can be transported between seemingly isolated biomes (e.g. ocean to land, desert to ocean). Because they are attached to ambient aerosol particles (or are the particle themselves), deposition of these microbes should be controlled by the same mechanisms found to control deposition of ecologically-relevant nutrients and pollutants. On the coast of Maine, we found that the deposition of viable microbial aerosols increased by three orders of magnitude when fog was present. Molecular identification of these microbes revealed a diverse community of predominantly marine organisms, confirming the atmospheric transfer of viable bacteria from the ocean surface to the coastal environment. Implications for this transfer include bi-directional atmospheric feedbacks between terrestrial and coastal ocean systems and the potential for water quality to affect air quality at coastal sites.

Free Tropospheric Export of East Asian Atmospheric Mercury Observed at Lulin Atmospheric Background Station in Taiwan

Guey-Rong Sheu^{*1}, Neng-Huei Lin¹, Jia-Lin Wang², Chung-Te Lee³
National Central University
300 Chung-Da Rd., Chung-Li, Taiwan

Taiwan is located downwind of the East Asian continent, which is the largest anthropogenic mercury (Hg) source region globally. Measurements of speciated atmospheric Hg have been conducted at Lulin Atmospheric Background Station (LABS: 120.87°E, 23.47°N, 2862 m a.s.l.) in Taiwan since April 2006 to study the export of East Asian atmospheric mercury in the free troposphere. Between April 2006 and May 2011, the mean concentrations of GEM, RGM, and PHg were 1.75 ng m^{-3} , 14.6 pg m^{-3} , and 3.0 pg m^{-3} , respectively. GEM usually peaked in the afternoon. In contrast, spikes of RGM were frequently observed between midnight and early morning with concurrent decreases in GEM and relative humidity and increases in O₃, suggesting the oxidation of GEM and formation of RGM in free troposphere (FT). Upslope movement of boundary layer (BL) air in daytime and subsidence of FT air at night resulted in these diurnal patterns. Considering only the nighttime data, which were more representative of FT air, seasonal variation in GEM was evident, with lower concentrations usually occurring in summer when marine air masses prevailed. Between fall and spring, air masses usually passed the East Asian continent prior to reaching LABS. Trajectory cluster analysis identified 9 groups of air mass transport paths, 5 groups mainly passed over the East Asian continent and the other 4 groups mainly passed over the Pacific Ocean/South China Sea. Concentrations of GEM, CO, O₃ and PM₁₀ were significantly elevated in air masses coming from the East Asian continent, demonstrating the influence of human activities. Analysis of GEM/CO correlation further supported the argument. Good GEM/CO correlations were observed in fall, winter, and spring, suggesting influence of anthropogenic emission sources. Our results demonstrate the significance of East Asian Hg emissions, including both anthropogenic and biomass burning emissions, and their long-range transport in the FT. Because of the pronounced seasonal monsoon activity and the seasonal variation in regional wind field, eastward export of the Asian Hg emissions occurs mainly during fall, winter, and spring.

Corresponding author: *+886-3-4227151 ext. 65514, grsheu@atm.ncu.edu.tw
¹Department of Atmospheric Sciences
²Department of Chemistry
³Graduate Institute of Environmental Engineering

Solar dimming & brightening as related to airborne particulate matter.

*Victoria Kelly, Charles Canham, Kathleen Weathers, Gary Lovett
Cary Institute of Ecosystem Studies, Millbrook, New York, USA
P.O. Box AB, Millbrook, NY 12545
(845) 677-5343

Global trends show dimming of solar radiation between 1960 and 1990 due to the increased water-holding capacity and resultant increase in atmospheric moisture of the globally warmer atmosphere. However, a subsequent increase in solar radiation since 1990 has occurred in many locations. The often reported explanation for brightening is a decrease in particulate matter. Several studies have shown a correlation between emissions of precursors to particulate matter and solar radiation, but none has shown the relationship between particulate matter and solar radiation measured simultaneously at the same site. In the rural northeastern U.S., particulate matter is dominated by sulfate particles that are a result of SO₂ emissions, which have decreased since 1990 with a resultant decrease in sulfate particles. This decrease in sulfate particles should result in a decrease in diffuse solar radiation, which should result in an increase in direct solar radiation, i.e., brightening. A decrease in diffuse radiation could also be the result of decreased cloudiness or a decrease in airborne water vapor (i.e. humidity). Here we describe changes in solar radiation, particulate matter, cloudiness and humidity at the Cary Institute and the relationships among those variables. We compare this site with two CASTNET sites for which solar radiation data are available from nearby NOAA, Surface Radiation Budget Network (SURFRAD) stations.

*Corresponding Author: Vicky Kelly KellyV@caryinstitute.org (845) 677-7600 ext. 174

Modeling of Global Source Contributions to Atmospheric Mercury Deposition in the United States

Krish Vijayaraghavan, Jaegun Jung, Greg Yarwood, Ralph Morris
ENVIRON International Corporation,
773 San Marin Drive, Suite 2115,
Novato, CA 94998

Atmospheric deposition is a major source of loading of mercury (Hg) to terrestrial and aquatic ecosystems in several parts of the United States. The relative contributions of local, regional, and global anthropogenic sources as well as natural sources to Hg deposition vary across the U.S. Due to its long atmospheric lifetime of several months, Hg is subject to long-range transport. This paper presents the results of a modeling study that simulates the global cycle of atmospheric Hg to identify the contributions of global anthropogenic and natural sources to several regions in the U.S. A global 3-D model of atmospheric mercury (GEOS-Chem) is used to simulate the emissions, transport, transformations and wet and dry deposition of elemental, gaseous divalent and particulate-bound Hg. Modeling is conducted for calendar year 2008. Regions selected for global source contribution analysis include Alaska, the western U.S., the southeastern U.S. and the northeastern U.S. Hg source regions and categories selected for analysis include anthropogenic emissions over Asia, European anthropogenic emissions, N. American anthropogenic emissions, legacy anthropogenic emissions, biomass burning and other natural emission sources.

POSTER SESSION

IN ALPHABETICAL ORDER BY AUTHOR

Recent Updates in the CAL

Kim Attig, Lee Green, Tracy Dombek, and Nina Gartman
Central Analytical Laboratory (CAL)
National Atmospheric Deposition Program
Illinois State Water Survey
Champaign, IL 61820

In the past five years, important updates have taken place in the Central Analytical Laboratory (CAL). In the fall of 2007, the bucket cleaning room was moved to a refurbished and expanded area, which allowed the CAL to purchase and start using two new washers for cleaning buckets, lids, and bottles. In the summer of 2010, a new flow injection analysis instrument (FIA) was purchased. The new instrument is capable of doing low flow analysis as well as the method currently run at the CAL. Both methods on the new instrument were tested and results compared to the current method on the original FIA. In the summer of 2011, a new system and autosampler was purchased for ion chromatography (IC). Both the new ICS-5000 system and the new autosampler were tested and results compared with the ICS-2000 systems which are currently used. Purchases such as these new instruments are important developments and show that the CAL is striving to progress and move forward along with the changing technology, while at the same time maintaining the standards of accuracy and precision which the lab already adheres to.

In A Changing Climate, How Do Projected Changes in Precipitation Affect Wet Deposition – A GIS Approach

Drew Bingham
National Park Service – Air Resources Division
PO Box 25287, Denver, CO 80209

As part of its efforts to make air quality data more accessible to policy and decision makers, the National Park Service Air Resources Division created a GIS based model designed to integrate several air quality parameters into a single aggregate score. This air quality score would convey the overall condition for each park unit, even those without on-site air quality monitoring.

In order to obtain condition scores for each national park unit, interpolations covering the entire continental US were created from monitored data. Along with ozone and visibility layers, total nitrogen and sulfur wet deposition (using NADP monitor data) were the primary inputs used to determine the overall condition score. The first step in creating the wet deposition layers needed for the model was to create interpolations of concentration using the most recent 5-year average of NADP monitored data. This interpolation was then multiplied by the normalized 30-year precipitation average from the PRISM Climate Group in order to minimize interannual variation in deposition caused by fluctuations in precipitation.

Recently the National Center for Atmospheric Research (NCAR) made available datasets of climate change projections in GIS format. These projections from the Climate Change System Model (CCSM-3, created for the 4th Assessment Report of the Intergovernmental Panel on Climate Change) included downscaled projections of not only monthly mean temperature but also total precipitation for the contiguous United States at a similar resolution to that of the PRISM data. It is now possible, using a process similar to the one used to determine present day deposition estimates, to estimate the effect of different precipitation scenarios on wet deposition of nitrogen and sulfur.

Wet deposition estimates for future climate conditions were created using different emissions scenarios and various future time frames. While there are issues with this approach (uncertainties inherent in the climate model as well as the assumption that concentrations will remain constant at today's levels) nevertheless, these deposition estimates are useful to park managers as they prepare for an uncertain future.

Corresponding author, Phone: 303.969.2341, Email: Drew_Bingham@contractor.nps.gov

**NADP CLAD's FOCUS Project- Phase I: Submission of US National-Scale
Critical Loads to the UNECE-CCE**

Tamara Blett, Richard Hacuber, Jason Lynch, Linda Pardo, Richard Pouyat, Tom Moore

The alphabet soup of acronyms in the title is a key indicator that multi-agency coordination projects are underway. FOCUS (Focal Center Utility Study) is a project of NADP's Critical Loads Atmospheric Deposition (CLAD) Science Committee. FOCUS was initiated as a small scale prototype of a US Focal Center to coordinate and manage the development and implementation of a clear, consistent repeatable process for standardized, mapable critical loads within the U.S. The process the European Union uses to collect, analyze and map critical loads data from participating countries around the globe utilizes a "Focal Center" in each country to serve as a point of contact for regional and national-scale critical loads data. In the "FOCUS Phase I Pilot Study" project, CLAD gathered and synthesized empirical and calculated critical loads data from dozens of regional and national-scale projects. CLAD members provided that data as an informal, unofficial submission to the UNECE-CCE (United Nations Economic Commission for Europe -Coordinating Center on Effects) in the interests of international cooperation and exchange of information on the effects of atmospheric deposition on ecosystems. CLAD envisions that this data will enable U.S scientists and land managers to enter into a productive and meaningful dialogue with the international scientific community on methods for estimating, calculating, mapping, interpreting, and refining critical loads for the effects of acidification and excess nutrients on terrestrial & aquatic ecosystems. This poster summarizes the FOCUS Phase I effort, and illustrates some of the preliminary critical loads mapping products produced by the effort.

Affiliations:

Tamara Blett- National Park Service, 303-969-2011, tamara_blett@nps.gov
Richard Hacuber – Environmental Protection Agency, 202-343-9250, hacuber_richard@epa.gov
Jason Lynch – Environmental Protection Agency, 202-343-9257, lynch_jason@epa.gov
Linda Pardo – USDA Forest Service, 802-951-6771, lpardo@fs.fed.us
Richard Pouyat – USDA Forest Service, 703-605-5286, rpouyat@fs.fed.us
Tom Moore – Western Governors' Association, 970-491-8837, mooret@cira.colostate.edu

Mercury Wet Deposition at KS03

Rick Campbell, Environmental Department Director and
Scott Weir, Air Quality Coordinator
Sac and Fox Nation of Missouri in Kansas and Nebraska
305 N. Main St.
Reserve, KS 66434

In 2007, the Kansas Legislature required, *per* KSA 75-5673, that the Kansas Department of Health and Environment (KDHE) establish a statewide mercury deposition network consisting of at least six monitoring sites. Monitoring for a period of time long enough to determine trends (five or more years) was specified. The Kansas Mercury Deposition Network (KMDN) was designed to assure compatibility with the national Mercury Deposition Network (MDN). Operation of the KMDN began in January 2008, when KS03, operated by Sac and Fox Nation of Missouri in Kansas and Nebraska, began collecting data.

