2010 Annual Meeting & Scientific Symposium

Networking the Networks

October 19-21, 2010 | Lake Tahoe, California

National Atmospheric Deposition Program

The National Atmospheric Deposition Program (NADP) provides quality-assured data and information in support of research on the exposure of managed and natural ecosystems and cultural resources to acidic compounds, nutrients, mercury, and base cations in precipitation. These data support informed decisions on air quality issues. The NADP responds to emerging issues and continues to evaluate changes in its measurement systems, including the addition of other chemical and biological species. In 2009, scientists, educators, students, and others interested in the NADP logged about 355,000 sessions on the NADP Web site and viewed more than 124,200 concentration and deposition maps. Users downloaded approximately 25,500 data files from this site, which now annually receives more than 1.65 million hits.

The NADP was organized 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 analyzed by the Central Analytical Laboratory (CAL) at the Illinois State Water Survey. 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. The NADP initially was organized as SAES North Central Regional Project NC-141, which all four SAES regions endorsed as Interregional Project IR-7 in 1982. A decade later, IR-7 was reclassified as National Research Support Project NRSP-3, which it remains.

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. Many NADP/NTN sites were supported by the U.S. Geological Survey, NAPAP's lead federal agency for deposition monitoring. Under Title IX of the federal Clean Air Act Amendments of 1990, NAPAP continues. Today there are about 250 sites in the network, and the network designation has been shortened to NTN.

In October 1992, the Atmospheric Integrated Research Monitoring Network (AIRMoN), currently with seven sites, joined the NADP. AIRMoN sites collect samples daily when precipitation occurs. Samples are refrigerated until analysis at the CAL for the same constituents measured in NTN samples. The AIRMoN investigates pollutant source/receptor relationships and the effect of emissions changes on precipitation chemistry, combining measurements with atmospheric models. The AIRMoN also evaluates sample collection and preservation methods.

In January 1996, the Mercury Deposition Network (MDN), currently with more than 115 sites, joined the NADP. MDN sites collect weekly, wet-only deposition samples that are sent to the MDN analytical laboratory at Frontier Global Sciences. The MDN was formed to provide data on the wet deposition of mercury to surface waters, forested watersheds, and other receptors. Forty-eight states and eight Canadian provinces have advisories against consuming fish from lakes with high mercury concentrations in fish tissues. MDN data enable researchers to investigate the link between mercury in precipitation and this problem. **At the 2009 Fall Meeting, the NADP Executive Committee accepted the Atmospheric Mercury Network (AMNet) as a new, official NADP network. This network measures the atmospheric mercury concentrations of gaseous oxidized, particulate-bound, and elemental mercury fractions. AMNet currently has 21 U.S and Canadian sites, and uses automated, continuous measuring systems and standardized methods. The AMNet was formed to offer high-quality measurement data to estimate dry and total deposition of atmospheric mercury, to standardize operating methods, and to provide data quality assurance, management, and access.**

The NADP receives support from the U.S. Geological Survey; Environmental Protection Agency; National Park Service; National Oceanic and Atmospheric Administration; U.S. Department of Agriculture - Forest Service; U.S. Fish & Wildlife Service; Tennessee Valley Authority; Bureau of Land Management; and U.S. Department of Agriculture - National Institute of Food and Agriculture (NIFA) under agreement 2008-39134-19508. Additional support is provided by other federal, state, local, and tribal agencies, State Agricultural Experiment Stations, universities, and nongovernmental organizations. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the U.S. Department of Agriculture or any other sponsor.

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The Illinois State Water Survey is a Division of the Institute of Natural Resource Sustainability at the University of Illinois - Urbana-Champaign.

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NADP 2010
Technical Committee Meeting

October 19 – 21, 2010
North Lake Tahoe, CA

Scientific Symposium Chair
Pamela Padgett
USDA Forest Service

PROCEEDINGS

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October 2010

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NADP Scientific Symposium Agenda

NADP Annual Meeting and Scientific Symposium
Lake Tahoe, California
October 19 – 21, 2010

Tuesday, October 19, 2010		**Room Location**
Registration Desk Open All Day		**Salon I**
8:00 a.m. – 9:15 a.m.	Joint Subcommittee Meeting	
9:15 a.m. – 9:30 a.m.	Break	
9:30 a.m. – 12:00 noon	Subcommittee Meetings	**Salon I**
	Network Operations	**Salon I**
	Data Management & Analysis	**Lodgepole**
	Ecological Response and Outreach	**Foxtail**
	Critical Loads	**Pinyon**
12:00 noon - 1:30 p.m.	Lunch - On your own	
1:30 p.m. - 3:30 p.m.	Joint Subcommittee Meeting	
3:30 p.m. - 3:45 p.m.	Break	
3:45 p.m. - 6:00 p.m.	Executive Committee Meeting	

Wednesday, October 20, 2010	**Room Location**
Registration Desk Open All Day	**Salon 1**

8:30 a.m. - 9:10 a.m. **Welcome, Program Office Report, Awards and Announcements**

Pam Padgett: NADP Vice Chair, Symposium Chair
U.S. Forest Service
David Gay: NADP Coordinator
Mark Nilles: NADP Chair
U.S. Geological Survey

Wednesday, October 20, 2010 **Room Location**
Salon I & Salon II

Keynote Addresses

9:10 – 9:40 **Welcome and Introduction to Lake Tahoe**
Geoff Schladow, Director
Tahoe Environmental Research Center

9:40 – 10:10 **NEON: The National Ecological Observatory Network**
Lou Pitelka, Senior Scientist, NEON

10:10 – 10:30 Break

Technical Session 1: **Climate Change**
Session Chair: Greg Wetherbee
U.S. Geological Survey

10:30 – 11:00 **How Do We Maintain Sustainable High-quality Climate Observation Networks than Can Answer the Question: How has the climate changed over the past 50 years?**
Bruce Baker, National Oceanic and Atmospheric Administration

11:00 – 11:20 **Insights into the Moisture Budget for the Western US using Isotopic Measurements from the NADP Sample Archive**
Max Berkelhammer, University of Southern California

11:20 – 11:40 **USNIP – Isotopes in the Hydrologic Cycle: Recent Findings and Trajectories**
Jeff Welker, University of Alaska Anchorage

11:40 – 12:00 **Evidence of Climate Change Related Shifts in Epiphytic Vegetation Communities in the Pacific Northwest**
Linda Geiser, U.S. Forest Service

12:00 – 12:20 **Climate Change Indicators in the United States**
Mike Kolian, U.S. Environmental Protection Agency

12:20 noon – 1:40 p.m. Lunch – On your own

Wednesday, October 20, 2010 **Room Location**
Salon I & Salon II

Technical Session 2:	**Networks Monitoring Ecosystems** Session Chair: Rich Pouyat U.S. Forest Service
1:40p.m. – 2:10p.m.	**Synthesizing Data on Stream Flow and Chemistry at Research Watersheds to Assess Effects of Atmospheric Deposition and Environmental Change** Steven Sebestyen, U.S. Forest Service
2:10 – 2:30	**Factors Controlling the Critical Loads and Dynamic Critical Loads in Lake-Watersheds of the Adirondack Region of New York** Charles Driscoll, Syracuse University
2:30 – 2:50	**Deposition of Reduced Nitrogen (NHx) in California and Other Western Regions: Prevalence and Ecological Importance** Mark Fenn, U.S. Forest Service
2:50 – 3:10	**Total Mercury and Methyl-mercury Concentrations and Pools across 14 U.S. Forest Sites: Factors that Determine Mercury Loads in Remote Terrestrial Ecosystems** Daniel Obrist, Desert Research Institute
3:10 – 3:30	**Atmospheric Observations of Nitrogen: Linking Regulatory Applications and Science across Atmospheric, Terrestrial and Aquatic Media** Rich Scheffe, U.S. Environmental Protection Agency
3:30 – 3:50	Break
Technical Session 3:	**Soil Networks** Session Chair: Hobie Perry U.S. Forest Service
3:50 - 4:20	**National Soil Carbon Network** Chris Swanston, U.S. Forest Service
4:20 – 4:40	**Advancing the Study of Soil Change through the Northeastern Soil Monitoring Cooperative** Greg Lawrence, U.S. Geological Survey

Wednesday, October 20, 2010 **Room Location**
Salon I & Salon II

Technical Session 3: **Soil Networks (continued)**
Session Chair: Hobie Perry
US Forest Service

4:40p.m. - 5:00p.m. **Mercury in Litterfall at Selected National Atmospheric Deposition Program Mercury Deposition Network Sites in the Eastern United States, 2007-- 2009**
Marty Risch, US Geological Survey

5:00 - 5:20 **Acid Deposition and Soil Acidification in China: A Multipollutant Perspective**
Zhao Yu, Harvard University

5:20 – 5:40 **Mercury Accumulation in the Forest Floor of the United States**
Hobie Perry, US Forest Service

5:45 p.m. – 8:00 p.m. **Poster Session and Reception**

Thursday, October 21, 2010 **Room Location**
Salon I & Salon II

8:00 a.m. – 8:10 a.m. **Opening remarks, announcements and overview of Day 2** –Pam Padgett, NADP Vice Chair, U.S. Forest Service

Keynote Day 2
8:10 – 8:40 **USGS's Network of Networks**
Pete Murdoch, U.S. Geological Survey

Technical Session 4: **Air Monitoring Networks**
Session Chair: John Walker
U.S. Environmental Protection Agency

8:40 – 9:10 **The World Meteorological Organization Global Assessment of Precipitation Chemistry and Deposition**
Bob Vet, Environment Canada

9:10 – 9:30 **Mercury Dry Deposition Monitor Development**
Matthew Landis, U.S. Environmental Protection Agency
Elizabeth Oswald, U.S. Environmental Protection Agency

Thursday, October 21, 2010 **Room Location**
Salon I & Salon II

Technical Session 4: **Air Monitoring Networks (continued)**
Session Chair: John Walker
U.S. Environmental Protection Agency

9:30 a.m. – 9:50 a.m. **An Overview of the Measurements of the Canadian Air and Precipitation Monitoring Network with a Focus on the Measurements of Nitrogen Species**
Jason O'Brien, Environment Canada

9:50 – 10:10 **Estimation of Speciated and Total Mercury Dry Deposition**
Leiming Zhang, Environment Canada

10:10 – 10:30 Break

10:30 – 10:50 **Distribution of Ozone, Ozone Precursors and Gaseous Components of Atmospheric Nitrogen Deposition in the Lake Tahoe Basin**
Andrzej Bytnerowicz, U.S. Forest Service

10:50 – 11:10 **Passive Monitoring of Ambient Reactive Gaseous Mercury in the Four Corners Area and Eastern Oklahoma**
Mark Sather, U.S. Environmental Protection Agency

11:10 – 11:30 **Long-term Trends in Atmospheric Reactive Nitrogen across Canada: 1988–2007**
Antoni Zbieranowski, Trent University

Technical Session 5: **Water Networks**
Session Chair: Maggie Kerchner
National Oceanic and Atmospheric Administration

11:30 – 11:55 **Water Quality Monitoring and Atmospheric Deposition: How are they Linked?**
Doug Burns, U.S. Geological Survey

11:55 – 12:15 **Use of Regression-Based Models to Map Sensitivity of Aquatic Resources to Atmospheric Deposition in Yosemite National Park, USA**
David Clow, U.S. Geological Survey