A brief characterization of the MDN monitoring site (KS03) operated by the Sac and Fox Nation of Missouri in Kansas and Nebraska for the Kansas Department of Health and Environment is provided. Significant and unique features of this site are discussed. A brief summary of data is presented. Brochures about the KMDN and KS03 are available.

Rick Campbell – 785.742.4707 - rick.campbell@sacfoxenviro.org
Scott Weir – 785.742.4704- scott.weir@sacfoxenviro.org

Ambient air concentrations and wet deposition of mercury at two urban locations in New York: temporal patterns, comparison with rural sites, and episodes

Kevin Civerolo¹ and Dirk Felton
New York State DEC, Division of Air Resources
625 Broadway, Albany, NY 12233

Since 2008, the New York State Department of Environmental Conservation (NYSDEC) has been monitoring mercury in air and wet deposition at two urban sites – Rochester and New York City – under the auspices of the MDN and AMNet programs, with the support of the Great Lakes Commission (GLC), US EPA, and the New York State Energy Research and Development Authority (NYSERDA). Here we present average diurnal patterns in ambient concentrations of particle-bound mercury (PBM), reactive gaseous mercury (RGM), and gaseous elemental mercury (GEM), as well as seasonal patterns and year-to-year variations in both ambient concentrations and wet deposition. We also compare the magnitudes of these parameters to air concentrations and wet deposition at rural MDN and AMNet monitors in the state, and examine correlations with other gas-phase and particulate pollutants measured at these sites. Finally, we present examples of highly elevated mercury, especially PBM, during the colder months due to meteorological conditions and sources such as wood smoke and coal combustion.

¹Phone: 518-402-8383; Fax: 518-402-9035; E-mail: kxcivero@dec.state.ny.us

Detection Limits in the Central Analytical Laboratory's NADP Networks

Tracy Dombek and Mark Rhodes
National Atmospheric Deposition Program
Prairie Research Institute
University of Illinois
Champaign, IL 61820

The Central Analytical Laboratory (CAL) located in Champaign, Illinois on the campus of the University of Illinois has analyzed wet deposition samples for the National Atmospheric Deposition Program (NADP) since 1978. NADP is composed of five monitoring networks. The CAL analyzes samples for three of the networks: the Atmospheric Integrated Research Monitoring Network (AIRMoN), the National Trends Network (NTN) and the Ammonia Monitoring Network (AMoN).

Each year, the CAL publishes a Minimum Detection Limit (MDL) for each analyte that it measures. An MDL is defined as the minimum concentration that can be reported as a quantitated value¹. By contrast a Practical Quantitation Limit (PQL) is the lowest concentration that can be reliably measured. Providing both an MDL and PQL to data users will give them a more complete perspective of NADP data.

MDL's are calculated from results obtained for Quality Assurance (QA) samples submitted monthly as blind samples to analysts. The concentrations for all analytes are approximately 1-5 times the estimated MDL. In the past ten years, new instrument technologies available to the CAL have enabled them to improve their methods and thus lower MDL's for analytes. The lower MDL's increase the need to evaluate data throughout the entire process. The CAL is currently evaluating its QA/QC data to determine PQL values for each analyte and each network.

¹ EPA CFR 136 Appendix B

Ammonia Monitoring Network (AMoN) Blank Study

N. Gartman¹, L. Green¹, B. Riney¹, S. Henson¹, T. Dombek¹, C. Lehmann¹, M. Rhodes¹ & J. Walker²

¹National Atmospheric Deposition Program/Central Analytical Laboratory
Illinois State Water Survey, Prairie Research Institute,
University of Illinois at Urbana-Champaign
2204 Griffith Dr., Champaign, IL 61820
Tel. 217-244-0869; Email ngartman@illinois.edu

²U.S. EPA National Risk Management Research Laboratory, RTP

Starting in October 2007, the National Atmospheric Deposition Program (NADP) has operated the Ammonia Monitoring Network (AMoN) Study using Radiello™ type passive diffusion ammonia gas samplers.

The purpose of present study is to evaluate the ammonia contamination which can occur in all stages of AMoN sampler processing: preparation, storing and transportation of Radiello™ samplers; extraction of Radiello™ samplers and final analysis of extracts. A number of blank studies were carried out: special laboratory and freezer air studies, new core blank studies, as well as blue Radiello™ bodies cleaning and storing studies. The results of above-mentioned studies will minimize the influence of potential accompanying contamination factors on the accuracy of ambient ammonia concentrations. This is important in terms of both the AMoN travel blanks, and the deployed AMoN samplers.

Measurement of Total Phosphorous in AIRMoN Samples by the NADP/CAL

Lee Green and Christopher Lehmann
National Atmospheric Deposition Program
Central Analytical Laboratory (CAL), Illinois State Water Survey
Institute of Natural Resource Sustainability
University of Illinois at Urbana-Champaign
Champaign, IL 61820
leegreen@illinois.edu

Phosphorus can be present in water samples in at least three forms: orthophosphate, acid-hydrolysable phosphate and total or organic phosphorus. Organic phosphorus is changed to inorganic by bacterial action. Orthophosphate can be measured directly and the other two forms must be converted to orthophosphate prior to testing.

Total Phosphorus measurements in precipitation samples from the National Atmospheric Deposition Network (NADP) were determined by flow injection analysis (FIA) from samples received in February 2011 to present. Precipitation samples for this study were collected from the Atmospheric Integrated Monitoring Network (AIRMoN). These samples are collected within a 24 hour precipitation event, are immediately refrigerated, and remain chilled during shipment to the NADP Central Analytical Laboratory (CAL) in Champaign, IL.

These samples were tested by the CAL for Orthophosphate and Total Phosphorus within one week of arrival at the CAL. A second set of samples were collected at the Bondville, IL (IL11) site as a special study. These samples were collected side by side with the AIRMoN sample at this site but the sample was collected directly into a refrigerated compartment and never allowed to come to seasonal temperature. Only total phosphorus was analyzed on the special study samples. The total phosphorus method detection limit was determined to be 0.005 mg/L. Total conversion to orthophosphate was determined by using two quality control standards every nine samples during analysis. The recovery for a 0.025 mg/L trimethyl phosphate (TMP) was found to be 96% and a 0.05 mg/L sodium tripolyphosphate (3P) was found to be 100%. Seasonal data from this study will be presented as well as site specific total phosphorus vs orthophosphate concentrations throughout the year.

Equipment Modernization

Matt Layden and Jeff Pribble
Central Analytical Laboratory, Illinois State Water Survey,
Prairie Research Institute,
University of Illinois,
2204 Griffith Drive,
Champaign, IL 61820

With a goal of maintaining an efficient measurement system that meets the data and information needs of scientists, policy-makers, educators, and the public, NADP committees in 2006 passed a resolution requiring equipment changes for all NTN, MDN, and AIRMoN sites. The resolution required all sites to install an approved electronic precipitation gage by the end of 2011. As the end of 2011 rapidly approaches over 240 NADP sites have an electronic raingage.

At the NADP Executive Committee meeting on October 19th, 2010, a new wet-deposition collector was accepted for use in the NADP/National Trends Network for collection of precipitation chemistry samples. The new collector is the N-CON Systems Co., Inc.'s Atmospheric Deposition Sampler (Model 00-120-2, ADS/NTN). This new sampler was tested following the NADP requirements and was deemed to have met these standards and to fulfill the needs of the network. Therefore N-CON Systems ADS/NTN sampler is now acceptable for use in collecting wet deposition samples.

The equipment modernization process has not been without its' challenges. This poster will examine some of those challenges as well as chart the progress of modernization effort.

An assessment of long-term monitoring programs in New York State

Carrie R. Levine*, Ruth D. Yanai
SUNY College of Environmental Science and Forestry
Department of Forest and Natural Resources Management
1 Forestry Dr., Syracuse NY 13210

Air pollutants such as nitrogen oxides, sulfur dioxide, and mercury have had significant impacts on the quality of lakes, rivers, soils, biota, and tree health throughout the Northeastern US. Some areas of New York State are particularly susceptible to environmental degradation, such as the Adirondack and Catskill regions, which receive some of the highest rates of acid and mercury deposition in the country. Long-term monitoring efforts have produced data sets that have been extremely valuable for evaluating changes over time in air pollution loads and effects on the environment.

It is important to reevaluate long-term monitoring programs to ensure that these programs remain efficient and effective. To our knowledge, a comprehensive evaluation of state-wide long-term monitoring of acid and mercury deposition has never been undertaken in New York State. We are working with stakeholders to create a comprehensive database of long-term monitoring efforts in New York State, including monitoring of lakes, streams, soils, vegetation, and biota. These monitoring efforts include projects funded by a variety of federal and state agencies, private non-profit organizations, and academic institutions. Additionally, we are working to identify key science and policy questions to which the findings from long-term monitoring efforts can be applied.

We will undertake statistical analysis of select data sets to address the efficiency of monitoring efforts by identifying redundancies and gaps in monitoring efforts. After documenting data availability and identifying the policy needs for environmental monitoring, we can begin to analyze whether current monitoring practices are excessive (involving more effort than is justified by the results produced) and/or inadequate (producing results that are not sufficiently accurate or precise to meet policy needs). These analyses will include estimates of uncertainty in measurement and model parameters in order to most successfully answer key science and policy questions.

By summer 2012, we plan to have identified optimal, cost-effective monitoring options based on our inventory of long-term monitoring data sets and statistical analysis of select data sets. Ultimately this stakeholder driven, collaborative project will provide guidance for optimizing the efficiency and cost-effectiveness of long-term monitoring activities for sulfur, nitrogen and mercury in New York State.

Email: carrie.rose.levine@gmail.com Phone: 773.307.2583

NEON's Collection and Analysis of the Atmospheric Wet Deposition

Hongyan Luo^{1,2,3}, Henry W. Loeschner^{2,3}

The National Ecological Observatory Network (NEON) is a large facility project funded by the National Science Foundation. NEON is creating a new national observatory to collect ecological and climatic observations across the continental U.S., Alaska, Hawaii and Puerto Rico, whose overarching question is "how will ecosystems respond to changes in natural- and human-induced forcings such as climate, land use, and invasive species across a range of spatial and temporal scales". As such, chemical climate will be observed, and as a chemical input in wet deposition. NEON will collect wet deposition samples from strategically selected sites across the continent for 30 years to provide insight in the generation, transportation and deposition of the some atmospheric pollutants.

The chemical analyses and archival samples will follow NADP protocols. However, our collection design have three key differences from NADP protocols: 1) NEON collectors locates at a tower top above the canopy in the well mixed surface layer verses NADP protocols on the ground in clearings of various sizes, 2) NEON will use the refrigerated N-COM dual collector, while NADP approved, few NADP sites utilize them, and 3) NEON sample collection are planned to be every 2 weeks. But before NEON establishes a final operational design, NADP and NEON will be conducting side by side comparisons at sites where both organizations already co-exist: Walker Branch TN, Harvard Forest MA, Windriver WA, Rocky Mountain NP CO, Santa Rita AZ, etc. Once we collectively characterize how our approaches compare, then we will assess what, if any, changes in NEON collection approaches are needed (e.g., some sites may need more frequent sampling).

Here, we also outline the overall NEON observatory strategy, detail the wet deposition measurement strategy, and plans on how NADP and NEON are working together.

1-E-mail: hluo@neoninc.org

2-NEON, Inc. 1685 38th Street, Suite 100, Boulder, CO 80301 www.neoninc.org

3-Institute of Arctic and Alpine Research, University of Colorado, Boulder, CO 80309

You've determined the critical load: now what? Tracking progress at Rocky Mountain National Park using NADP data

Kristi Morris¹, Alisa Mast², Dave Clow², Greg Wetherbee³, Jill Baron⁴, Curt Taipale⁵, Tamara Blett¹, David Gay⁶, and Eric Richer⁷

Through much collaboration the National Parks Service, the Colorado Department of Public Health and Environment and the Environmental Protection Agency issued the Nitrogen Deposition Reduction Plan (NDRP) in 2007 for Rocky Mountain National Park (RMNP). As part of the NDRP, the agencies endorsed a critical load of 1.5 kg/ha/yr in order to protect aquatic and terrestrial resources at RMNP. To achieve this threshold, the agencies have chosen a glidepath approach which anticipates gradual improvement over time. The baseline condition at RMNP is 3.1 kg N/ha/yr. The first interim milestone requires a reduction of wet nitrogen deposition from baseline conditions to 2.7 kg N/ha/yr by the year 2012. Progress towards this and subsequent interim milestones will be assessed using the weight of evidence at 5-year intervals starting in 2013 until the critical load is achieved in the year 2032. The weight of evidence approach uses multiple types of information to determine the success or failure of the goals of the NDRP. Several analyses will be used to track nitrogen deposition at RMNP and include, but are not limited to the following: (1) assessment of progress along the glidepath, (2) long-term trend analyses for RMNP and other regional sites, and (3) short-term trend analyses for RMNP and other regional sites. These analyses and the rationale for their use will be presented along with other key challenges of monitoring in a remote high-elevation ecosystem.

¹National Park Service, Air Resources Division

²US Geological Survey, Rocky Mountain Region, Colorado Water Science Center

³US Geological Survey, Branch of Quality Systems, NADP External QA Project

⁴US Geological Survey, Colorado State University-Natural Resource Ecology Laboratory

⁵Colorado Department of Public Health and Environment, Air Pollution Control Division

⁶NADP Program Office, Program Coordinator

⁷Colorado State University-Natural Resource Ecology Laboratory

Atmospheric Mercury Network (AMNet)

Mark L. Olson¹, David Gay¹, Tim Sharac², David Schmeltz², and Eric Prestbo³

The NADP Atmospheric Mercury Network (AMNet) was officially adopted by the NADP Executive Committee in October 2009. The network monitors, summarizes, and reports atmospheric mercury species which contribute to dry and total mercury deposition. Manuals and Standard Operating Procedures have been developed to ensure proper collection and handling of the data. Data is quality assured by the Site Liaison using an automated database. Quality assured data is sent to the Operators for final approval prior to posting to the public. All the data collected from January 2009 thru June of 2011 has been validated and is available. In 2011 AMNet added 5 sites and lost 4 for a total of 22 sites within the network. In 2011 fifteen site visits were conducted. This poster is an overview of the network, status of data and future direction.

⁽¹⁾NADP; ⁽²⁾US EPA; ⁽³⁾Tekran Research and Development

Development of a base cation weathering (BCw) datalayer to support the calculation of critical loads of nitrogen (N) and sulfur (S) deposition of in the United States: Pennsylvania as the trial state.

Jennifer Phelan¹, Harald Sverdrup², Salim Belyazid³, Randall Waite⁴

Determination of critical loads of atmospheric deposition is becoming an increasingly important component of natural resource policy and management. However, availability of good-quality and defensible estimates of base cation weathering (BCw) rates limits the ability to calculate accurate critical loads of nitrogen (N) and sulfur (S) deposition in terrestrial ecosystems in the United States. The objective of our study was to evaluate the feasibility of a PROFILE model-based methodology to produce a high-quality, continuous coverage datalayer of BCw. The methodology was applied to forested areas in Pennsylvania using currently existing national- and state-level databases, and BCw rates were calculated at the U.S. Department of Agriculture (USDA)-National Resources Conservation Service (NRCS) SSURGO soil polygon level (0.1 km²). The model was successfully applied to 617,249 sites and BCw rates were found to range between 0.02 and 320.43 kcq/ha/yr. The average BCw rate was 2.34 kcq/ha/yr. Insufficient forest parameter and soil mineralogy data were found to be the main limitation to the model estimates of BCw.

¹ RTI International (corresponding author), USA; ²Lund University, Sweden; ³Belyazid Consulting and Communication AB, Sweden; ⁴U.S. Environmental Protection Agency (US EPA)

Federal Interagency Guidance for Nitrogen and Sulfur Deposition Analyses

Ellen M. Porter¹, Cindy M. Huber², Rick Graw³ and Jill Webster⁴

This poster will describe recent guidance developed by the Federal Land Managers (FLMs) to assess potential impacts in national parks, forests, refuges, and wilderness areas from proposed powerplants, industry, and other sources of nitrogen (N) or sulfur (S) deposition. New or modified facilities are required by the Clean Air Act to undergo preconstruction New Source Review (NSR), including analyses for air quality and air quality-sensitive resources. Similarly, projects such as oil and gas development may be required to analyze their potential impacts on FLM lands under the National Environmental Policy Act (NEPA). The FLMs, including the National Park Service, the U.S. Forest Service, and the U.S. Fish and Wildlife Service, previously developed guidance for evaluating the impact of additional N or S deposition on lands under their management in the Federal Land Managers' Air Quality Related Values Workgroup Report (FLAG 2010). FLAG describes deposition modeling tools as well as the Deposition Analysis Thresholds (DATs) used to assess a source's modeled contribution to deposition in an FLM area. Below the DAT, deposition from the source is considered insignificant. Above the DAT, the FLM is likely to require a refined analysis to determine if the affected area is, or is likely to be, harmed by the increase in deposition. Recently, the FLMs have issued additional guidance on the refined analysis, including the use of critical loads and target loads. The critical load is the amount of deposition below which a resource is unlikely to be harmed; the target load is based on the critical load, but may include other considerations such as time to recovery. The refined analysis considers whether air quality-sensitive resources in the affected area are sensitive to or currently impacted by deposition, whether critical or target loads have been developed for the area's resources, and whether the critical or target loads are exceeded by current or predicted deposition. The new guidance is part of a continuing effort by the FLM to ensure consistent, predictable review processes for NSR permits and Environmental Assessments and/or Environmental Impact Statements under NEPA.

¹ National Park Service Air Resources Division, Lakewood, CO, 303.969.2617, Ellen_Porter@NPS.gov

² USDA Forest Service, Roanoke, VA, 540.265.5156, chuber@fs.fed.us

³ USDA Forest Service, Portland, OR, 503.808.2918, rgraw@fs.fed.us

⁴ US Fish and Wildlife Service, Lakewood, CO, 303.914.3804, Jill_Webster@fws.gov

An Analysis of Co-located Atmospheric Mercury Speciation Data from AMNet

Eric M. Prestbo¹, David Gay², Mark Olson³, Winston Luke⁴, Paul Kelley⁵, Dirk Felton⁶, Thomas Holsen⁷, Jiaoyan Huang⁸, and Hyun-Deok Choi⁹

Atmospheric mercury speciation measurements are being made and reported on-line as part of the new Atmospheric Mercury Network (AMNet). It is easy to overlook that mercury is the only atmospheric constituent routinely and continuously measured at the part per quadrillion level (ppqv, mixing ratio). Typical values range from a few hundred ppqv for gaseous elemental mercury (GEM) to 0.5 to 10 ppqv for gaseous oxidized mercury (GOM) and particulate-bound mercury (PBM). For contrast, background ozone concentrations are roughly 30 million times higher than average GOM concentrations. Because of the exceedingly low atmospheric mercury species concentrations, it is technically very difficult to generate and deliver stable and traceable standards to the inlet of automated measurement systems for quality assurance and calibration purposes. Thus, quality assurance has normally consisted of 1) routine automated internal calibration of the detector with a traceable elemental mercury permeation source, 2) manual injections of elemental mercury at locations upstream of the detector and 3) direct intercomparisons of measurements with two or more instruments over a short time period. Both manual injections and direct intercomparisons are done infrequently and few are reported in the literature. Fortunately, within AMNet, there have been 3 sites where two instruments have been co-located for an extended period of time. From this data we have learned that: 1) harmonized methods and one operator produce the highest quality results, 2) inlet height differences may lead to significant GOM differences and 3) the automated data reduction program must be supplemented by well documented field observer forms. A statistical analysis of co-located, synchronous atmospheric mercury speciation data will be presented. Additionally, a summary of historical atmospheric mercury speciation quality assurance data will be shown.

¹ Tekran Research & Development

^{2,3} University of Illinois

⁴ NOAA Air Resources Laboratory

⁵ New York Department of Environmental Conservation

^{7,8} Clarkson University

⁹ National Institute of Aerospace

Passive Ammonia Monitoring in the United States: Comparing Three Different Sampling Devices

Puchalski, Melissa^a; Sather, Mark^b; Walker, John T.^c; Lehmann, Christopher^d; Gay, David^d; Mathew, Johnson^e; Robarge, Wayne^f

The contribution of nitrogen to ecosystems and to PM_{2.5} formation is known to be significant in the United States. To date, there have been few monitoring efforts to establish a total nitrogen baseline, or measure trends and regional variability of total nitrogen. The US EPA is faced with tightening budgets and stricter PM_{2.5} National Ambient Air Quality Standards (NAAQS) with an increasing need to understand the spatial and temporal variability of NH₃ concentrations to evaluate and validate air quality models and deposition flux estimates. Passive samplers have the benefit of being easy to deploy, cost-effective and provide an accurate measurement. The trade-off is that passive samplers provide lower temporal resolution, typically 1 to 2 weeks. The US EPA's ORD has deployed the Adapted Low-Cost Passive High Absorption (ALPHIA) passive sampler at several sites throughout NC as part of the CAMNet study. The NADP has deployed Radiello[®] passive samplers at more than 50 sites as part of the Ammonia Monitoring Network (AMoN). EPA's Region 6 Air Quality group deployed Ogawa passive samplers throughout the southwest and central US to begin studying the potential effects of NOx controls from the oil/gas and power generation industries on ambient NH₃ concentrations and regional haze. This paper compares the accuracy and precision of the three passive samplers. Each sampler was shown to be comparable and reliable; however, each sampler also has pros and cons. The lessons learned from the deployment of each sampler should be used when planning a research or network-wide study.

^a Clean Air Markets Division, U.S. EPA 1200 Pennsylvania Ave NW Washington D.C. (202)343-9882 puchalski.melissa@epa.gov

^b Air Quality Analysis Section, U.S. EPA Region 6 1445 Ross Ave. Dallas, TX

^c National Risk Management Research Laboratory, U.S. EPA 109 T.W. Alexander Dr. Research Triangle Park, NC

^d National Atmospheric Deposition Program, Illinois State Water Survey, University of Illinois at Urbana-Champaign 2204 Griffith Dr.