12:15 noon – 1:40 p.m. Lunch – On your own

Thursday, October 21, 2010 **Room Location**
Salon I & Salon II

Technical Session 5:	**Water Networks (continued)** Session Chair: Maggie Kerchner National Oceanic and Atmospheric Administration
1:40 p.m. – 2:00 p.m.	**Developing Critical Loads for Atmospheric Deposition of Nitrogen to Alpine Lakes in the Pacific Northwest using Sediment Diatoms** Rich Sheibley, U.S. Geological Survey
2:00 – 2:20	**MAGIC Model Estimates of Critical Load of Sulfur Deposition to Protect Acid-Sensitive Resources in the Adirondack Mountains, New York** Tim Sullivan, E&S Environmental Chemistry, Inc.
2:20 – 2:40	**Establishing a Collaborative and Multipurpose Long Term National Reference Site Network for Freshwater Streams in the United States** Bill Wilber, U.S. Geological Survey
2:40 - 3:00	**The Long Term Response of Adirondack Surface Waters to Reductions in Acidic Deposition** Kristin Waller, Syracuse University
3:00 – 3:25	Break
Technical Session 6:	**Biological Networks** Session Chair: Kristi Morris National Park Service
3:25 – 3:55	**Phenology as a Tool for Science, Management and Education in a Changing Environment: The USA National Phenology Network** Jake Weltzin, Executive Director National Phenology Network
3:55 – 4:15	**Recent Evidence of Biological Recovery from Acidification in the Adirondacks (NY, USA): A New Regional Paleolimnological Perspective** Kristina Arseneau, Queen"s University

Thursday, October 21, 2010 **Room Location**
Salon I & Salon II

Technical Session 6: **Biological Networks**
Session Chair: Kristi Morris
National Park Service

4:15 p.m. – 4:35 p.m. **Predicting Nitrogen Deposition to Forests in the Los Angeles Basin using Lichen Communities**
Sarah Jovan, U.S. Forest Service

4:35 – 4:55 **Critical Nitrogen Deposition Loads in High-Elevation Lakes of the Western U.S. Inferred from Shifts in Diatom Community Structure**

Jasmine Saros, University of Maine

4:55 – 5:15 **Changes in Diatom Taxa in Sierra Nevada Lakes during the 20th Century: Implications for Critical Loads Development**
James Sickman, University of California

5:15 – 5:25 **Closing Comments**

Friday, October 22, 2010

Scientific Tour

8:00 a.m. Depart from hotel

Lake Tahoe Research Institute

Lunch at Sand Harbor Lake State Park (box lunch provided)

Tahoe Meadow Interpretive Loop Trail

5:00 p.m. Return to hotel

2010 NADP SITE OPERATOR AWARDS

National Atmospheric Deposition Program Operator Awards

5 – YEAR AWARDS

SITE	OPERATOR NAME	SITE NAME	WET START	AGENCY
CA76-NTN	Eric Olson	Montague	Jun-85	US Geological Survey
IN34-MDN and NTN	Laura Thompson	Indiana Dunes National Lakeshore	MDN-Oct-00 NTN- Jul-80	National Park Service-Indiana Dunes National Lakeshore
MA01-MDN and NTN	Kelly Medeiros	North Atlantic Coastal Lab	MDN-Jul-03 NTN- Dec-81	National Park Service-Air Resources Division
MD18-NTN	Eric Sherry	Assateague Island National Seashore-Woodcock	Sep-00	Maryland Department of Natural Resources
MI53-NTN	Mike Reilly	Wellston	Oct-78	US Forest Service
MN99-NTN	Peter Harris	Wolf Ridge	Dec-96	Minnesota Pollution Control Agency

10 – YEAR AWARDS

SITE	OPERATOR NAME	SITE NAME	WET START	AGENCY
FL14-NTN	Tom Bolton	Quincy	Mar-84	US Geological Survey
NF09-MDN	Hazel Crocker	Cormak	May-00	Environment Canada
VA24-NTN	Gene Brooks	Prince Edward	Jan-99	US Environmental Protection Agency

15 – YEAR AWARDS

SITE	OPERATOR NAME	SITE NAME	WET START	AGENCY
MD15-NTN	Francis “Hoss” Parks	Smith Island	Jun-04	NOAA
NM07-NTN	Kay Beeley	Bandelier National Monument	Jun-82	DOE/Los Alamos National Laboratory
OK00-NTN	Rodger Hill	Salt Plains National Wildlife Refuge	Dec-83	US Geological Survey
VA00-NTN	John Maben	Charlottesville	Oct-84	US Geological Survey

20 – YEAR AWARDS

SITE	OPERATOR NAME	SITE NAME	WET START	AGENCY
CA88-NTN	Mike Mata	Davis	Sep-78	US Geological Survey
IN22-NTN	Angie Thompson-Hewitt	Southwest Purdue Agricultural Center	Sep-84	US Geological Survey/ Purdue University State Agricultural Experiment Station
MT05-NTN	Lindy Key	Glacier National Park-Fire Weather Station	Jun-80	National Park Service-Air Resources Division
NC03-NTN	Margaret Pierce	Lewiston	Oct-78	North Carolina State University
NM01-NTN	Daniel Galindo	Gila Cliff Dwellings National Monument	Jul-85	New Mexico Environment Department - Air Quality Bureau

25 – YEAR AWARDS

SITE	OPERATOR NAME	SITE NAME	WET START	AGENCY
IA23-NTN	Jim Secor	McNay Research Center	Sep-84	US Geological Survey
WI25-NTN	James Trochta	Suring	Jan-85	Wisconsin Department of National Resources

30 – YEAR AWARDS

SITE	OPERATOR NAME	SITE NAME	WET START	AGENCY
FL03-NTN	Larry Korhnak	Bradford Forest	Oct-78	St. Johns River Water Management District
ME02-NTN	Peter Lowell	Bridgton	Sep-80	US Environmental Protection Agency/Maine Department of Environmental Protection
OR10-NTN	John Moreau	H. J. Andrews Experimental Forest	May-80	US Forest Service

KEYNOTE SPEAKER:

GEOFF SCHLADOW, DIRECTOR, TAHOE ENVIRONMENTAL RESEARCH CENTER

Geoff Schladow, Ph. D.

Geoff Schladow holds B. Eng. and Ph.D. degrees in civil engineering from the University of Western Australia, and an M. Eng. in hydraulic engineering from the University of California at Berkeley. For over thirty years his research has focused on the interactions between the complex fluid motions found in nature and their impacts on water quality, ecosystem health and renewable energy production. His research papers have been published in journals including the *Journal of Fluid Mechanics, Limnology and Oceanography, Water Resources Research, the Journal of Geophysical Research, Ecological Modeling, Climatic Change and Proceedings of the Royal Society*. Dr Schladow is also the North American Editor for the *Journal of Water and Climate.* He has published over 80 research papers, and has guided over 50 graduate students. Dr Schladow is an expert on both field data collection and numerical modeling, and frequently brings together teams of researchers to work on large, interdisciplinary projects. He holds a position of Professor of water resources and environmental engineering at UC Davis, and is the founding director of the UC Davis Tahoe Environmental Research Center. He divides his work time between Davis and Lake Tahoe, as well as study sites in remote parts of Patagonia and Spain.

KEYNOTE SPEAKER:

LOU PITELKA, SENIOR SCIENTIST, NATIONAL ECOLOGICAL OBSERVATORY NETWORK

The National Ecological Observatory Network

Louis F. Pitelka
Senior Visiting Scientist at NEON, Inc.

The US National Ecological Observatory Network (NEON) is a large facility project funded by the National Science Foundation. NEON"s goal is to contribute to ecological understanding and decision-making at the regional to national-scale through integrated observations and experiments. NEON will create a new national observatory network to collect ecological and climatic observations on both the drivers of change and the responses across the continental U.S., Alaska, Hawaii and Puerto Rico. The observatory will be the first of its kind designed to detect and enable forecasting of ecological change at national scales over multiple decades. NEON has partitioned the U. S. into 20 ecoclimatic domains, representing different regions of vegetation, landforms, climate, and ecosystem performance. Data will be collected from strategically selected sites within each domain and synthesized into information products that can be used to describe changes in the nation"s ecosystem through space and time. The data NEON collects will focus on how land use, climate change and invasive species affect biodiversity, disease ecology, and ecosystem services. Obtaining integrated data on these relationships over a long-term period is crucial to improving forecast models and resource management for environmental changes. These data and information products will be freely and openly available to scientists, educators, students, decision makers, and the public to enable them to understand and address ecological questions and issues.

TECHNICAL SESSION 1: CLIMATE CHANGE

Session Chair: Greg Wetherbee, U.S. Geological Survey

How Do We Maintain Sustainable High-Quality Climate Observation Networks That Can Answer the Question: How has the climate changed over the past 50 years?

C. Bruce Baker
NOAA/OAR/ARL/ATDD
Oak Ridge, TN USA 37830

As we experience a new era in which the Earth"s climate is forced by human activities, it is critically important to maintain an observing system capable of detecting and documenting global climate variability and change. Policy makers and the general public require climate observations to assess the present state of the ocean, cryosphere, atmosphere, and land, and place them in context with the past. To be of widespread value to scientists and society, these observations must be sustained over many decades and remain of the highest quality. Climate observations are needed to evaluate and initialize climate models and to improve predictions of climate change. Such efforts are essential for guiding national and international policies that govern climate-related resources, and for building agreements aimed at mitigating long-term climate change. Climate researchers have used existing, operational networks because they gave been the best, and sometimes only, source of data available. Guidelines have been developed for climate observing systems, specifically the ten climate monitoring principles. These principles should be considered in the design of new networks.

Insights into the Moisture Budget for the Western US Using Isotopic Measurements from the NADP Sample Archive

Max Berkelhammer and Lowell Stott
Department of Earth Sciences
University of Southern California
Los Angeles, CA

The isotopic composition of precipitation ($\delta^{18}O$ and δD) is a useful but complex tracer of both local meteorological conditions and broader synoptic and mesoscale climate. One of the impediments to a richer understanding of the multi-scale controls on the isotopic composition of precipitation has been the reliance on collection sites that are sparsely distributed and have only seasonal to monthly temporal resolution. Because the NADP sampling and archiving protocol has been shown to be adequate for preserving an unadulterated record of the isotopic composition of precipitation, a handful of researchers have begun to use these samples for the development of a dense high-resolution (event-scale) network of the isotopic composition of precipitation for the United States. We discuss one facet of this effort, which has been in the development of an isotopic catalog for storms that struck the west coast of the United States from 2001-2010. This work is motivated by a demand to improve our understanding of the relationship between atmospheric circulation patterns and drought in the western United States. We show using a lagrangian analysis how the relative contributions of isotopically enriched moisture from the tropics and isotopically depleted waters from the high latitudes can explain the wide range of isotopic variability between storms. The results suggest that remote moisture sources provide a critical contribution to the annual precipitation budget and that through careful monitoring of the isotopic composition of precipitation from coastal sites, we can elucidate how dynamical climate behavior such as El Nino events or evolving changes in the mean latitude of the jet stream influence moisture convergence to the western United States. A related application of this dataset that will be discussed involves a unique approach to benchmarking the performance of Global Climate Models (GCMs), which have been fitted with numerical routines for isotope tracers. The ability for a GCM with isotope tracers to reproduce the empirical results from the isotopic network provides one of the most rigorous tests available to benchmark the skill of a climate model. We highlight specifically the robustness of the Experimental Climate Prediction Center's Global Spectral Model and suggest that similar benchmarking efforts are crucial to improving hydrological forecasts for the western United States.