^e Houston Laboratory, U.S. EPA Region 6 10625 Fallstone Rd. Houston, TX

^f North Carolina State University P O Box 7619 Raleigh, NC

National Trends Network, Sample Evaporation

Mark Rhodes, Lydia Douglas, Caroline Koch, and Tracy Dombek
University of Illinois

The National Atmospheric Deposition Program's National Trends Network (NADP/NTN) collects weekly precipitation samples across the United States. Samples are analyzed for acids, nutrients, and base cations. NTN samples may be deployed for up to 194 hours and remain valid. During that time evaporation of the sample may occur. The impact of evaporation on sample chemistry is not well defined. In this study, sample evaporation is considered in 3 different locations: a climate controlled laboratory, an open field, and a protected courtyard. In addition, two different sample volumes (150mL and 500mL) are considered. Results from a 12 week study conducted June - September 2011 are presented.

Combining Passive Samplers and a Bi-Directional Exchange Model to Calculate Ammonia (NH₃) Dry Deposition

Wayne P. Robarge^{*1}, John T. Walker^{*2} and Robert E. Austin¹

Dry deposition of NH₃ to vegetation near local sources of NH₃ emissions is difficult to measure, and is best estimated via models. Presented here are results for a semi-empirical approach for estimating air-surface exchange fluxes of NH₃ downwind of a poultry facility (~ 3.5 million layers) using a bi-directional air-surface exchange model. The modeling domain is the Pocosin Lakes National Wildlife Refuge in eastern North Carolina. Vegetation is pocosin wetlands, with peat soils (pH 3.6) and shrub canopy (leatherwood (*Cyrilla racemiflora*), inkberry (*Ilex glabra*), wax myrtle (*Morella cerifera*)). Ammonia air-surface exchange (flux) was calculated using a two-layer canopy compensation point model (Nemitz et al. 2001, *Quart. J. Roy. Met. Soc.* 127, 815 – 833.) as implemented by Walker et al. (2008, *Atmos. Environ.* 42, 3407 – 3418.), in which the competing processes of emission and deposition were taken into account by relating the net canopy-scale NH₃ flux to the net emission potential of the canopy (both foliage and soil). Weekly NH₃ air concentrations were calculated using A1.P11A (Center for Ecology and Hydrology, Edinburgh) passive samplers (h=5.8 m) along three transects to the north/northeast of the facility at 800, 2000 and 3200 m. The NH₃ concentrations were used to develop a nonlinear regression model for predicting gridded NH₃ concentrations as a function of distance and wind direction from the facility. Soil and foliar extracts were used to determine critical compensation points. Seasonal concentration fields and diurnal flux profiles were used to produce representative daily fluxes at each grid point (100 m by 100 m grid). Daily fluxes were scaled to seasonal fluxes, which were summed to an annual flux estimate. Dry deposition was 10.1 kg N/ha/yr at the refuge boundary, decreasing non-linearly to 5.4 kg N/ha/yr at 1.5 km, and 1.4 kg N/ha/yr 8 - 10 km downwind of the facility. Approximately 10% of the refuge model domain receives ≥ 3.0 kg N/ha/yr as dry NH₃ deposition. Limitations of the approach include potential multiple sources of NH₃ inherent in use of passive samplers, and modeling results valid only for the vegetation type included in the model (e.g. in this study a “pocosin” land use type, not adjacent agricultural land).

*Corresponding authors: wayne_robarge@ncsu.edu (919-515-1454), walker.john1@epa.gov (919-541-2288)

¹Department of Soil Science, NC State University, Raleigh, NC

²U. S. EPA, ORD, NRMRL, APPCD, APB, RTP, NC

Nutrient Loading Via Atmospheric Deposition To Marine Corp Base Camp Lejeune (MCBCL), Jacksonville, NC

Wayne P. Robarge^{*1}, Karsten Baumann², Patricia Cunningham¹
and Susan Cohen³

The goal of this project was to quantify the spatial and temporal scale of nutrient loading from wet and dry deposition to terrestrial and aquatic ecosystems within the confines of MCBCL. This effort is part of the Defense Coastal/Estuarine Research Program (<http://dcerp.rti.org>) funded by the DOD Strategic Environmental Research and Development Program, to identify significant ecosystem stressors and develop conceptual/mechanistic ecological models that lead to effective management for the long-term sustainability of military training. Four battery-powered approved Mercury Deposition Network collectors located across MCBCL were used to determine the weekly composition of rainfall. Spatial patterns in weekly rainfall amounts were determined using manual rain gauges and tipping-bucket gauges. Throughfall collectors under the three dominant forested canopies were used to provide an indirect estimate of dry deposition. On an annual basis, relative standard deviation of rainfall amounts were < 10% across MCBCL for 2009 (1730 mm) and 2010 (1560 mm). From July 2009 to December 2010, wet deposition of total N was ~ 8 kg N/ha. Only Na and Cl demonstrated gradients in wet deposition amounts, decreasing moving away from the ocean (36 kg Cl/ha, 19 kg Na/ha) to the furthest point inland (25 kg Cl/ha, 14 kg Na/ha). On an annual basis (October 2009 – November 2010), total N (6-8 kg N/ha/yr) reaching the forest floor is ~ 2x wet deposition, ~55% of which is organic-N. Chloride, Na and sulfate (SO₄) demonstrate substantial inputs via dry deposition (64 kg Cl/ha/yr, 50 kg Na/ha/yr, 46 kg SO₄/ha/yr). Comparison of wet deposition amounts to a nearby National Trend Network (NTN) collector (NC29; Hofmann Forest, NC) indicated close agreement in seasonal trends of deposition amounts for inorganic N species. Use of thymol as a preservative resulted in 50-80% of inorganic N in rainfall as ammonium-N. Results from this project, and historical NTN deposition records, indicate that wet deposition has contributed ~ 250 metric tons of total N per year to terrestrial and aquatic ecosystems at MCBCL. Under forested canopies, total N reaching the forest floor essentially doubles to ~ 500 metric tons of total N per year.

*Corresponding author: wayne_robarge@ncsu.edu; 919-515-1454

¹Soil Science, NC State University, Raleigh, NC

²Atmospheric Research and Analysis, Inc., Cary, NC

³RTI International, Research Triangle Park, NC

⁴DCERP Coordinator, Marine Corps Base Camp Lejeune, NC

Tracking the Maryland Healthy Air Act

John Sherwell
Power Plant Research Program
Department of Natural Resources
Tawes Building B-3
Annapolis, MD 21401
Ph – 410 260 8667
Email – jsherwell@dnr.state.md.us

In 2006 the Maryland legislature passed the Healthy Air Act [HAA]. This Act affected all the coal-fired generating stations in the State and called for cuts in the emissions of sulfur dioxide [SO₂], oxides of nitrogen [NO_x] and mercury [Hg] and also required that the State join the Regional Greenhouse Gas Initiative [RGGI] to manage reductions in carbon dioxide [CO₂]. Overall, the emission reductions were similar to those called out in the then federal rules – Clean Air Interstate Rule [CAIR] affecting SO₂ and NO_x and the Clean Air Mercury Rule [CAMR] – but was on a significantly more aggressive schedule. The phase 1 NO_x reductions took effect on January 1, 2009 and the phase 1 SO₂ and Hg reductions began on January 1, 2010. Maryland has also participated in the RGGI cap-and-trade program with each generation company acquiring sufficient emission allowances to cover their CO₂ emissions. At the end of 2010 all affected facilities were in compliance with their HAA emissions caps.

This poster will describe the emission reductions achieved under the HAA and the response in the regional monitors to these reductions. Predictive modeling associated with the passing of the Act will also be compared. A brief assessment will be made of the benefits of the newly passed federal rule – the Cross-State Air Pollution Control Rule [CSAPR] particularly as it relates to reductions in nutrient-nitrogen delivered to the Chesapeake Bay.

Evaluation of Methods for Measuring Particulate Carbon in Precipitation

Alexander Torres*, Tami Bond, and Christopher Lehmann
University of Illinois at Urbana-Champaign

Black carbon (BC) and organic carbon (OC) affect the Earth's radiance balance and contribute to climate change. OC also contributes to the nutrient enrichment of surface water. The exact extent of these negative impacts is unknown because the life cycle of carbon aerosols and their removal process has not been studied exhaustively. Wet deposition is the major removal mechanism (~80%) of these aerosols. OC and BC are emitted from the same sources and their scavenging process could be linked. Some studies have focused on the monitoring of individual species but only one study has measured OC and BC in precipitation. The low concentration of BC in rain and the susceptibility of the OC analysis to contamination are the key challenges in developing a standard analytical method.

Different analytical techniques were tested to measure BC in precipitation, including: Thermal/Optical Analysis, Single Particle Soot Photometer (SP2), and UV/VIS Spectrophotometer. Water soluble OC was measured by Total Organic Carbon (TOC) Analysis and water insoluble OC was measured by Thermal/Optical Analysis. The evaluation was performed using laboratory standard solutions made by burning pine wood and aging with ozone, and rain samples collected by the National Atmospheric Deposition Program at Bondville (Champaign County), Illinois.

*Corresponding author: (787) 515-7225, 337 Paddock DR W, Savoy IL 61874, torresn1@illinois.edu

Ammonia air-surface exchange in an unfertilized hay field in the southeastern U.S.

John T. Walker*¹, Matthew Jones^{1,2}, Jesse O. Bash¹, Eiko Nemitz², and Wayne Robarge³

The processes of ammonia (NH_3) air-surface exchange in unfertilized grass ecosystems remain largely uncharacterized in the U.S. This study was conducted near Chapel Hill, North Carolina during the spring and summer of 2008 to quantify the flux of ammonia (NH_3) above an unfertilized grass field managed for hay production. Objectives were to examine the influence of management practices (e.g., cutting and removal of cuttings) on fluxes and to assess the relative importance of soil versus foliage processes with respect to the net canopy-scale flux. Ammonia fluxes above the vegetation were measured by the modified Bowen-ratio technique using an AMANDA continuous rotating wet denuder system with online conductivity detection to measure vertical concentration gradients. Additionally, ammonium (NH_4^+) and hydrogen ion (H^+) concentrations in the soil solution, grass tissue, and grass surface water (i.e., dew and guttation) were measured throughout the experiment to assess component emission potentials. Differences in flux characteristics before and after cutting, patterns of soil and foliage chemistry, and the relationships between fluxes and surface characteristics are discussed.

*Corresponding author
Email: Walker.johnt@epa.gov
Phone: 919-541-2288

¹U.S. EPA, Office of Research and Development, Research Triangle Park, NC, USA

²Center for Ecology and Hydrology, Edinburgh, Scotland

³North Carolina State University, Department of Soil Science, Raleigh, NC, USA

Variation in atmospheric deposition along the Appalachian Trail

Weathers, K.C., Ewing, H.A., Lindsey, A.M., Bourne, C.E.

Total atmospheric deposition, including precipitation, dry particles and gases, and cloud, is highly variable in both space and time making assessment of its impact on ecosystems dependent upon understanding this spatial and temporal heterogeneity. To understand the spatial variability in atmospheric deposition and its ecosystem effects, a collaborative project among soil scientists, physiological ecologists, watershed scientists, modelers, and specialists in atmospheric deposition was initiated in 2010. We collected throughfall (TF), a measure of total deposition, at high and low elevations at five locations (Sugarloaf Mountain, ME; White Mountains, NH; Delaware Water Gap, NJ; Shenandoah, VA; and Coweeta, NC) along the Appalachian Trail during the summer of 2010 as part of the AT MegaTransect Project.

Based on previous work and modeling, we expected higher deposition with increasing elevation interacting with a general trend of higher deposition with decreasing latitude along the trail. Nitrogen (N) and sulfur (S) deposition generally increased with elevation, but the slope of this relationship varied across sites. N and S deposition were both highest at Delaware Water Gap, with Coweeta also having high N deposition but the lowest S deposition. Sugarloaf experienced the lowest N deposition but some of the highest S deposition at high elevation. Our collaborators have also sampled soil, vegetation, and stream water at these sites. We expect that the chemical and biological responsiveness of sites will depend upon the deposition load and the buffering capacity of the soils.

National Atmospheric Deposition Program/National Trends Network Sites

July 31, 2011

State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Alabama					
	AL03	Centerville	MDN	Atmospheric Research & Analysis	02/11
	AL10	Black Belt Research & Extension Center		US Geological Survey	08/83
	AL99	Sand Mountain Research & Extension Center	AMoN	Tennessee Valley Authority	10/84
Alaska					
101	AK01	Poker Creek		USDA Forest Service	12/92
	AK02	Juneau		USDA Forest Service/University of Alaska Southeast	06/04
	AK03	Denali NP - Mount McKinley		National Park Service - Air Resources Division	06/80
	AK06	Gates of the Arctic NP - Bettles	MDN	US Bureau of Land Management	11/08
	AK97	Katmai National Park - King Salmon		National Park Service - Air Resources Division	11/09
Arizona					
	AZ03	Grand Canyon NP - Hopi Point		National Park Service - Air Resources Division	08/81
	AZ06	Organ Pipe Cactus NM		National Park Service - Air Resources Division	04/80
	AZ97	Petrified Forest NP-Rainbow Forest		National Park Service - Air Resources Division	12/02
	AZ98	Chiricahua	AMoN	US Environmental Protection Agency-CAMD	02/99
	AZ99	Oliver Knoll		US Geological Survey	08/81

State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Arkansas					
	AR02	Warren 2WSW		US Geological Survey	05/82
	AR03	Caddo Valley	AMoN	US Geological Survey	12/83
	AR16	Buffalo NR - Buffalo Point		National Park Service - Air Resources Division	07/82
	AR27	Fayetteville		US Geological Survey	05/80
California					
102	CA28	Kings River Experimental Watershed		USDA Forest Service	04/07
	CA42	Tanbark Flat		USDA Forest Service	01/82
	CA45	Hopland		US Geological Survey	10/79
	CA50	Sagehen Creek		US Geological Survey	11/01
	CA66	Pinnacles NM - Bear Valley		National Park Service - Air Resources Division	11/99
	CA67	Joshua Tree NP - Black Rock	AMoN	National Park Service - Air Resources Division	09/00
	CA75	Sequoia NP - Giant Forest	MDN	National Park Service - Air Resources Division	07/80
	CA76	Montague		US Geological Survey	06/85
	CA88	Davis		US Geological Survey	09/78
	CA94	Converse Flats	MDN	USDA Forest Service	05/06
	CA96	Lassen Volcanic NP - Manzanita Lake		National Park Service - Air Resources Division	06/00
	CA99	Yosemite NP - Hodgdon Meadow		National Park Service - Air Resources Division	12/81

State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Colorado					
103	CO00	Alamosa		US Geological Survey	04/80
	CO01	Las Animas Fish Hatchery		US Geological Survey	10/83
	CO02	Niwot Saddle		NSF-Institute of Arctic & Alpine Research/University of	06/84
	CO08	Four Mile Park		US Environmental Protection Agency-CAMD	12/87
	CO10	Gothic		US Environmental Protection Agency-CAMD	02/99
	CO15	Sand Spring		US Bureau of Land Management	03/79
	CO19	Rocky Mountain NP - Beaver Meadows		National Park Service - Air Resources Division	05/80
	CO21	Manitou		USDA Forest Service	10/78
	CO22	Pawnee		NSF-Shortgrass Steppe LTER/Colorado State University	05/79
	CO89	Rocky Mountain National Park-Loch Vail		National Park Service-Rocky Mountain National Park	09/09
	CO90	Niwot Ridge-Southeast		NSF-Institute of Arctic & Alpine Research University of	01/06
	CO91	Wolf Creek Pass		USDA Forest Service	05/92
	CO92	Sunlight Peak		US Environmental Protection Agency-CAMD	01/88
	CO93	Buffalo Pass - Dry Lake		USDA Forest Service	10/86
	CO94	Sugarloaf		US Environmental Protection Agency-CAMD	11/86
	CO96	Molas Pass	MDN	USDA Forest Service	07/86
	CO97	Buffalo Pass - Summit Lake	MDN	USDA Forest Service	02/84
	CO98	Rocky Mountain NP - Loch Vale	AMoN	USGS/Colorado State University	08/83
	CO99	Mesa Verde NP - Chapin Mesa	MDN	US Geological Survey	04/81

State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Connecticut					
	CT15	Abington	AMoN	US Environmental Protection Agency-CAMD	01/99
Florida					
104	FL05	Chassahowitzka NWR	MDN	US Fish & Wildlife Service - Air Quality Branch	08/96
	FL11	Everglades NP - Research Center	MDN/AMoN	National Park Service - Air Resources Division	06/80
	FL14	Quincy		US Geological Survey	03/84
	FL23	Sumatra		US Environmental Protection Agency-CAMD	01/99
	FL32	Orlando		Seminole County Public Works Department	12/05
	FL41	Verna Well Field		US Geological Survey	08/83
	FL99	Kennedy Space Center		NASA/Innovative Health Applications, LLC	08/83
Georgia					
	GA09	Okefenokee NWR	MDN	US Fish & Wildlife Service - Air Quality Branch	06/97
	GA20	Bellville		US Environmental Protection Agency-CAMD	04/83
	GA33	Sapelo Island	MDN	NSF/UGA, NOAA-NERR, & GA Dept of Natural Resources	11/02
	GA41	Georgia Station	AMoN	Atmospheric Research & Analysis	10/78
	GA99	Chula		US Geological Survey	02/94
Idaho					
	ID02	Priest River Experimental Forest		USDA Forest Service	12/02
	ID03	Craters of the Moon NM	MDN AMoN	National Park Service - Air Resources Division	08/80
	ID11	Reynolds Creek		US Geological Survey	11/83

State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Illinois					
			AIRMoN/MD		
	IL11	Bondville	N/AMoN	US Environmental Protection Agency-CAMD	02/79
	IL18	Shabbona		SAES-University of Illinois	05/81
	IL46	Alhambra	AMoN	US Environmental Protection Agency-CAMD	01/99
	IL63	Dixon Springs Agricultural Center		SAES-University of Illinois	01/79
	IL78	Monmouth		US Geological Survey	01/85
Indiana					
	IN20	Roush Lake		US Geological Survey	08/83
	IN34	Indiana Dunes NL	MDN	National Park Service - Air Resources Division	07/80
	IN41	Agronomy Center for Research and Extension		SAES-Purdue University	07/82
Iowa					
	IA08	Big Springs Fish Hatchery		US Geological Survey	08/84
	IA23	McNay Memorial Research Center		US Geological Survey	09/84
Kansas					
	KS07	Furlington Fish Hatchery		US Geological Survey	03/84
	KS31	Konza Prairie	AMoN	SAES-Kansas State University	08/82
	KS32	Lake Scott State Park	MDN	US Geological Survey	03/84

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State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Kentucky					
	KY03	Mackville	AMoN	US Geological Survey	11/83
	KY10	Mammoth Cave NP-Houchin Meadow	MDN	National Park Service - Air Resources Division	08/02
	KY19	Seneca Park		US Geological Survey	10/03
	KY22	Lilley Cornett Woods		US Geological Survey	09/83
	KY35	Clark State Fish Hatchery		US Geological Survey	08/83
	KY99	Mulberry Flats		TVA/Murray State University	12/94
Louisiana					
	LA30	Southeast Research Station		US Geological Survey	01/83
Maine					
	ME00	Caribou	MDN	LPA/Maine Dept of Environmental Protection	04/80
	ME02	Bridgton	MDN	EPA Maine Dept of Environmental Protection	09/80
	ME04	Carrabassett Valley	MDN	US Environmental Protection Agency	03/02
	ME08	Gilead		US Geological Survey	09/99
	ME09	Greenville Station	MDN	EPA/Maine Dept of Environmental Protection	11/79
	ME96	Casco Bay - Wolfe's Neck Farm	MDN	EPA/Maine Dept of Environmental Protection	01/98
	ME98	Acadia NP - McFarland Hill	MDN	National Park Service - Air Resources Division	11/81

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State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Maryland				
MD07	Catoctin Mountain Park		National Park Service - Air Resources Division	05/03
MD08	Piney Reservoir	MDN/AMNet AMoN	Maryland Department of Natural Resources	06/04
MD13	Wye		SAES-University of Maryland	03/83
MD15	Smith Island		NOAA-Air Resources Lab	06/04
MD18	Assateague Island NS - Woodcock		Maryland Department of Natural Resources	09/00
MD99	Beltsville	MDN/AMNet AMoN	Maryland Department of Natural Resources	06/04
Massachusetts				
MA01	North Atlantic Coastal Lab	MDN	National Park Service - Air Resources Division	12/81
MA08	Quabbin Reservoir		Northeast States for Coordinated Air Use Management	03/82
Michigan				
MI09	Douglas Lake		SAES-Michigan State University	07/79
MI26	Kellogg Biological Station		SAES-Michigan State University	06/79
MI48	Seney NWR - Headquarters	MDN	US Fish & Wildlife Service - Air Quality Branch	11/00
MI51	Unionville		US Environmental Protection Agency-CAMD	01/99
MI52	Ann Arbor		US Environmental Protection Agency-CAMD	01/99
MI53	Wellston		USDA Forest Service	10/78
MI98	Raco		US Environmental Protection Agency-CAMD	05/84
MI99	Chassell		National Park Service - Air Resources Division	02/83

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State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Minnesota				
MN01	Cedar Creek		Minnesota Pollution Control Agency	12/96
MN08	Hovland		Minnesota Pollution Control Agency	12/96
MN16	Marcell Experimental Forest	MDN	USDA Forest Service	07/78
MN18	Fernberg	MDN/AMoN	US Environmental Protection Agency-CAMD	11/80
MN23	Camp Ripley	MDN	US Geological Survey	10/83
MN27	Lamberton	MDN	Minnesota Pollution Control Agency	01/79
MN28	Grindstone Lake		Minnesota Pollution Control Agency	12/96
MN32	Voyageurs NP - Sullivan Bay		National Park Service - Air Resources Division	05/00
MN99	Wolf Ridge		Minnesota Pollution Control Agency	12/96
Mississippi				
MS10	Clinton		US Geological Survey	07/84
MS12	Grand Bay NERR	MDN/AMNet	Mississippi Department of Environmental Quality	03/10
MS19	Newton		NOAA-Air Resources Lab	11/86
MS30	Coffeerville		Tennessee Valley Authority	07/84
Missouri				
MO03	Ashland Wildlife Area	MDN	US Geological Survey	10/81
MO05	University Forest		US Geological Survey	10/81