USNIP-Isotopes in the Hydrologic Cycle: Recent Findings and Trajectories

J M Welker[1], G Bowen[2], B Cohn[1], M Rogers[1]

In collaboration with NADP, the US Network for Isotopes in Precipitation has been characterizing the water isotope ($\delta^{18}O$ and δD) traits across the US beginning with samples from 1989. We have now completed over 10 published manuscripts which have focused on the patterns and processes governing the isoscapes of precipitation and those findings will be highlighted in the presentation. A component of our focus now is on time-series analysis as we begin to develop isotope-climate (temperature) coefficients that can be used in site-specific climate reconstructions and in GCM model calibrations. New NSF-funded analytical capacity is greatly expanding our capacity and our collaborations have grown to include university and agency colleagues across the US.

[1]Environment and Natural Resources Institute, University of Alaska Anchorage,
[2]Geosciences Department, Purdue University

Evidence of Climate Change Related Shifts in Epiphytic Vegetation Communities in the Pacific Northwest

Linda Geiser[1], Sarah Jovan[2] and Doug Glavich[1]

Within the US Pacific Northwest, one of many anticipated effects of climate change is a shift in species distributions, including extirpation. The Forest Health Monitoring lichen indicator is designed to track climate-related changes in epiphyte communities, a type of forest vegetation that is diverse, ecologically integral, and particularly sensitive to climate. Ten year re-measurements of lichen communities in western Oregon and Washington provide some of the first evidence of climate impacts on regional vegetation. Lichen communities in the coastal ranges are shifting towards cooler climate species, possibly associated with greater moisture and cooling from more frequent storms. No change has been detected in communities of low elevation valleys, including the Columbia River Gorge NSA. Shifts in species composition towards warmer-climate communities are widespread in the Oregon Cascades, especially at mid to high elevations. These results are consistent with PRISM modeled temperature and precipitation data. With regard to other vegetation, the results suggest that managers can anticipate earliest biodiversity threats to arctic-alpine and boreal species in the mid to high elevation Cascades and less imminent threats to coast range and low elevation communities.

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Climate Change Indicators in the United States

Michael Kolian*, Jason Samenow, Kevin Rosseel and Jim Titus
USEPA, OAR/OAP/Climate Change Division
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Washington, DC 20460

Collecting and interpreting environmental indicators play a critical role in our understanding of climate change and its causes. An indicator represents the state of certain environmental conditions over a given area and a specified period of time. Examples of climate-related indicators include surface temperature, precipitation, sea level, and greenhouse gas concentrations in the atmosphere. They can be either directly measured or derived from underlying measurement data and then related to climate variables. Although some indicators may show that fundamental environmental changes are now occurring likely as a result of climate change, others are not as clear. In addition, indicators may represent changes in complex large-scale ecological processes which occur over several decades to centuries.

Understanding the causes and effects of climate change require consideration of a broad suite of conditions than climate variables alone. Approaches for identifying relevant climate indicators including basic criteria and discussion of how various agencies can cooperatively contribute to providing useful indicators shall be presented.

Context is provided by EPA"s recently released *Climate Change Indicators in the United States* report which presents a set of 24 key climate indicators to better understand and communicate climate change. The report describes how the indicator relates to the causes and effects of climate change, how the indicator was developed, data sources, and factors associated with uncertainty or „indicator limitations". The report focuses primarily on the United States, but in some cases trends are representative of global changes to provide appropriate context or a basis for comparison. EPA uses these indicators to:

- Monitor the effects/impacts of climate change in the United States
- Assist decision–makers on how to best use policymaking and program resources to respond to climate change
- Assist EPA and its constituents in evaluating the success of their climate change efforts and a basis for comparison for modeled projections

EPA will be continuing to develop a national capacity related to climate indicators by expanding existing ones and adding others where gaps currently exist (e.g., hydrologic processes, forest resources, air quality) in the future. In addition, EPA will continue to engage multiple stakeholders in the project to provide credibility, avoid duplicative efforts, and diversify input. This is an important opportunity for long-term monitoring and research programs to contribute policy-relevant information and demonstrate the environmental effects of climate change on ecosystems and society.

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TECHNICAL SESSION 2: NETWORKS MONITORING ECOSYSTEMS

Session Chair: Rich Pouyat, U.S. Forest Service

Synthesizing Data on Stream Flow and Chemistry at Research Watersheds to Assess Effects of Atmospheric Deposition and Environmental Change

Stephen D. Sebestyen
USDA Forest Service
Grand Rapids, MN 55744 USA

Watershed studies in the Experimental Forest and Range Network of the USDA Forest Service and of other institutions span the USA. These sites encompass gradients of forest types, climate, atmospheric deposition, and disturbance regimes. Long-term data on stream flow and chemistry at these sites are: 1) important records of climate, hydrology, and ecosystem productivity, and 2) instrumental in quantifying how diverse ecosystems respond to disturbances. Findings from site-based research document ecosystem conditions, identify environmental problems, and provide evidence of management decisions that have been effective solutions. Moving beyond individual site analyses, a group of scientists are synthesizing data from research watersheds throughout the USA to evaluate ecosystem responses to climate change, atmospheric deposition, natural disturbance, and forest management practices to gain a broader understanding at national and global scales. In this talk, I will give an overview of watershed data that are critical to documenting environmental disturbance effects on water flow and chemistry, including tracers that are providing new insight on the effects of atmospheric pollutants on forest and water resources as well as summarize the research directions that we are pursuing as part of the synthesis project.

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Factors Controlling the Critical Loads and Dynamic Critical Loads in Lake-Watersheds of the Adirondack Region of New York

Qingtao Zhou[1], Charles T Driscoll[1*], Timothy J.Sullivan[2] and Bernard J.Cosby[3]

Critical loads and dynamic critical loads were calculated for 20 lake-watersheds from the Adirondack Long-Term Monitoring Program of New York using the dynamic model, PnET-BGC. These lake-watersheds represent different lake types, including thin till, medium till and seepage lakes. Following a 1000 year spin up period for the model to come to steady-state with respect to background deposition, lake-watershed simulations were run using a sequence of reconstructed historical deposition and a range of future scenarios of decreases in SO_4^{2-}, NO_3^- and NH_4^+ deposition ranging from 0% to 100% that was ramped down from 2008 to 2020 and remained constant thereafter until steady-state was attained. We evaluated several metrics that are indicative of the extent of historical acidification, the potential for recovery following decreases in atmospheric deposition and the hysteresis acid-base chemistry in the lake acidification and recovery sequence. The general pattern of historical acidification and recovery was similar across the sites, although the magnitude varied from lake to lake. Declines in lake acid neutralizing capacity (ANC) were simulated to start around 1900 with the onset of acidic deposition. Minimum ANC values occurred around 1990 some years after peak emissions (1973), and lake ANC increased in response to hypothetical future decreases in acidic deposition reaching steady-state around 2200. Our results show that decreases in SO_4^{2-} deposition were much more effective in achieving increases in ANC than decreases N deposition, and decreases in NH_4^+ and NO_3^- deposition had comparable and but limited effects on increasing in lake ANC. Our metrics of the extent of lake acidification, recovery and hysteresis were correlated with a suite of interrelated site factors, including Ca weathering rate, elevation, soil % base saturation, and lake ANC prior to acidic deposition (~1850).

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Deposition of Reduced Nitrogen (NH_x) in California and Other Western Regions: Prevalence and Ecological Importance

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Recent data on atmospheric ammonia (NH_3) concentrations and ammonium deposition fluxes in southern and central California suggest a greater prevalence of reduced N deposition than N emissions inventories in California indicate. According to the California Air Resources Board approximately 80% of NH_3 emissions statewide are from livestock waste. However, other NH_3 emissions sources such as motor vehicles equipped with three-way catalytic converters seem to be an underappreciated source of NH_3 emissions. Large scale infrared satellite observations of atmospheric NH_3 indicate that NH_3 emissions are underestimated in much of the northern hemisphere, including California and much of the western U.S. As NO_x emissions continue to decrease, reduced N is becoming proportionally more important as a driver of eutrophication and acidification effects to ecosystems and as a contributor to particulate matter. Ammonia is important ecologically because of its high deposition velocity, its ready biological availability, toxicity to lichens and bryophytes, and because of direct stomatal uptake by higher plants. In soils of the western U.S. ammonium is generally taken up by plants or microbes or nitrified rapidly when moisture is not limiting, which contributes to NO_3 leaching losses and soil acidification. Even in forests downwind of major urban emissions sources in southern California with elevated photochemical oxidant exposure, 43% of throughfall deposition is in reduced form. At 19 sites in the Sierra Nevada Mountains 42-67% of the N deposited as throughfall was as ammonium. Atmospheric concentrations and deposition of reduced N is highly elevated adjacent to highways, thus contributing to eutrophication effects along transportation corridors. Exposure to NH_3 can be far reaching, as demonstrated by two-week average concentrations in summer as high as 1-4 μg m^{-3} in the eastern Sierra Nevada. Concentrations of NH_3 have increased significantly in the eastern Sierra Nevada since the mid 1980s. Ammonia exposure has caused major changes in lichen communities throughout much of the Sierra Nevada in California and is a major component driving the N excess effects observed in a number of vegetation types in California and elsewhere and as recently reported in high elevation lakes in the eastern Sierra Nevada and in the Greater Yellowstone Ecosystem.

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Total Mercury and Methyl-Mercury Concentrations and Pools across 14 U.S. Forest Sites: Factors that Determine Mercury Loads in Remote Terrestrial Ecosystems

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The Mercury Deposition Network of the National Atmospheric Deposition Program and various atmospheric monitoring stations across the United States continuously record atmospheric pollution levels of mercury and their significance for deposition loads. Little information, however, is known how these atmospheric pollution measurements relate to ultimate mercury loads observed in terrestrial ecosystems. We performed a systematic investigation of total mercury and methyl-mercury concentrations and pools in 14 sites in order to determine the main factors that determine large-scale distribution of mercury in remote U.S. forests. Analysis included all major ecosystems compartments of forests, including foliage, branches, bark, bole, different surface litter horizons, and soils at various depths. We also calculated total pools of mercury and methyl-mercury using full biomass, soil mass, or carbon inventories on all sites.

Total Hg concentrations in aboveground biomass (i.e., leaves, bark, bole, and understory) was distributed in a highly random fashion, possibly reflecting previous reports that mercury levels vary greatly among different species, tissue age, or location within canopies. In litter and soils, however, we observed clear spatial patterns of Hg concentrations: four variables, including latitude, annual precipitation, and soil carbon and clay contents (in soils) explained most of the variability in observed Hg concentrations. Observed spatial patterns of mercury concentrations were mostly unrelated to extrapolated values of atmospheric pollution, including atmospheric mercury wet deposition loads, mercury air emissions from EPA"s toxics emission inventory, or measured air Hg(0) and Hg(II) levels. Pools of aboveground biomass mercury and litter mercury were directly related to the respective mass of these components, and hence were mainly determined by environmental factors that determined biomass and litter pools. Sites with high concentrations of total Hg also showed higher levels of methyl-mercury. Our results show that ecosystem properties, such as biomass, litter, and soil carbon dynamics, play a key role in determining mercury loads across remote U.S. forests.