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Montana				
MT00	Little Bighorn Battlefield NM		US Geological Survey	07/84
MT05	Glacier NP - Fire Weather Station	MDN	National Park Service - Air Resources Division	06/80
MT07	Clancy		US Geological Survey	01/84
MT96	Poplar River		EPA/Fort Peck Tribes	12/99
MT97	Lost Trail Pass		USDA Forest Service	09/90
MT98	Havre - Northern Agricultural Research Center		US Geological Survey	07/85
Nebraska				
NE15	Mead	MDN	SAES-University of Nebraska	07/78
NE99	North Platte Agricultural Experiment Station		US Geological Survey	09/85
Nevada				
NV03	Smith Valley		US Geological Survey	08/85
NV05	Great Basin NP - Lehman Caves		National Park Service - Air Resources Division	01/85
New Hampshire				
NH02	Hubbard Brook		USDA Forest Service	07/78
New Jersey				
NJ00	Edwin B Forsythe NWR		US Fish & Wildlife Service - Air Quality Branch	10/98
NJ99	Washington Crossing		US Environmental Protection Agency	08/81

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State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
New Mexico				
NM01	Gila Cliff Dwellings NM		New Mexico Environment Department - AQB	07/85
NM07	Bandelier NM		National Park Service-Air Resources Division	06/82
NM08	Mayhill		US Geological Survey	01/84
NM12	Capulin Volcano NM		New Mexico Environment Department - AQB	11/84
New York				
NY01	Alfred		US Geological Survey	08/04
NY08	Aurora Research Farm		USDA/Cornell University	04/79
NY10	Chautauqua		US Geological Survey	06/80
NY20	Huntington Wildlife	MDN/AMNet	EPA/SUNY-College of Environmental Science & Forest	10/78
NY22	Akwesasne Mohawk - Fort Covington		US Environmental Protection Agency - CAMD	08/99
NY29	Moss Lake		US Geological Survey	07/03
NY52	Bennett Bridge		EPA/State University of New York-Oswego	06/80
NY68	Biscuit Brook	MDN	US Geological Survey	10/83
NY96	Cedar Beach, Southold		EPA Suffolk Dept of Health Service-Peconic Estuary Pr	11/03
NY98	Whiteface Mountain		US Geological Survey	07/84
NY99	West Point		US Geological Survey	09/83

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State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
North Carolina				
NC03	Lewiston		North Carolina State University	10/78
NC06	Beaufort	AMoN	US Environmental Protection Agency-CAMD	01/99
NC25	Coweeta	AMoN	USDA Forest Service	07/78
NC29	Hofmann Forest		North Carolina State University	07/02
NC34	Piedmont Research Station		North Carolina State University	10/78
NC35	Clinton Crops Research Station		North Carolina State University	10/78
NC36	Jordan Creek		US Geological Survey	10/83
NC41	Finley Farms		North Carolina State University	10/78
NC45	Mount Mitchell		North Carolina State University	11/85
North Dakota				
ND00	Theodore Roosevelt NP-Painted Canyon		National Park Service-Air Resources Division	01/01
ND08	Icelandic State Park		US Geological Survey	10/83
ND11	Woodworth		US Geological Survey	11/83
Ohio				
OH09	Oxford		US Geological Survey	08/84
OH17	Delaware		USDA Forest Service	10/78
OH49	Caldwell		US Geological Survey	09/78
OH54	Deer Creek State Park	AMoN	US Environmental Protection Agency-CAMD	01/99
OH71	Wooster		US Geological Survey	09/78

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State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Oklahoma				
OK00	Salt Plains NWR		US Geological Survey	12/83
OK17	Kessler Farm Field Laboratory		NOAA-Air Resources Lab	03/83
OK29	Goodwell Research Station		US Geological Survey	01/85
Oregon				
OR09	Silver Lake Ranger Station		US Geological Survey	08/83
OR10	H J Andrews Experimental Forest		USDA Forest Service	05/80
OR18	Starkey Experimental Forest		US Geological Survey	03/84
OR97	Hyslop Farm		US Environmental Protection Agency-CAMD	04/83
Pennsylvania				
PA00	Arendtsville	MDN/AMoN	US Environmental Protection Agency-CAMD	01/99
PA15	Penn State	AIRMoN	NOAA-Air Resources Lab Pennsylvania Game Commiss	06/83
PA18	Young Woman's Creek		US Geological Survey	04/99
PA29	Kane Experimental Forest		USDA Forest Service	07/78
PA42	Leading Ridge	MDN	SAES-Pennsylvania State University	04/79
PA47	Millersville	MDN	Pennsylvania Department of Environmental Protection	11/02
PA72	Milford	MDN	USDA Forest Service	12/83
Puerto Rico				
PR20	El Verde		USDA Forest Service	02/85

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State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
South Carolina				
SC05	Cape Romain NWR	MDN/AMoN	US Fish & Wildlife Service - Air Quality Branch	11/00
SC06	Santee NWR		US Geological Survey	07/84
South Dakota				
SD04	Wind Cave National Park-Elk Mountain		National Park Service - Air Resources Division	11/02
SD08	Cottonwood		US Geological Survey	10/83
SD99	Huron Well Field		US Geological Survey	11/83
Tennessee				
TN00	Walker Branch Watershed	AIRMoN	DOE: Oak Ridge National Lab Lockheed-Martin	03/80
TN04	Speedwell		US Environmental Protection Agency-CAMD	01/99
TN11	Great Smoky Mountain NP - Elkmont	MDN	National Park Service - Air Resources Division	08/80
TN14	Hatchie NWR		Tennessee Valley Authority	10/84
Texas				
TX02	Muleshoe NWR		US Geological Survey	06/85
TX03	Beeville		US Geological Survey	02/84
TX04	Big Bend NP - K-Bar		National Park Service - Air Resources Division	04/80
TX10	Attwater Prairie Chicken NWR		US Geological Survey	07/84
TX16	Sonora		US Geological Survey	06/84
TX21	Longview	MDN	Texas Commission on Environmental Quality	06/82
TX22	Guadalupe Mountains NP-Frijole Ranger Stn		US Geological Survey	06/84

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State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
TX43	Cañonceta	AMoN	Texas A&M University Texas Agrilife Research	07/07
TX56	LBJ National Grasslands		US Geological Survey	09/83
Utah				
UT01	Logan		US Geological Survey	12/83
UT08	Murphy Ridge		Wyoming Department of Environmental Quality	03/86
UT09	Canyonlands NP - Island in the Sky		National Park Service - Air Resources Division	11/97
UT98	Green River		US Geological Survey	04/85
UT99	Bryce Canyon NP - Repeater Hill		National Park Service - Air Resources Division	01/85
Vermont				
VT01	Bennington		US Geological Survey	04/81
VT99	Underhill	AIRMoN MDN AMoN	US Geological Survey	06/84
Virgin Islands				
VI01	Virgin Islands NP - Lind Point		National Park Service - Air Resources Division	04/98
Virginia				
VA00	Charlottesville		US Geological Survey	10/84
VA13	Horton's Station		Tennessee Valley Authority	07/78
VA24	Prince Edward	AMoN	US Environmental Protection Agency-CAMD	01/99
VA28	Shenandoah NP - Big Meadows	MDN	National Park Service - Air Resources Division	05/81
VA98	Harcum	MDN	Virginia Institute of Marine Science	08/04

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State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
VA99	Natural Bridge Station		USDA Forest Service - Air Program	07/02
Washington				
WA14	Olympic NP - Hoh Ranger Station		National Park Service - Air Resources Division	05/80
WA19	North Cascades NP-Marblemount Ranger Stn		US Geological Survey	02/84
WA21	La Grande		US Environmental Protection Agency-CAMD	04/84
WA24	Palouse Conservation Farm		US Geological Survey	08/85
WA98	Columbia River Gorge		USDA Forest Service - Pacific Northwest Region	05/02
WA99	Mount Rainier NP - Tahoma Woods	AMoN	National Park Service - Air Resources Division	10/99
West Virginia				
WV04	Babcock State Park		US Geological Survey	09/83
WV05	Cedar Creek State Park		US Environmental Protection Agency-CAMD	01/99
WV18	Parsons	AMoN	USDA Forest Service	07/78
Wisconsin				
WI09	Popples River	MDN	Wisconsin Department of Natural Resources	12/86
WI10	Potawatomi	MDN	EPA Forest County Potawatomi Community	06/05
WI25	Suring		Wisconsin Department of Natural Resources	01/85
WI28	Lake Dubay		Wisconsin Department of Natural Resources	06/82

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State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
WI35	Perkinstown	AMoN	US Environmental Protection Agency-CAMD	01/99
WI36	Trout Lake	MDN	Wisconsin Department of Natural Resources	01/80
WI37	Spooner		Wisconsin Department of Natural Resources	06/80
WI98	Wildcat Mountain		Wisconsin Department of Natural Resources	08/89
WI99	Lake Geneva	MDN	Wisconsin Department of Natural Resources	06/84
Wyoming				
WY00	Snowy Range		USDA Forest Service	04/86
WY02	Sinks Canyon		Bureau of Land Management	08/84
WY06	Pinedale		Bureau of Land Management	01/82
WY08	Yellowstone NP - Tower Falls	MDN	National Park Service - Air Resources Division	06/80
WY95	Brooklyn Lake		USDA Forest Service	09/92
WY97	South Pass City		USDA Forest Service/Bridger Teton NF	04/85
WY98	Gypsum Creek		USDA Forest Service/Bridger Teton NF	12/84
WY99	Newcastle		Bureau of Land Management	08/81
Canada				
CAN5	Frelighsburg		US Geological Survey	10/01

AIRMon Map and Site Listings

**National Atmospheric Deposition Program
Atmospheric Integrated Research Monitoring Network**



National Atmospheric Deposition Program/Atmospheric Integrated Research Monitoring Network Sites

July 31, 2011

State	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Delaware					
	DE02	Lewes		NOAA-Air Resources Laboratory	09/92
Illinois					
	IL11	Bondville	MDN/NTN/AMoN	NOAA-Air Resources Laboratory	10/92
New York					
	NY67	Cornell University	AMoN	NOAA-Air Resources Laboratory	09/92
Pennsylvania					
	PA15	Penn State	NTN	NOAA-Air Resources Laboratory	10/92
Tennessee					
	TN00	Oak Ridge National Lab	NTN	NOAA-Air Resources Laboratory	09/92
Vermont					
	VT99	Underhill	MDN/NTN/AMNet	University of Vermont /NEIWPCC	01/93
West Virginia					
	WV99	Canaan Valley Institute	AMNet/MDN	NOAA-Air Resources Laboratory	06/00

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National Atmospheric Deposition Program/Ammonia Monitoring Network Sites

July 31, 2011

State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Alabama					
	AL99	Sand Mountain Research & Extension Center	NTN	US Environmental Protection Agency	03/11
Arizona					
	AZ98	Chiricahua	NTN	National Park Service - Air Resources Division	03/11
Arkansas					
	AR03	Caddo Valley	NTN	US Environmental Protection Agency	03/11
California					
	CA44	Yosemite NP- Turtleback Dome		National Park Service - Air Resources Division	03/11
	CA67	Joshua Tree NP - Black Rock	NTN	National Park Service - Air Resources Division	03/11
	CA83	Sequoia NP-Ash Mountain		National Park Service - Air Resources Division	03/11
Colorado					
	CO13	Fort Collins		US Environmental Protection Agency	11/07
	CO88	Rock Mountain NP- Longs Peak		National Park Service - Air Resources Division	05/11
	CO98	Rocky Mountain NP - Loch Vale	NTN	National Park Service - Air Resources Division	05/11
Connecticut					
	CT15	Abington	NTN	US Environmental Protection Agency	03/11
Florida					
	FL11	Everglades NP - Research Center	NTN/MDN	National Park Service - Air Resources Division	03/11
	FL19	Indian River		US Environmental Protection Agency	04/11