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Atmospheric Observations of Nitrogen: Linking Regulatory Applications and Science across Atmospheric, Terrestrial and Aquatic Media

Rich Scheffe[1], Adam Reff[2], Eric Edgerton[3], Joe Sickles[4], Robin Dennis[4], Gary Lear[1], John Walker[4], Rob Pinder[4], John Ray[5], Norm Possiel[1] and Jeff Brook[6]

Observations of atmospheric nitrogen support environmental management and scientific research efforts bridging ambient air and terrestrial and aquatic environments. Atmospheric nitrogen influences ecosystem acidification and nutrient enrichment and is a principal precursor driving human health effects associated with ozone and fine particle pollution – collectively representing some our most prominent environmental issues over the last two decades. Indeed, emissions of oxides of nitrogen have been the central backbone of national level air pollution emission mitigation regulations over the last decade. Prospectively, the relative importance of nitrogen is escalating as air pollution management gradually takes on a multiple pollutant, multiple media framework recognizing the variety of linkages across physical-chemical processes throughout the source to effects continuum. Additional complexity will arise from future energy driven policies that likely will alter atmospheric nitrogen composition. Despite the relative importance of nitrogen and considerable resources allocated to controlling nitrogen emissions, existing nitrogen observation networks are severely challenged with respect to the relevancy of species measured and the associated spatial and temporal coverage of sample collection. Examples of these shortcomings include the reliance on satellite based total column nitrogen dioxide observations to confirm the atmospheric response to the NOx SIP CALL reductions from 2000 – 2005 and the lack of virtually any deployed instruments that measure nitrogen dioxide, despite the promulgation of a tighter nitrogen dioxide air quality standard in 2010. As we accelerate efforts to develop standards that protect aquatic and terrestrial ecosystems, we are forced to proceed without an observational basis for characterizing either oxidized or reduced forms of nitrogen. This presentation will use a combination of measurements and air quality model results to guide the development of a responsive observational network of key nitrogen species in addressing multiple environmental issues.

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TECHNICAL SESSION 3: SOIL NETWORKS

Session Chair: Hobie Perry, U.S. Forest Service

The National Soil Carbon Network: A „Stone Soup" Approach to Sharing Data, Infrastructure and Expertise

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The National Soil Carbon Network (NSCN; soilcarb.net) is a multi-component, science-based network created to enhance communication, collaboration, efficient use of scientific resources, and the advancement of soil carbon research. The NSCN is self-chartered and is the result of the interest from research scientists associated with a variety of agencies and institutions. It is anticipated that the NSCN will play a vital role in multiple national carbon cycle programs by helping to identify and fill data gaps in national-scale soil carbon data coverage and facilitate spatially explicit assessments of soil carbon turnover and vulnerability through multiple approaches to modeling and experimentation. We have three fundamental focus areas: Synthesis, Prediction, and Measurement. **Synthesis** efforts involve (1) *database development:* supporting the development of a coherent, searchable, and expandable database designed for use by individual and small-group research efforts; and (2) *data synthesis:* combining data from multiple large datasets, including multiple data input forms, and facilitating the production of synthesis products related to soil carbon distribution and vulnerability. **Prediction** efforts involve the use of the database and data synthesis products to better inform process models and risk maps, as well as aid in identification of data gaps. Networked **measurement** efforts involve the sharing of infrastructure, personnel, and expertise to fill gaps in data and knowledge. A common theme in all major focus areas is facilitating community organization through issue-based workshops and advanced website engineering for database interaction and community discussion. All of these activities will contribute to the coordination of multi-scale, interdisciplinary research within the larger scientific community. This presentation will cover the origin of the network, current support and activities, and next steps for growth and community involvement.

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Advancing the Study of Soil Change through the Northeastern Soil Monitoring Cooperative

Gregory B. Lawrence[1] and Scott W. Bailey[2]

We have long known that soils are continually changed through natural processes and human activities, but the recognition that these changes can be better understood through repeated measurement of soil properties is a more recent development. Measurements of soil change over periods ranging from a century to less than a decade can now be found in the literature. Opportunities for measuring soil change are expanding through the use of archived soils collected in past decades for various studies of acid deposition and forest ecosystems. To promote the study of soil change through the development and oversight of consistent methodologies, the Northeastern Soil Monitoring Cooperative was formed in March 2007 at the first annual workshop. A fifth workshop is planned for March 2011. Information on the structure and activities of the Cooperative will be presented in this talk. As an example of methodological and interpretive issues addressed by the Cooperative, soil data will be presented from northeastern red spruce stands that were sampled in 1992-93 and resampled in 2003-2004. Detailed evaluation was done to verify consistency in sampling approaches and chemical analyses, and to evaluate possible storage effects. Several statistically significant differences in soil chemistry were identified, including changes in organic carbon concentrations and exchangeable Al concentrations. These differences provided insight into processes that may be responding to changes in atmospheric deposition and climate on a decadal time scale.

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Mercury in Litterfall at Selected National Atmospheric Deposition Program Mercury Deposition Network Sites in the Eastern United States, 2007-2009

Martin R. Risch[1], John F. DeWild[1], David P. Krabbenhoft[1], Randall K. Kolka[2], and Leiming Zhang[3]

Forest canopies can accumulate more mercury from the atmosphere than other landscapes because of their relatively large leaf areas. In autumn in the eastern United States, the mercury mass in the annual litterfall of deciduous or predominantly deciduous forests represents a large portion of the atmospheric mercury dry deposition that was retained in the forest landscape that year. The Mercury Deposition Network (MDN) of the National Atmospheric Deposition Program (NADP) provides a framework for litterfall mercury monitoring because it has long-term sites, a broad geographic coverage, capacity for supplementary sample collection, and weekly mercury wet-deposition data.

A study of mercury in litterfall at selected MDN sites, which were thought to represent different forest-cover types and geographic regions in the eastern US, was completed during autumn months in 2007, 2008, and 2009. Trace-metal-free methods for collecting, processing, and analyzing litterfall samples for mercury were developed for the study. Data obtained in the study include total mercury concentrations in litterfall samples and litterfall sample-catch amounts from four passive collectors randomly deployed for approximately 2 months each autumn in study plots located near as many as 23 MDN sites in 15 states.

The annual total mercury concentrations in litterfall samples ranged from 21.4 to 67.8 ng/g (nanograms per gram) and had a median of 43.7 ng/g. The median percent relative standard deviation of the total mercury concentrations among the four collectors at a site was 7 percent. The median relative percent difference between the total mercury concentrations in 40 pairs of duplicates was 3.8 percent. The annual litterfall sample-catch amounts ranged from 42.1 to 499 g and had a median of 229 g. Mean mercury concentration in the samples and sample-catch amount were used to estimate annual litterfall-mercury deposition at each MDN site. Litterfall-mercury deposition ranged from 1.6 to 23.4 $\mu g/m^2/yr$ (micrograms per square meter per year) and had a median of 10.9 $\mu g/m^2/yr$. On average, litterfall accounted for 50 percent of the annual sum of mercury wet deposition plus litterfall-mercury deposition at the MDN sites in the study. The mean ratio of annual litterfall-mercury deposition to mercury wet deposition was 1.2 to 1.

Litterfall-mercury concentrations, sample catch, and litterfall-mercury deposition differed significantly among MDN sites and were highest in areas with deciduous oak-hickory forest-cover types. Annual litterfall-mercury deposition was highest at three sites near urban areas in Indiana and Maryland and two sites in the Ohio River Valley in Indiana and Ohio. The results of this study provide a reference for potential future litterfall-mercury monitoring at NADP-MDN sites.

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Acid Deposition and Soil Acidification in China: A Multipollutant Perspective

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To explore the future trends of soil acidification in China, a multipollutant framework is applied combining the possible variations of emission and deposition of sulfur (S), nitrogen (N) and particulate matter (PM). Under ongoing SO_2 control regulations for power sector and the assumptions of forthcoming NO_X control policies, national emissions of SO_2, NO_X and NH_3 in 2020, the target year of this study, are estimated to be 23.0, 23.4 and 22.0 Mt, i.e., 78%, 124%, and 132% of the levels in 2005, respectively. Emissions of base cations (BC), the important species mitigating acidification, are calculated with detailed technology information by sector in 2005 and projected for 2020 under two scenarios, one a base case and the other with stronger emission control policies. The anthropogenic emissions in 2005 and base and control scenarios in 2020 are estimated to be 5970, 7147 and 3250 kt for Ca^{2+}, and 236, 462, and 308 kt for Mg^{2+}, respectively. Depositions of acidifying species (i.e., S and N) and BCs are simulated with the Community Multiscale Air Quality (CMAQ) model and a multi-layer Eulerian model respectively. From 2005 to 2020, S depositions in north-central and eastern China, the most polluted areas, are estimated to decline by over 20%, while N deposition will rise by at least 10% in all provinces except Tibet even with application of denitrogenation technologies in the power sector. Compared to 2005, BC deposition will increase by 16% in the base scenario 2020, but decrease by 32% in the control scenario. By comparing the simulated S, N, and BC depositions and critical load (CL), the criterion of acidification below which harmful ecological effects do not occur, current and future soil acidification are evaluated in terms of exceedance of CL. In 2005, the area exceeding CL covered 15.6% of mainland China, with a total exceedance of 2.2 Mt S. These values will decrease to 14.1% and 1.8 Mt S, respectively, in the base scenario 2020, implying recovery from soil acidification. In the control scenario, however, the respective estimates are 17.9% and 2.4 Mt S, implying even higher acidification risks than 2005, particularly in south-central and eastern China. In other words, the recovery from soil acidification in China may be delayed substantially by PM control motivated mainly by human health benefits. To better understand the different effects of atmospheric pollutants, a multieffect perspective should be taken combining local, regional and global environmental considerations.

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Mercury Accumulation in the Forest Floor of the United States

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R.K. Kolka[1] and L. Woodruff[2]

Atmospherically-deposited Hg has a strong affinity for soil organic matter. Fluxes of Hg in soil water of upland watersheds are generally small, but forest fires may release stored Hg to the ecosystem. The contribution of Hg from forest fires relative to other anthropogenic sources is an important unknown. The Forest Service, US Department of Agriculture, Forest Inventory and Analysis (FIA) program collects soil samples from forested areas across the United States as part of its sampling program, and annual soils inventories are underway or completed in 45 of the 50 states (Alaska, Hawaii, Mississippi, New Mexico, and Oklahoma have yet to be sampled). Our objective is to inventory the spatial distribution of forest floor Hg for a transect running across the United States, from Arizona in the southwest to Maine in the northeast. The collection of forest floor samples was accomplished as part of the standard FIA Phase 3 Soil Quality Indicator program. Field protocols include the measurement of the thickness of the forest floor and the collection of the entire forest floor found within a 30-cm diameter sampling frame. We removed approximately 0.1 g of the sample for plots in our region of interest, and these were sent to two different laboratories for Hg analysis by cold-vapor atomic absorption. The two laboratories calibrated their instruments against common Hg standards. We found good agreement between samples analyzed at both laboratories. Observations of mercury concentrations were joined with the Forest Inventory and Analysis Database to assign basic location information and associated inventory data. There is a strong gradient of mercury storage across the United States. Once the data are spatially detrended, forest-type group remain significant predictors of Hg storage; conifer species tend to store more mercury than hardwood species.

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KEYNOTE SPEAKER DAY 2:

USGS's NETWORK OF NETWORKS

PETE MURDOCH, U.S. GEOLOGICAL SURVEY

Biographical Sketch

Pete Murdoch has spent most of his career as a Research Hydrologist with the Watershed Research Group of the US Geological Survey in Troy, New York. Since 1982, he has lead research projects on watershed biogeochemical processes, and the effects of acid rain and climate change on aquatic systems. In the mid-1990s he served as the Department of Interior (DOI) representative to the White House Committee on Environmental and Natural Resources (CENR), which developed a framework for integrating Federal Research and Monitoring programs to support resource managers in meeting the GAO mandate for "Ecosystem Management of Federal Lands." In 2004-06, he served as the DOI representative to the GCRP"s Inter-agency Carbon Cycle Working Group, and currently serves as a US representative to the Arctic Monitoring and Assessment Program Climate Experts Group, the Sustainable Arctic Observing Network (SAON), and the OSTP"s US-Russia Working Group on Science and Technology. His current role is Coordinator of the DOI National Climate Effects Network (CEN), a collaborative strategy for supplying science to support climate change decisions by leveraging and enhancing existing programs.

TECHNICAL SESSION 4: AIR MONITORING NETWORKS

Session Chair: John Walker, U.S. Environmental Protection Agency

The World Meteorological Organization Global Assessment of Precipitation Chemistry and Deposition

Robert Vet*, R. Artz, S. Carou, V. Bowersox, C.-U. Ro, M. Shaw, W. Aas, A. Baker, F. Dentener, C. Galy-Lacaux, R. Gillett, S. Gromov, H. Hara, T. Khodzhur, K. Pienaar, Nickovic, K. Pienaar and P.S.P. Rao

A Global Assessment of Precipitation Chemistry and Deposition is being written for the World Meteorological Organization by scientists from South Africa, Norway, Russia, Australia, Japan, India, Italy, Switzerland, France, England, the USA and Canada. The Assessment covers the period 2000 to 2007 and describes the global composition of precipitation and patterns of wet deposition of SO_4^{2-}, NO_3^-, Cl^-, H^+, pH, NH_4^+, Ca^{2+}, Mg^{2+}, Na^+, K^+, P and organic acids. The global discussion is supplemented by detailed regional discussions of Africa, South America, North America, Europe, Asia and Australia, focusing on the characterization of acid-base chemistry, temporal trends and, in some regions, dry deposition fluxes.

Given the paucity of measurements in many areas of the world, the global and regional wet deposition patterns were developed from measurement data combined with model predictions. The data were collected from the major deposition monitoring networks of the world (including NADP) and the model predictions were obtained from the Coordinated Model Studies Activity of the Task Force on Hemispheric Transport of Air Pollution (TF HTAP) under the framework of the United Nations Economic Commission for Europe (UN ECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP). The measurement-model results were combined into maps of sulfur and nitrogen wet deposition and, where possible, dry deposition.

The production of the global and regional deposition maps and the assessment of precipitation deposition science required considerable effort to gather, quality control and interpret the measurement data. In this context, the NTN and AIRMON networks of the National Atmospheric Deposition Program and the Clean Air Status and Trends Network in the United States and the Canadian Air and Precipitation Monitoring Network were vital. Their roles and contributions are discussed in this global context.

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Mercury Dry Deposition Monitor Development

Matthew S. Landis, Ph.D.[1] and Elizabeth Oswald, M.S.[2]

Monitoring for total mercury in wet deposition has become a relatively routine effort over the last decade, but the development of methods for direct measurement of dry deposition is widely recognized as an area needing considerable research. EPA has worked over the last five years to develop multiple surrogate surface techniques to quantify dry deposition. EPA developed an automated water surrogate surface collector and worked with the University of Michigan Air Quality Laboratory to develop a turf surrogate surface approach. The EPA ORD automated water surrogate dry deposition monitor was designed for the unattended collection of seven daily (24 hour) samples per week of operation. Dry deposition samples are collected using an airfoil/Teflon insert plate filled with reagent grade water in six 4-hour sample periods per day. Redundant automated rain sensors and an ambient weather station are utilized by the monitor to detect adverse weather conditions to ensure that only dry deposition is measured. The turf sampler consists of a circle of artificial grass surface fit into a well-style insert of an aerodynamic airfoil. The surrogate turf surface provides a controlled medium which simulates non-water surfaces for determining dry deposition of mercury, major ions and trace metals, as well as integrating wet deposition. Both surrogate surface techniques were evaluated in pilot studies and found to provide valuable data for dry deposition research. The performance characteristics of both techniques will be presented and discussed.

In 2009, as part of a joint ORD / Region 4 study and in conjunction with the Florida Department of Environmental Protection Mercury Total Maximum Daily Load (TMDL) study, EPA ORD initiated a long term dry deposition methods evaluation study using the automated water and manual turf surrogate surface dry deposition collector to (i) investigate the utility of both methods for quantifying dry deposition of mercury, major nutrients, and trace elements, (ii) evaluate the application of source apportionment models to measured dry deposition, (iii) bound the uncertainties between dry deposition to a flat water surface and a three-dimensional vegetative-like structure, and (iv) compare direct measurement of surrogate surfaces to inferential models and evaluate contemporary model algorithms. Also in the summer of 2009, EPA ORD conducted the Cleveland Multiple Air Pollutant Study (CMAPS) which included deployment of turf surrogate surface dry deposition collectors at seven sites during a six week intensive. The spatial and temporal variability of mercury dry deposition was measured to investigate the impact of local and regional sources to the observed wet and dry deposition. Data validation from both studies is ongoing. Initial study results and implications will be presented and discussed.

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An Overview of the Measurements of the Canadian Air and Precipitation Monitoring Network with a Focus on the Measurements of Nitrogen species

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The Canadian Air and Precipitation Monitoring Network (CAPMoN) was established in 1988 to determine temporal trends and spatial distribution for wet deposition and provide estimates of dry deposition at regional representative sites in Canada. The network currently monitors precipitation, aerosols and trace gases, ozone, $PM_{2.5}$ mass and $PM_{2.5}$ speciation, mercury in precipitation, total gaseous mercury and several nitrogen species. An overview of the network measurements, intercomparisons, and future monitoring initiatives will be discussed. A more detailed description of the CAPMoN nitrogen species measurements will be portayed. The continuous measurement of gas phase nitrogen species at selected CAPMoN sites began in 2002 in part to estimate their contributions to the total nitrogen dry deposition flux at selected CAPMoN sites. Current measurements include NO, NO_2, NO_y, peroxyacetic nitric anhydride (PAN), and ammonia with detection limits of each species of approx. 100 ppt or better. These continuous measurements are complemented by daily integrated filter pack measurements of HNO_3 and particle nitrate. A description of the nitrogen measurement system, measurement challenges, and preliminary findings will be presented.

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Estimation of Speciated and Total Mercury Dry Deposition

Leiming Zhang[1], Pierrette Blanchard[1] and David Gay[2]

Mercury transport models are needed to provide estimates of dry deposition amounts at regional scales. Two model runs, one from the Community Multiscale Air Quality Modeling System (CMAQ) and another from the Global/Regional Atmospheric Heavy Metals Model (GRAHM), are analyzed to provide a first estimation of mercury dry deposition over the Great Lakes region. The modeled annual dry deposition of Hg_p plus RGM is in the range of 10-40 $\mu g\ m^{-2}$ from CMAQ and in the range of 5-40 $\mu g\ m^{-2}$ from GRAHM over most of the areas south of the border. CMAQ shows a clear gradient with the highest deposition in Pennsylvania and its surrounding areas while GRAHM shows no such gradient in this region; however, GRAHM has more hot spots (> 40 $\mu g\ m^{-2}$) than those of CMAQ. Dry deposition of Hg_p plus RGM in the areas north of the border are lower than 15 $\mu g\ m^{-2}$ from CMAQ and lower than 5 $\mu g\ m^{-2}$ from GRAHM. Modeled deposition to the water surfaces is mostly lower than 5 $\mu g\ m^{-2}$ from both models. The large differences in the Hg_p and RGM concentrations between the measurements and the modeled values provide little confidence in the modeled dry deposition distributions in a quantitative sense. Mercury dry deposition at monitoring sites can be estimated routinely by combining monitored speciated ambient concentrations and modeled dry deposition velocities, the latter can be provided by dry deposition models with surface-layer meteorological input from a weather forecast model. As an example, speciated dry deposition fluxes at multiple locations across eastern North America are calculated and analyzed for one year period.

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Distribution of Ozone, Ozone Precursors and Gaseous Components of Atmospheric Nitrogen Deposition in the Lake Tahoe Basin

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In the 2010 -2012 study, we will characterize ozone (O_3), precursors of O_3 formation, and gaseous pollutants that are important contributors to atmospheric nitrogen (N) deposition in the Lake Tahoe Basin (California & Nevada). We will use passive samplers for monitoring of O_3, nitric oxide (NO), nitrogen dioxide (NO_2), ammonia (NH_3), nitric acid (HNO_3) and volatile organic compounds (VOCs) on a network of 32 sites inside and outside of the Basin. Using statistical and geostatistical models we will create distribution maps of the measured compounds for the entire Basin. On a subset of 10 monitoring sites, we will also measure real-time O_3 concentrations with active UV absorption monitors to evaluate diurnal changes of the pollutant, calibrate passive O_3 samplers, and use that data for evaluation of the exceedances of O_3 air pollution standards in the Basin. At the same sites we will also measure N deposition with ion exchange resin (IER) collectors placed in forest clearings (bulk precipitation) and under tree canopies (throughfall). In these bulk and throughfall samples from the IER collectors we will measure the stable isotope composition (^{15}N and ^{18}O) of NO_3 and from passive sampler extracts of NH_3 (^{15}N) to evaluate the origin of N deposition in the Basin. Results of this study will help to evaluate the present and future potential of O_3 formation as well as the biological/ecological effects of N air pollutants and the resulting N deposition in the Lake Tahoe Basin. These results will also help to develop science-based management strategies aimed at improving air quality and ecological sustainability of the Basin. Establishment of monitoring sites has been accomplished and the study is progressing according as planned. First results on air quality measurements will be presented.