State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Georgia					
	GA41	Georgia Station	NTN	US Environmental Protection Agency	06/11
Idaho					
	ID03	Craters of the Moon NM	NTN MDN	National Park Service - Air Resources Division	06/10
Illinois					
	IL11	Bondville	AIRMoN/MDN /NTN	US Environmental Protection Agency	10/07
	IL37	Stockton		US Environmental Protection Agency	04/11
	IL46	Alhambra	NTN	US Environmental Protection Agency	03/11
Indiana					
	IN99	Indianapolis		US Environmental Protection Agency	10/07
Kansas					
	KS31	Konza Prairie	NTN	US Environmental Protection Agency	03/11
Kentucky					
	KY03	Mackville	NTN	US Environmental Protection Agency	03/11
	KY98	Cadiz		US Environmental Protection Agency	03/11
Maryland					
	MD08	Piney Reservoir	MDN/AMNet/ NTN	State of MD/ Department of Natural Resources	08/10
	MD99	Beltsville	MDN/AMNet NTN	State of MD/ Department of Natural Resources	08/10

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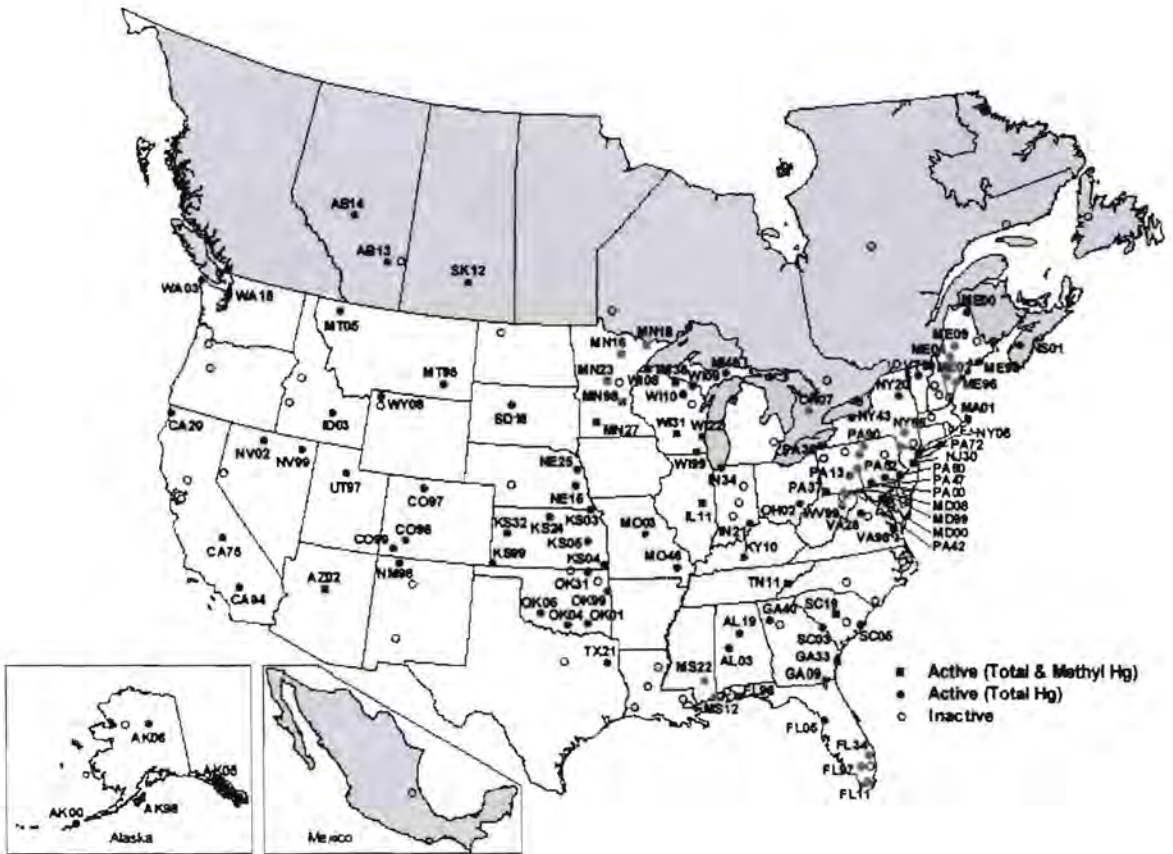
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State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Michigan					
	M196	Detroit		US Environmental Protection Agency	10/07
Minnesota					
	MN18	Fernberg	NTN/MDN	US Environmental Protection Agency	10/07
Nebraska					
	NE98	Santee		US Environmental Protection Agency	04/11
New Jersey					
	NJ98	Washington Crossing CAST NET		US Environmental Protection Agency	04/11
New Mexico					
	NM98	Navajo Lake	MDN	US Environmental Protection Agency	01/08
	NM99	Farmington		US Environmental Protection Agency	01/08
New York					
	NY16	Cary Institute		Cary Institute Of Ecosystem Studies	10/09
	NY67	Ithaca	AIRMoN	US Environmental Protection Agency	10/07
North Carolina					
	NC06	Beaufort	NTN	US Environmental Protection Agency	04/10
	NC25	Coweeta	NTN	US Environmental Protection Agency	05/11
	NC26	Candor		US Environmental Protection Agency	04/11

State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Ohio					
	OH02	Athens Super Site	AMNet	US Environmental Protection Agency	10/07
	OH27	Cincinnati		US Environmental Protection Agency	10/07
	OH54	Deer Creek State Park	NTN	US Environmental Protection Agency	03/11
Oklahoma					
	OK99	Stilwell	MDN/AMNet	US Environmental Protection Agency	10/07
Pennsylvania					
	PA00	Arendtsville	NTN/MDN	US Environmental Protection Agency	10/09
	PA29	Kane Experimental Forest	NTN	US Environmental Protection Agency	03/11
South Carolina					
	SC05	Cape Romain NWR	NTN MDN	US Environmental Protection Agency	10/07
Tennessee					
	TN01	Great Smoky Mountains NP- Look Rock		National Park Service - Air Resources Division	03/11
Texas					
	TX43	Cañonceta	NTN	US Environmental Protection Agency	10/07
Virginia					
	VA24	Prince Edward	NTN	US Environmental Protection Agency	03/11
Washington					
	WA99	Mount Rainier NP - Tahoma Woods	NTN	National Park Service - Air Resources Division	03/11
West Virginia					
	WV18	Parsons	NTN	US Environmental Protection Agency	06/11

State/Province	Site Name	Collocation	Sponsoring Agency	Start Date
Wisconsin				
W107	Horicon Marsh		US Environmental Protection Agency	10/07
W135	Perkinstown	NTN	US Environmental Protection Agency	03/11

MDN Map and Site Listings



National Atmospheric Deposition Program/Mercury Deposition Network Sites

July 31, 2011

State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Alabama					
	AL03	Centreville	NTN	Atmospheric Research and Analysis, Inc	06/00
	AL19	Birmingham	AMNet	Atmospheric Research and Analysis, Inc	12/10
Alaska					
	AK00	Dutch Harbor		State of Alaska Department of Environmental Conservation	09/09
	AK05	Glacier Bay National Park-Bartlett Cove		National Park Service-Air Resources Division	03/10
	AK06	Gates of the Arctic NP - Bettles	NTN	US Bureau of Land Management	11/08
	AK98	Kodiak		State of Alaska Department of Environmental Conservation	09/07
Arizona					
	AZ02	Sycamore Canyon		Arizona Department of Environmental Quality EPA	02/06
California					
	CA20	Yurok Tribe-Requa		Electric Power Research Institute	08/06
	CA75	Sequoia NP-Giant Forest	NTN	National Park Service - Air Resources Division	07/03
	CA94	Converse Flats	NTN	USDA Forest Service	04/06
Colorado					
	CO96	Molas Pass	NTN	US Bureau of Land Management	06/09
	CO97	Buffalo Pass - Summit Lake	NTN	USDA Forest Service	09/98
	CO99	Mesa Verde NP-Chapin Mesa	NTN	National Park Service - Air Resources Division	12/01

State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Florida					
	FL05	Chassahowitzka NWR	NTN	US Fish & Wildlife Service - Chassahowitzka NWR	07/97
	FL11	Everglades NP - Research Center	NTN/AMoN	South Florida Water Management District	03/96
	FL34	Everglades Nutrient Removal Project		South Florida Water Management District	07/97
	FL96	Pensacola	AMNet	Atmospheric Research and Analysis, Inc	12/10
	FL97	Everglades - Western Broward County		South Florida Water Management District	11/06
Georgia					
	GA09	Okefenokee NWR	NTN	US Fish & Wildlife Service - Air Quality Branch	07/97
	GA33	Sapelo Island	NTN	Georgia Department of Natural Resources /Sapelo Island	09/07
	GA40	Yorkville	AMNet	Atmospheric Research and Analysis, Inc	06/00
Idaho					
	ID03	Craters of the Moon NM	NTN/AMoN	National Park Service - Air Resources Division	10/06
Illinois					
	IL11	Bondville	AIRMoN/NTN/AMoN	Illinois State Water Survey NADP	01/99
Indiana					
	IN21	Clifty Falls State Park		LADCO	01/01
	IN34	Indiana Dunes NL	NTN	LADCO	10/00

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State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Kansas					
	KS03	Reserve		Kansas Department of Health and Environment	01/08
	KS04	West Mineral		Kansas Department of Health and Environment	10/08
	KS05	Coffey County Lake		Kansas Department of Health and Environment	12/08
	KS24	Glen Elder State Park		Kansas Department of Health and Environment	05/08
	KS32	Lake Scott State Park	NTN	Kansas Department of Health and Environment	06/08
	KS99	Cimarron National Grassland		Kansas Department of Health and Environment	12/08
Kentucky					
	KY10	Mammoth Cave NP-Houchin Meadow	NTN	National Park Service - Air Resources Division	08/02
Maine					
	ME00	Caribou	NTN	University of Maine	05/07
	ME02	Bridgton	NTN	Maine Department of Environmental Protection/EP	06/97
	ME04	Carrabassett Valley	NTN	Penobscot Indian Nation	02/09
	ME09	Greenville Station	NTN	Maine Department of Environmental Protection/EP	09/96
	ME96	Casco Bay - Wolfe's Neck Farm	NTN	Maine Department of Environmental Protection/EP	01/98
	ME98	Acadia NP - McFarland Hill	NTN	Maine Dept of Environmental Protection/NPS-Acad	03/96