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Passive Monitoring of Ambient Reactive Gaseous Mercury in the Four Corners Area and Eastern Oklahoma

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This presentation summarizes the first year of a two year air monitoring project estimating reactive gaseous mercury (RGM, a.k.a. gaseous oxidized mercury, GOM) dry deposition rates in the Four Corners area and eastern Oklahoma. The project collaborators include the U.S. Environmental Protection Agency (EPA) Region 6, EPA"s Office of Research and Development (ORD), Frontier Global Sciences, Alion, the New Mexico Environment Department (NMED), the National Park Service (NPS), the Bureau of Land Management (BLM), the Jemez Pueblo, and the Cherokee Nation. Ambient monitoring began in August, 2009, and will run through August, 2011, at six sites in the Four Corners area (i.e., NW New Mexico and SW Colorado) and one site in eastern Oklahoma. The two years of ambient monitoring enables robust field testing of the new Frontier Atmospheric Dry Deposition (FADD) surrogate surface device for passive monitoring of RGM, and will enable assessment of inter-annual and spatial variability of the RGM data. This project also provides first-time RGM dry deposition flux estimates for 24 consecutive months at six sites in the Four Corners area and one site in eastern Oklahoma to set a valuable ambient mercury deposition estimate baseline in those areas. Five of the seven sites are collocated with wet deposition mercury measurements to evaluate total mercury deposition impacts. Project site types include regional background, power plant, rural, urban, and elevated mountain sites. The eastern Oklahoma site houses a continuous Tekran mercury instrument, which provides continuous RGM measurements to compare to the collocated passive RGM measurements from the FADD samplers. FADD samples are deployed for two-week integrated time periods, and include duplicate field and blank samples. In the first year of the study significant dry deposition rate estimates are being detected at all of the project sites, with a predominance of the highest flux estimates measured at the Mesa Verde National Park site. This abstract of a proposed presentation does not necessarily represent EPA policy.

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Long-Term Trends in Atmospheric Reactive Nitrogen across Canada: 1988–2007

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The long-term trends in atmospheric reactive nitrogen (Nr) species at 12 Canadian Air and Precipitation Monitoring Network (CAPMoN) stations (9 with air and precipitation observations) across Canada were evaluated during the period 1988–2007. The non-parametric Mann-Kendall test was used to determine monotonic trends in the annual chemistry of gaseous nitric acid (HNO_3), particulate nitrate (pNO_3^-), particulate ammonium (pNH_4^+), wet ammonium (NH_4^+) and wet nitrate (NO_3^-) in response to emission reductions primarily driven by the Canada-United States Air Quality Agreement. The (trend) slope was estimated using the non-parametric Sen's method, and trend significance was assumed at the 0.05 confidence level in the current study. Annual air concentrations (1988–2007) of pNH_4^+ and HNO_3 significantly decreased at all CAPMoN stations, while pNO_3^- concentrations increased at 7 of 9 stations. Precipitation NH_4^+ had no significant or consistent trend whereas precipitation NO_3^- concentrations significantly decreased at 9 of the 11 stations and increased at one (non-significant). Normalized temporal sequences showed consistent temporal patterns across Canada for several Nr species. Annual average air concentrations of pNH_4^+ and HNO_3 had synchronous time-series of consistently decreasing concentrations across all CAPMoN stations (1988–2007), in contrast, pNO_3^- had a complex temporal pattern, dominated by an initial period of no change (1988–1993), followed by a period of steep increase (1993–2002) and then a period of steep decrease (2002–2007). The period of steep decrease started around 2002 and was observed at all CAPMoN stations (all Nr species except wet NH_4^+). The steep decrease was consistent with the observed decrease in NO_x emissions from power plants and on-road vehicles in the United States. Southern Ontario consistently had the highest concentrations of all Nr species measured across Canada. These stations are located in (or close to) agricultural areas that are in close proximity to the most concentrated industrialized region in eastern Canada; moreover, they are located downwind of the largest anthropogenic emissions sources in North America (Ohio valley), therefore emissions in the eastern United States drive deposition trends observed in eastern Canada.

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TECHNICAL SESSION 5: WATER NETWORKS

Session Chair: Maggie Kerchner
National Oceanic and Atmospheric Administration

Water Quality Monitoring and Atmospheric Deposition: How are they Linked?

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The atmospheric deposition of air pollutants triggers numerous interactions with ecosystems including uptake as a nutrient, toxicity, and changes in species richness and biodiversity. One way in which scientists document the effects of air pollutant deposition is through monitoring surface water quality. This presentation focuses on water quality monitoring to document the effects of atmospheric sulfur (S), nitrogen (N), and mercury (Hg) deposition on aquatic ecosystems. An underlying assumption of such monitoring is that surface water chemistry is a surrogate for the effects of air pollutants on aquatic ecosystems. Biological monitoring is more costly and time consuming than water quality monitoring, and is therefore less common; however, biological recovery of aquatic ecosystems from decreased loads of acid deposition often does not parallel water quality recovery because of ecological factors such as competition and dispersal. The extent to which water chemistry reflects air pollutant deposition varies widely among solutes and among different regions of the US. For example, surface water sulfate concentrations in the Northeast generally reflect sulfate deposition, whereas the same is not true in the Southeast where soils readily adsorb sulfate. Spatial patterns of N deposition are often reflected by surface water nitrate concentrations, but temporal deposition patterns commonly show little synchronicity with these concentrations because of high demand for N as a nutrient. Mercury deposition is generally even less clearly related to surface water Hg concentrations than is S or N because watershed factors (for example, wetlands) generally affect mobility to a greater extent than does recent atmospheric loads. Soils generally play a key role as either source or sink, and predictive models greatly benefit from soil monitoring data and an understanding of key soil processes. Several monitoring programs focus on the link between air pollutant deposition and water quality including the LTM/TIME program of the U.S. Environmental Protection Agency, the Hydrologic Benchmark program of the U.S. Geological Survey, monitoring in several National Parks (i.e. - Rocky Mountain and Shenandoah), several experimental forests operated by the U.S. Forest Service (i.e. - Hubbard Brook and Coweeta), and several LTER sites funded by the National Science Foundation (i.e. - Andrews Forest and Niwot Ridge). Little monitoring of Hg in waters exists in the US with no operating national network. Because watersheds serve as chemical stores and can greatly alter air pollutants during transit, water quality monitoring can provide greater understanding and improved models of the ecosystem effects of air pollutants.

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Use of Regression-Based Models to Map Sensitivity of Aquatic Resources to Atmospheric Deposition in Yosemite National Park, USA

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An abundance of exposed bedrock, sparse soil and vegetation, and fast hydrologic flushing rates make aquatic ecosystems in Yosemite National Park susceptible to nutrient enrichment and episodic acidification due to atmospheric deposition of nitrogen (N) and sulfur (S). In this study, multiple-linear regression (MLR) models were created to estimate fall-season nitrate and acid neutralizing capacity (ANC) in surface water in Yosemite wilderness. Input data included estimated winter N deposition, fall-season surface-water chemistry measurements at 52 sites, and basin characteristics derived from geographic information system layers of topography, geology, and vegetation. The MLR models accounted for 84% and 70% of the variance in surface-water nitrate and ANC, respectively. Explanatory variables (and the sign of their coefficients) for nitrate included elevation (positive) and the abundance of neoglacial and talus deposits (positive), unvegetated terrain (positive), alluvium (negative), and riparian (negative) areas in the basins. Explanatory variables for ANC included basin area (positive) and the abundance of metamorphic rocks (positive), unvegetated terrain (negative), water (negative), and winter N deposition (negative) in the basins. The MLR equations were applied to 1407 stream reaches delineated in the National Hydrography Dataset for Yosemite, and maps of predicted surface-water nitrate and ANC concentrations were created. Predicted surface-water nitrate concentrations were highest in small, high-elevation cirques, and concentrations declined downstream. Predicted ANC concentrations showed the opposite pattern, except in high-elevation areas underlain by metamorphic rocks along the Sierran Crest, which had relatively high predicted ANC (>200 μeq L^{-1}). Maps were created to show where basin characteristics predispose aquatic resources to nutrient enrichment and acidification effects from N and S deposition. The maps can be used to help guide development of water-quality programs designed to monitor and protect natural resources in national parks.

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Developing Critical Loads for Atmospheric Deposition of Nitrogen to Alpine Lakes in the Pacific Northwest using Sediment Diatoms

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Excessive nitrogen from atmospheric deposition can be an important component of eutrophication in some aquatic ecosystems. Alpine lake ecosystems are nitrogen limited and especially sensitive to additional inputs of atmospheric nitrogen because they have adapted to an oligotrophic environment and may be sensitive to additional inputs. In Washington State, long term National Atmospheric Deposition Program (NADP) monitoring at low elevation (<1,500 feet) has shown deposition (loads) similar to the 1.5 kg/ha/yr effects-level determined for Rocky Mountain National Park (ROMO) in Colorado. Deposition data for higher elevations in Washington is lacking. The U.S. Geological Survey initiated a study with the National Park Service to address this data gap and work to determine effects-level critical loads for Washington State. Like ROMO, our approach to determine a critical load for nitrogen deposition is based on shifts in sediment diatom community composition in 12 lakes in Mount Rainier, North Cascades, and Olympic National Parks. Sites were at elevations above 4,000 feet with minimal forest cover to reduce non-atmospheric inputs of nitrogen subsequently increasing the potential effect from atmospheric deposition of nitrogen to these lakes. During summer 2008, bulk nitrogen deposition was determined using ion exchange resin collectors. Total N deposition rates ranged from 0.6 to 2.5 kg-N/ha/yr across all sites, and typically were higher (by about 0.5 kg/ha/yr) than the low elevation NAPD sites in Washington during the same period. The lowest summer deposition was in Olympic National Park and highest summer deposition was in North Cascades National Park. In summer 2009, each lake was sampled for nutrients and a sediment core was collected for diatom analysis. All lakes were extremely oligotrophic and at most sites ammonium, nitrate, and phosphate were at or below detection limits. Initial diatom analysis of top and bottom sections of each sediment core was done to identify the most affected lakes. Of the nine top-bottom diatom analyses completed, only two lakes showed signs of degradation. These lakes were in Olympic National Park where the lowest N deposition was measured. These cores will have a more complete diatom profile analyzed, and the sediment will be dated to indicate when major diatom changes have occurred, which will allow us to relate these changes to N deposition at nearby NADP sites to identify a critical load for N. Results from this ongoing project will be available by early 2011.

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MAGIC Model Estimates of Critical Load of Sulfur Deposition to Protect Acid-Sensitive Resources in the Adirondack Mountains, New York

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The MAGIC model was applied to 97 lake watersheds in the Adirondack Mountains, New York, to estimate the critical load (CL) of sulfur deposition required to protect aquatic and terrestrial resources against acidification. The sensitive receptors that were evaluated included lake acid neutralizing capacity (ANC), soil base saturation (BS), soil solution nutrient base cation-to-aluminum ratio (Bc:Al), and soil solution calcium-to-aluminum ratio (Ca:Al).Varying critical criteria thresholds and endpoint years were examined. Critical load and exceedance results were extrapolated numerically to the broader population of Adirondack lakes using the mathematical frame from EPA"s Environmental Monitoring and Assessment Program (EMAP). Spatial extrapolation and mapping were performed using the Adirondack Lakes Survey as the basis for extrapolating MAGIC-simulated CL values to the regional population of surveyed lakes. Resulting critical loads were compared to reveal patterns related to selection of sensitive receptor, critical criterion threshold, and endpoint year. This information will be of substantial importance for natural resource management in the Adirondack Mountain region.

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Establishing a Collaborative and Multipurpose Long Term National Reference Site Network for Freshwater Streams in the United States

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U.S. Geological Survey

The U.S. Geological Survey is developing a plan for a collaborative and multi-purpose long-term national reference site network for freshwater streams in the United States to address increasing needs for information on the status and trends in streamflow and water quality of relatively unimpaired watersheds. An organizational structure similar to that of the National Atmospheric Deposition Program would help facilitate interagency collaboration to develop and encourage use of nationally-consistent field and laboratory protocols, procedures for quality assurance and quality control, and data management. A three tiered network design would consist of: 1) 75 to 100 minimally impaired watersheds geographically distributed across Level 2 ecoregions where real-time monitoring of hydrologic, climatic, and landscape variables would occur; 2) periodic synoptic sampling of a larger number of sites to provide higher spatial resolution of stream conditions; and 3) remote sensing and modeling to assist with extrapolation and forecasting. One approach for evaluating a network design involves characterizing the natural setting and anthropogenic disturbances of pre-designated "reference" basins relative to all Hydrologic Unit Code 10 basins within a Level 2 ecoregion. This will allow for placing existing and candidate reference basins in a larger environmental context and provide a mechanism for individual scientists and agencies to evaluate the suitability of different sites for achieving mission-specific goals. Initially this effort will include: an inventory of existing sites and data used by different agencies to characterize reference conditions and an analysis of existing and discontinued monitoring sites to determine where new sampling may be effective for enhancing a national reference site network. Data from this network will quantify reference conditions for a broad suite of chemical and ecological attributes that respond to anthropogenic and climate-related effects on water quality at watershed, regional, and national scales. For example, network data would be used in quantifying long-term trends for select constituents on a regional and national basis; establishing background concentrations for select constituents to guide the establishment of water-quality criteria; providing a benchmark for understanding environmental stressors on aquatic communities; quantifying episodic events with sufficient sampling frequency; and providing access to data for reference water-quality conditions. Increased collaboration among Federal and State agencies is a key mechanism for the success and support of a national reference site network that ultimately serves multiple agency objectives and program goals.

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The Long Term Response of Adirondack Surface Waters to Reductions in Acidic Deposition

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After years of adverse impacts to the acid sensitive regions of the United States, the US EPA formulated Title IV of the 1990 Clean Air Act Amendments to regulate sulfate emissions from power plants with the goal of decreasing acidic deposition. Post implementation, large scale decreases in sulfate emissions and deposition concentrations have been readily evident; however, due to the complexity of surface water systems, ecosystem recovery has been more elusive and less apparent in the immediate data. The Temporally Integrated Monitoring of Ecosystems (TIME) is a long term monitoring project developed in 1990 to sample statistically chosen subpopulations of lake and stream regions across the eastern US to compare regional trends in surface water chemistry to changes in air deposition. Forty-three TIME lakes were selected to represent the surface waters of the Adirondack ecosystems in upstate New York. Using the TIME and NADP data available from 1991-2007, substantial decreases in sulfate were confirmed for local wet deposition and lakes throughout the Adirondacks. Corresponding to a -1.04 meq/m^2-yr average regional trend in sulfate deposition for the time period, lake sulfate concentrations have decreased at an average rate of -1.92 µeq/L-yr and fluxes have decreased at an average rate of -1.19 meq/m^2-yr. Additionally, the percentage of these 43 lakes considered to be acidic (ANC <0 µeq/L) has decreased from 16.3 to 14.0 percent over the last ten years. Previous analysis of Adirondack TIME data, conducted in the late 1990s, concluded that although sulfates were decreasing appreciably, ANC recovery was limited by large decreases in base cation concentrations. While lake trends in ANC continue to show a dependence on changes in base cations, more than 80% of the TIME lakes now exhibit considerable increases in ANC at an average rate more than two-fold greater than previously reported (+.76 µeq/L-yr). The past seventeen years of Adirondack TIME data suggest that the surface water ecosystems are finally showing recovery from acidification. However, analyses of the four most recent years of data (2004 to 2007) reveal that several lakes are now experiencing increasing levels of sulfate deposition and decreasing DOC concentrations. It is possible that these unexpected trends coincide with increases in precipitation, which may advocate a need for stricter sulfate emission regulations to allow for continued recovery in the midst of variable weather conditions.

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TECHNICAL SESSION 6: BIOLOGICAL NETWORKS

Session Chair: Kristi Morris, National Park Service

Phenology as a Tool for Science, Management and Education in a Changing Environment: The USA National Phenology Network

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Patterns of phenology for plants and animals control ecosystem processes, determine land surface properties, control biosphere-atmosphere interactions, and affect food production, health, conservation, and recreation. The USA National Phenology Network (USA-NPN; www.usanpn.org) is an emerging and exciting partnership between federal agencies, the academic community, and the general public to establish a national science and monitoring initiative focused on phenology as a tool to understand how plants, animals and landscapes respond to climate variation, and as a tool to facilitate human adaptation to ongoing and potential future climate change. In its second year of operation, USA-NPN produced many new phenology products and venues for phenology research and citizen involvement. A new web-page contains an advanced on-line user interface to facilitate entry of contemporary organismal phenology data into the National Phenology Database. An integrated animal and plant phenology monitoring program provides standardized methods and monitoring protocols for over 400 local, regional, and nationally distributed animal and plant species. Monitoring methods are designed to facilitate collection of sampling intensity and absence data for both plants and animals. Future directions include increased integration with national and international formal and informal science networks; enhanced consistency and availability of remote sensing of phenology terminology, methods, products and services; tools for discovery, description, ingestion, curation and distribution of historic phenology datasets; and, improvement of tools for data entry, download and visualization.

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Recent Evidence of Biological Recovery from Acidification in the Adirondacks (NY, USA): A New Regional Paleolimnological Perspective

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The Adirondack region of New York (USA) has been significantly impacted by acid deposition. Since the implementation of the Clean Air Act Amendments, the area has shown improvements in water chemistry. However, little work has been done to assess biological recovery in the region. Assessing biological recovery is often difficult due to a lack of long-term monitoring data but paleolimnology can overcome this problem. Paleolimnology uses the physical and biological characteristics of lake sediments to infer lake histories. Biological proxies such as diatoms, chrysophytes, and cladocera can be correlated to environmental variables like pH and temperature. By quantifying changes in these proxies overtime, paleolimnologists can assess changes in the aquatic environment. The goal of this investigation was to identify if biological recovery has followed chemical recovery in three acid-impacted Adirondack lakes using paleolimnological techniques. Additionally, a lake which did not acidify was included in the study to serve a reference system. Changes in the lakes‟ chrysophyte and cladoceran fossil assemblages were analyzed from ca. 1760-present in ^{210}Pb dated sediment cores. Multivariate statistics were applied to compare changes in fossil species composition with measured changes in chemical and climatic variables. Recent (post-ca. 1995) declines in chrysophyte species with low pH optima suggest that biological recovery from acidification is occurring in the study lakes. However, recent (post-ca. 1970) increases in colonial chrysophyte taxa suggest that the species assemblages are not returning to their predisturbance state, likely due to an influence of climate warming. The cladocera remain unresponsive to increasing pH and several local/regional factors may be preventing their recovery (i.e. predation, calcium depletion, climate warming, etc.). This study provides evidence that biological recovery is underway in the Adirondacks but that recovered assemblages are unlikely to return to their pre-industrial state due to other environmental factors.

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Predicting Nitrogen Deposition to Forests in the Los Angeles Basin using Lichen Communities

Sarah Jovan[1], Jennifer Riddell[2] and Pamela E. Padgett[2]

Forests in the Los Angeles Basin receive the highest known levels of nitrogen (N) deposition in the United States. Excess N is implicated in a wide variety of detrimental ecological impacts to both terrestrial and aquatic systems, leading to shifts in vegetation communities that favor invasive species, elevated nitrate (NO_3^-) runoff, soil acidification, decreased frost-hardiness in trees, and so on. In 2008 we surveyed the epiphytic (tree-dwelling) lichen communities of *Quercus kelloggii* forests at 23 sites across the San Bernardino Mountains, the Palomar Mountain area (Cleveland National Forest), and the Sawmill Mountains (Angeles National Forest). We employed gradient analysis to determine how lichen community patterns relate to N measurements collected at some or all of our survey sites; these include throughfall N (kg ha^{-1} yr^{-1}), seasonal averages of NH_3, NO_2, and HNO_3 from Ogawa passive monitors (µg m^{-3}), modeled site N deposition (kg ha^{-1} yr^{-1}) from the Community Multi-scale Air Quality model (CMAQ), and assays of NO_3^- accumulated on twig surfaces (µg cm^{-2}). With non-metric multidimensional scaling ordination (NMS) we resolved a gradient explaining almost half the variability in lichen communities (r^2 = 0.48), which clearly reflected a community-level response to N. Lichen community scores along the gradient correlated exceptionally well with throughfall N (r^2= 0.94), an N measure that captures the hydrologic flux of ammonium (NH_4^+) and NO_3^- ions from the tree canopy to the forest floor. We then used simple linear regression (SLR) on community scores to predict throughfall N at all sampled sites. The two-phase model combining NMS and SLR yielded N predictions sufficiently accurate (error: ± 4.57 kg N ha^{-1} yr^{-1}) for use in the Basin where throughfall N spans 6.1 to 71.1 kg ha^{-1} yr^{-1}. The ability to make reasonably accurate N predictions based solely on lichen community information marks a significant utilitarian advancement in the lichen-bioindication field. In the highly N-compromised Basin, land managers and air quality regulators may use lichen estimates as a surrogate or justification for implementing more costly campaigns that measure N directly. For instance, lichens predict throughfall N in excess of 30 kg ha^{-1} yr^{-1} for most sites in Palomar and the Sawmill Mountain Ranges, an amount that far exceeds all published N critical loads for California forest ecosystems, yet N is not actively monitored in either of these forests.

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Critical Nitrogen Deposition Loads in High-Elevation Lakes of the Western U.S. Inferred from Shifts in Diatom Community Structure

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Critical loads of nitrogen (N) from atmospheric deposition were determined for alpine lake ecosystems in the western U.S. using fossil diatom assemblages in lake sediment cores. Changes in diatom species over the last century were indicative of N enrichment in two areas, the eastern Sierra Nevada, starting between 1960-1965, and the Greater Yellowstone Ecosystem, starting in 1980. In contrast, no changes in diatom community structure were apparent in lakes of Glacier National Park. To determine critical N loads that elicited these community changes, we modeled wet nitrogen deposition rates for the period in which diatom shifts first occurred in each area using deposition data spanning from 1980-2007. We determined a critical load of 1.4 kg N ha^{-1} yr^{-1} wet N deposition to elicit key nutrient enrichment effects on diatom communities in both the eastern Sierra Nevada and the Greater Yellowstone Ecosystem. Widespread phosphorus limitation in lakes of Glacier National Park may explain the lack of diatom community changes in that region.

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Changes in Diatom Taxa in Sierra Nevada Lakes during the 20th Century: Implications for Critical Loads Development

Dr. James O. Sickman[1*], Dr. Danuta Bennett[2], Andrea Heard[1] and Delores Lucero

The main objective of our study is to establish critical loads for nitrogen deposition in aquatic ecosystems of the Sierra Nevada, using reconstructions of past lake chemistry based on diatoms preserved in lake sediments. Using diatom and water quality data from an extensive survey of high-elevation lakes, we are developing diatom-based models of past nutrient and trophic conditions and applying these models to sediment cores collected from two high elevations, Moat Lake (Hoover Wilderness) and Hamilton Lake (Sequoia National Park). We will present initial water quality models derived from the lake survey, describe changes and trends in diatom flora over the past 100 years and discuss these findings in the context of critical loads development.