State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Maryland					
	MD00	Smithsonian Environmental Res Ctr		MD DNR/Smithsonian Environmental Research Cen	12/06
	MD08	Piney Reservoir	NTN /AMNet/ AMoN	MD DNR/University of Maryland-Appalachian Lab	06/04
	MD99	Beltsville	NTN /AMNet/ AMoN	Maryland Department of Natural Resources	06/04
Massachusetts					
	MA01	North Atlantic Coastal Lab	NTN	NPS - Cape Cod National Seashore	07/03
Michigan					
	MI48	Seney NWR - Headquarters	NTN	US Fish & Wildlife Service-Air Quality Branch	11/03
Minnesota					
	MN16	Marcell Experimental Forest	NTN	USDA Forest Service-North Central Research Station	02/96
	MN18	Fernberg	NTN /AMoN	Minnesota Pollution Control Agency	03/96
	MN23	Camp Ripley	NTN	Minnesota Pollution Control Agency	07/96
	MN27	Lamberton	NTN	Minnesota Pollution Control Agency	07/96
	MN98	Blaine		Minnesota Pollution Control Agency	02/08

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Mississippi				
MS12	Grand Bay NERR	NTN /AMNet	Mississippi Department of Environmental Quality	03/10
MS22	Oak Grove		Atmospheric Research and Analysis, Inc	06/00
Missouri				
MO03	Ashland Wildlife Area	NTN	Missouri Department of Natural Resources /EPA	07/10
MO46	Mingo NWR		Missouri Department of Natural Resources /EPA	03/02
Montana				
MT05	Glacier NP - Fire Weather Station	NTN	National Park Service - Air Resources Division	10/03
MT95	Badger Peak		Northern Cheyenne Tribe	11/10
Nebraska				
NE15	Mead	NTN	Nebraska Department of Environmental Quality	06/07
NE25	Winnebago		Winnebago Tribe of Nebraska	11/09
Nevada				
NV02	Lesperance Ranch		Nevada Dept of Conservation & Natural Resources Frontier Geosciences, Inc	01/03
NV99	Gibb's Ranch		Nevada Dept of Conservation & Natural Resources/Frontier Geosciences, Inc	02/03
New Jersey				
NJ30	New Brunswick	AMNet	US Geological Survey	01/06
New Mexico				
NM97	Valles Caldera National Preserver		Pueblo of Jemez Tribe	03/09
NM98	Navajo Lake	AMoN	New Mexico Environment Department-Air Quality	04/09

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
New York				
NY06	Bronx	AMNet	New York Department of Environmental Conservat	01/08
NY20	Huntington Wildlife	NTN /AMNet	Syracuse University /EPA	12/99
NY43	Rochester	AMNet	New York Department of Environmental Conservat	01/08
NY68	Biscuit Brook	NTN	US Geological Survey	03/04
North Carolina				
NC08	Waccamaw State Park		North Carolina Dept of Environment & Natural Res	02/96
NC42	Pettigrew State Park		North Carolina Dept of Environment & Natural Res	02/96
Oklahoma				
OK01	McGee Creek		Oklahoma Department of Environmental Quality	10/06
OK04	Lake Murray		Oklahoma Department of Environmental Quality	10/07
OK06	Wichita Mountains NWR		Oklahoma Department of Environmental Quality	11/07
OK31	Copan		Oklahoma Department of Environmental Quality	10/06
OK99	Stilwell	AMNet/AMoN	Cherokee Nation/EPA	04/03

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Pennsylvania				
PA00	Arendtsville	NTN	PA Dept of Env Protection/Penn State University	11/00
PA13	Allegheny Portage Railroad NHS		PA Dept of Env Protection/Penn State University	01/97
PA30	Erie		PA Dept of Env Protection/Penn State University	06/00
PA37	Waynesburg		Electrical Power Research Institute	05/99
PA42	Leading Ridge	NTN	PA Dept of Env Protection/Penn State University	03/10
PA47	Millersville	NTN	PA Dept of Env Protection/Penn State University	11/02
PA52	Little Pine State Park		PA Dept of Env Protection/Penn State University	07/07
PA60	Valley Forge		PA Dept of Env Protection/Penn State University	11/99
PA72	Milford	NTN	PA Dept of Env Protection/Penn State University	09/00
PA90	Hills Creek State Park		PA Dept of Env Protection/Penn State University	01/97
South Carolina				
SC03	Savannah River		Washington Savannah River Company	01/01
SC05	Cape Romaine NWR	NTN/AMoN	US Fish & Wildlife Service - Air Quality Branch	03/04
SC19	Congaree Swamp		South Carolina Dept of Health & Environmental Control	03/96

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
South Dakota				
SD18	Eagle Butte		Cheyenne River Sioux Tribe/EPA	03/07
Tennessee				
TN11	Great Smoky Mountains NP-Elkmont	NTN	National Park Service - Air Resources Division	01/02
Texas				
TX21	Longview	NTN	Texas Commission on Environmental Quality	03/96
Utah				
UT97	Salt Lake City	AMNet	Utah Department of Environmental Quality	05/07
Vermont				
VT99	Underhill	AIRMoN/NTN/ AMNet	Univ of VT-Rubinstein School of Env & Nat Res/NEI/WPC	07/04
Virginia				
VA28	Shenandoah NP-Big Meadows	NTN	National Park Service - Air Resources Division	10/02
VA98	Harcum	NTN	Virginia Department of Environmental Quality	12/04
Washington				
WA03	Makah National Fish Hatchery		Washington State Department of Ecology	03/07
WA18	Seattle - NOAA		Illinois State Water Survey & Frontier Geosciences Inc	03/96
West Virginia				
WV99	Canaan Valley Institute	AIRMoN/AMN et	NOAA - Air Resources Lab	06/07

State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Wisconsin					
	WI08	Brule River		Wisconsin Department of Natural Resources	03/96
	WI09	Popple River	NTN	Wisconsin Department of Natural Resources	03/96
	WI10	Potawatomi	NTN	Forest County Potawatomi Community EPA	06/05
	WI22	Milwaukee		Wisconsin Department of Natural Resources	10/02
	WI31	Devils Lake		Wisconsin Department of Natural Resources	01/01
	WI36	Trout Lake	NTN	Wisconsin Department of Natural Resources	03/96
	WI99	Lake Geneva	NTN	Wisconsin Department of Natural Resources	01/97
Wyoming					
	WY08	Yellowstone NP-Tower Falls	NTN	Wyoming Department of Environmental Quality	10/04
CANADA					
Alberta					
	AB13	Henry Kroeger		ATCO Power	09/04
	AB14	Genesee		Jacques Whitford Stantec Axys Ltd.	07/06
Nova Scotia					
	NS01	Kejinkujik NP	AMNet	Environment Canada	07/96
Ontario					
	ON07	Egbert		Environment Canada	03/00
Saskatchewan					
	SK12	Bratt's Lake BSRN		Environment Canada	05/01

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National Atmospheric Deposition Program/Atmospheric Mercury Network Sites

July 31, 2011

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Alabama				
	AL19 Birmingham	MDN	Atmospheric Research & Analysis, Inc.	12/10
California				
	CA48 Elkhorn Slough			01/10
Florida				
	FL96 Pensacola	MDN	Atmospheric Research & Analysis, Inc.	12/10
Georgia				
	GA40 Yorkville	MDN	Atmospheric Research & Analysis, Inc.	12/10
Maryland				
	MD08 Piney Reservoir	MDN/NTN/AMoI	MD DNR/University of Maryland-Appalachian Lab	01/08
	MD98 Beltsville II		NOAA/USEnvironmental Protection Agency	01/07
	MD99 Beltsville	MDN/NTN/AMoI	NOAA/USEnvironmental Protection Agency	11/06
Mississippi				
	MS12 Grand Bay NERR	MDN/NTN	National Oceanic & Atmospheric Administration	09/06
	MS99 Grand Bay NERR II		National Oceanic & Atmospheric Administration	10/09
New Hampshire				
	NH06 Thompson Farm		University of New Hampshire	01/09

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
New Jersey				
	NJ30 New Brunswick	MDN	State of New Jersey	07/02
	NJ32 Chester		State of New Jersey	03/05
	NJ54 Elizabeth Lab		State of New Jersey	01/04
New York				
	NY06 New York City	MDN	State of New York	08/08
	NY20 Huntington Wildlife Forest	MDN/NTN	US Environmental Protection Agency-CAMD	11/07
	NY43 Rochester	MDN	US Environmental Protection Agency-CAMD	11/07
	NY95 Rochester B		State of New York	09/08
Ohio				
	OH02 Athens	MDN/AMoN	US Environmental Protection Agency-CAMD	01/07
Oklahoma				
	OK99 Stilwell	MDN/AMoN	US Environmental Protection Agency-CAMD	10/08
Utah				
	UT96 Antelope Island		US Environmental Protection Agency-CAMD	06/09
	UT97 Salt Lake City	MDN	State of Utah	11/08
Vermont				
	VT99 Underhill	AIRMoN/MDN/N	National Oceanic & Atmospheric Administration	01/08
West Virginia				
	WV99 Canaan Valley Institute	MDN/AIRMoN	National Oceanic & Atmospheric Administration	01/07

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State/Province	Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
CANADA					
Nova Scotia					
	NS01	Kejimikujik NP	MDN	Environment Canada	01/09

The National Atmospheric Deposition Program was established in 1977 under State Agricultural Experiment Station (SAES) leadership to address the problem of atmospheric deposition and its effects on agricultural crops, forests, rangelands, surface waters, and other natural and cultural resources. In 1978, sites in the NADP precipitation chemistry network first began collecting one-week, wet-only deposition samples for analysis at the Illinois State Water Survey's Central Analytical Laboratory (CAL), located at the University of Illinois, Urbana-Champaign. The network was established to provide data on amounts, temporal trends, and geographic distributions of the atmospheric deposition of acids, nutrients, and base cations by precipitation.

Initially, the NADP was organized as SAES North Central Regional Project NC-141, which all four SAES regions further endorsed in 1982 as Interregional Project IR-7. A decade later, IR-7 was reclassified as National Research Support Project No. 3 (NRSP-3), which it remains. NRSP projects are multistate activities that support research on topics of concern to more than one state or region of the country. Multistate projects involve the SAES in partnership with the USDA National Institute of Food and Agriculture and other universities, institutions, and agencies. In October 1981, the federally supported National Acid Precipitation Assessment Program (NAPAP) was established to increase understanding of the causes and effects of acidic precipitation. This program sought to establish a long-term precipitation chemistry network of sampling sites distant from point source influences. Because of its experience in organizing and operating a national-scale network, the NADP agreed to coordinate operation of NAPAP's National Trends Network (NTN). To benefit from identical siting criteria and operating procedures and a shared analytical laboratory, NADP and NTN merged with the designation NADP/NTN. This merger brought substantial new federal agency participation into the program. Many NADP/NTN sites were supported by the USGS, NAPAP's lead federal agency for deposition monitoring. NAPAP continues under Title IX of the federal Clean Air Act Amendments of 1990.

In October 1992, the AIRMoN joined the NADP. AIRMoN sites collect samples daily when precipitation occurs. In January 1996, the NADP established the MDN, the third network in the organization. The MDN was formed to provide data on the wet deposition of mercury to surface waters, forested watersheds, and other receptors. In October 2009, AMNet joined the NADP as the fourth network. AMNet measures the concentration of atmospheric mercury. In October 2010, AMoN joined the NADP, measuring atmospheric ammonia concentrations using passive monitors.

SAES project NRSP-3 was renewed in 2009, and it continues to offer 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 nearly 100 different sponsoring agencies to address contemporary and emerging issues of national importance.

*NADP Program Office
Illinois State Water Survey
2204 Griffith Drive
Champaign, IL 61820-7495*

*NADP Home page: <http://nadp.isws.illinois.edu/NADP/>
Phone: 217/333-7871*