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Key Words: Diatoms, Critical Loads, Nitrogen, Lakes, Sierra Nevada

Progress on Implementation of a Decision-Support System to Assess Critical Loads of Atmospheric S Deposition in the Southeastern US

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The U.S. Environmental Protection Agency (EPA) and USDA Forest Service (USFS) are developing a decision-support system (DSS) for critical loads (CL) of atmospheric S deposition to protect stream resources against acidification in the southeastern United States. The spatial coverage of the study region includes the Ridge and Valley and Appalachian Plateau ecoregions in Virginia and West Virginia and the Blue Ridge ecoregion in Virginia, West Virginia, North Carolina, and Tennessee. The DSS is an application of the Ecosystem Management Decision Support (EMDS) system, originally developed at the USFS Pacific Northwest Research Station. EMDS is an application framework for knowledge-based decision support for environmental analysis and planning at multiple geographic scales. The system integrates geographic information with logic- and decision-modeling technologies to provide a spatial analysis system for data management and environmental risk assessment.

Water chemistry data across the study region were compiled from a variety of EPA, USFS, and other existing water quality databases. The final dataset includes 933 sites. Each site is represented by the most recent spring sample. Estimates of base cation weathering have been developed for 140 of the 933 water chemistry sites using the Model of Acidification of Groundwater in Catchments (MAGIC), and are being extrapolated to the broader region for use in the Steady State Water Chemistry (SSWC) model to estimate CL values throughout the region. Extrapolations of the weathering estimates and the regional distribution of stream water acid neutralizing capacity (ANC) are achieved using a variety of multivariate statistical modeling techniques. General data classes evaluated in the modeling include soil and lithology variables as well as wet and dry atmospheric S deposition, topographic wetness index, surface area ratio, and 36 Ameriflux variables. All data were upslope averaged in a geographic information system (GIS) to develop potential predictor variables above each pour point. Despite data limitations imposed by historic non-random selection of sample sites, initial modeling results for predicting regional distribution of ANC appear promising, and will be presented. Regional modeling of weathering is ongoing.

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POSTER SESSION

IN ALPHABETICAL ORDER BY AUTHOR

Empirical and Modeling Approaches to Setting Critical Loads for N Deposition in Southern California Shrublands

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Southern California deserts and coastal sage scrub (CSS) are undergoing vegetation-type conversion to exotic annual grassland, especially in regions downwind of urban areas that receive high N, primarily as dry deposition. To determine critical loads (CL) of N that cause negative impacts, we measured plant and soil responses along N deposition gradients, fertilized vegetation along the gradient at different N levels, and used biomass production output from the DayCent model. N deposition gradients were identified from the Community Multiscale Air Quality model and compared with measured N deposition values. CSS receives N deposition as high as 30 kg ha^{-1} yr^{-1}, while the desert has levels up to 16 kg ha^{-1} yr^{-1}. Unlike more mesic ecosystems where critical loads are determined by changes in soil chemistry or biogeocycling, these arid and semiarid ecosystems are subject to increases in exotic species production, loss of native species diversity, and increased fire risk at relatively low CL's. For instance, a gradient survey in CSS showed that exotic grass cover increased from 1 to 70% between 8 and 20 kg N ha^{-1} yr^{-1}, while native plant species and arbuscular mycorrhizal species richness declined by almost 50% above 10 kg N ha^{-1} yr^{-1}. Fertilization studies in desert creosote bush scrub showed a significant increase in exotic species biomass with 5 kg N ha^{-1} yr^{-1} in a wet year and a decrease in native species richness. In addition, biomass output from DayCent modeling indicated an increased fire risk from exotic grasses with 1 T per ha production during years with moderate to high precipitation at 3-9 kg N ha^{-1} yr^{-1}. The difference in CL between desert and CSS are related to the different criteria used (diversity loss in CSS, productivity and fire risk in desert) as well as responsiveness of native vs. exotic plant species to N and the degree to which precipitation and soil N limits plant growth in the two vegetation types.

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Leaking NTN Bottles

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After weekly collections, NTN samples are decanted into 1 liter bottles and sent to the Central Analytical Laboratory (CAL). The number of NTN samples with leaks received by the CAL in 2009 was about 40% of all samples received, or about 5,100 samples. As the percentage of leaks approaches half of all NTN samples, certain concerns ensue, such as the integrity of wet boxes being shipped, sample volume to analyze and archive, and potential sample contamination.

To remedy such concerns, the NADP should take action to reduce and hopefully eliminate leaks from NTN bottles during shipping. Re-using bottles is necessary; using new bottles for each shipment is not cost-effective and is wasteful. In order to do this, we have tried sealing the bottles with parafilm, holding the lids down tighter using rubber bands, and packing the boxes with bubble wrap. After initial testing, 4 participants were sent samples, measured any leaks, emptied any leakage from the sample bag, and returned the samples to the CAL. Upon receipt we measured any leaks and analyzed the samples for contamination from leaking during shipping. The preliminary recommendation is that the NADP should supply rubber bands with sample bottles to reduce sample leaks during shipping.

Measuring Nitrogenous Air Pollutants at Upper Columbia Basin Network Parks, Idaho

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Anthropogenic nitrogen (N) emissions have been increasing in the Snake River Plains of southern Idaho due largely to agricultural sources, especially confined animal feeding operations and possibly a fertilizer factory. CMAQ (Community Multiscale Air Quality) model simulations show that the region has N deposition in excess of 10 kg ha^{-1} yr^{-1}. Several National Park Service reserves and monuments are downwind of agricultural sources of reduced N, including Craters of the Moon National Monument and Reserve (CRMO), Hagerman Fossil Beds National Monument, Minidoka National Historic Site, and City of Rocks National Reserve. Highest levels of N deposition are modeled for BLM land near the town of Shoshone, and historic high levels are known from the region around a fertilizer factory in Pocatello. These high levels of N may be impacting the diverse native vegetation in sagebrush grassland, including some 700 species at CRMO alone. There is increasing evidence that N deposition may increase the invasion of non-native cheatgrass (*Bromus tectorum*), that is now found even in isolated and undisturbed areas of CRMO. The overall objective of this project is to evaluate the effects of atmospheric N deposition on the extent of cheatgrass invasion of the sagebrush steppe ecosystems of the Upper Columbia Basin Network monuments through a combination of field measurements of N inputs in bulk deposition collectors and passive samplers (both Ogawa samplers and Radiello samplers for comparative analyses), soil/plant N concentrations and stable isotope (^{15}N) analyses, vegetation composition, and MODIS image analysis. The study is designed to provide feedback to regulatory agencies and land managers to help protect sensitive natural resources including biodiversity of sagebrush-steppe. We report on the first stage of this project, analyses from a network of passive samplers that were set up in June 2010 to determine air quality at 10 NPS, BLM, and university field sites.

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AMoN: An Initial Look at the First Two Years

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The NADP passive ammonia monitoring network (AMoN) has been operating as a pilot study for over two years. The AMoN has consistently had approximately 20 sites measuring ambient NH_3 concentrations in the United States. Each site deploys triplicate Radiello passive samplers for a two week sampling time period. Passive samplers were chosen as a low-cost, easily deployable sampler and the Radiello samplers have been shown to be reliable and accurate when compared to URG annular denuders. The two week samples provide seasonal and annual trends in NH_3 concentrations which can be used to estimate NH_3 deposition. NH_3 has not been routinely measured in the United States and AMoN data will fill another gap of the total nitrogen budget.

NADP wet deposition data has shown areas of increasing NH_4^+ deposition. While there are only 2 years of data from AMoN, increasing NH_3 concentrations will pose a problem for $PM_{2.5}$ attainment in areas that have reduced SO_2 emissions but NO_3^- is still readily available for the formation of ammonium nitrate (NH_4NO_3). We have started to look at the seasonal and regional trends in NH_3 concentrations measured at AMoN sites to highlight areas that might face challenges in meeting $PM_{2.5}$ NAAQS regulations due to higher NH_3 concentrations as a way to utilize the NH_3 concentration measurements.

Preliminary analysis of the AMoN data show that travel or field blanks generally range from 0.1 to 0.2 $\mu g\ NH_3/m^3$ for the passive samplers, which may be an issue in areas of low NH_3 concentrations. We estimated annual NH_3 deposition at 21 AMoN sites using deposition velocities calculated within the CMAQ model. Seven sites show an annual NH_3 deposition of over 4 kg-N/ha-yr , with annual concentrations generally above 3.0 $\mu g\ NH_3/m^3$. For five collocated CASTNET sites (NY67, IL11, OK99, TX43, CO13) NH_3 deposition accounted for 20% (NY67)to 60% (TX43 and CO13) of the total measured wet + dry N deposition.

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2009-2010 Measurements of Atmospheric Mercury Species at Two Sites in Atlantic Canada

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In 2009, Environment Canada began continuously measuring the levels of three gaseous Hg species – gaseous elemental mercury (GEM), gaseous oxidized mercury (GOM) and particulate bound (<2.5 µm) mercury ($PBM_{2.5}$) at two sites in Atlantic Canada. One site located on a building roof adjacent to the Halifax harbour in Nova Scotia while the second site is located at Kejimkujik National Park on Environment Canada"s CAPMoN site (NS01). At both sites, two hour sampling cycles were conducted to pre-concentrate GOM and $PBM_{2.5}$ and the GEM was measured at 5 minute intervals during these cycles. The continuous sampling and analysis of gaseous mercury species was conducted using Tekran"s 1130/1135 samplers and the 2537 analyser. This poster illustrates and discusses the nine months of GEM, GOM and $PBM_{2.5}$ data collected at both sites from October 2009 to July 2010. The Halifax data for this time period show GEM having a median of 1.62 ng m^{-3} and a range from 0.63 to 371 ng m^{-3}; GOM show a median of 1.50 pg m^{-3} with a range from detection limit (dl) to 62 pg m^{-3} and for $PBM_{2.5}$ a median of 2.10 pg m^{-3} and a range from dl to 41 pg m^{-3}. The data from Kejimkujik, show GEM having a median of 1.42 ng m^{-3} and a range of 0.42 to 2.13 ng m^{-3}; GOM a median of 0.35 pg m^{-3} with a range from the detection limit (dl) to 12 pg m^{-3} and for $PBM_{2.5}$ a median of 1.78 pg m^{-3} and a range from dl to 34 pg m^{-3}. A comparison of the mercury species data from both sites show for GEM and GOM the median values from this 9 month data set are significantly (P=<0.001) different. A significant difference between median values of $PBM_{2.5}$ for Halifax and Kejimkujik was not evident from the data. This poster will also illustrate the temporal trends observed for the gaseous Hg species from both sites during this 9 month period.

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Determination of Total Dissolved Nitrogen (TDN) in NADP/NTN Samples

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Concentrations of ammonium and nitrate, the dissolved components of nitrogen, are routinely determined in wet deposition samples analyzed by the National Atmospheric Deposition Program/Central Analytical Laboratory (NADP/CAL). To quantify the contribution of all nitrogen species, the U.S. EPA has provided funding to the NADP/CAL to analyze total dissolved nitrogen (TDN) in select NADP National Trends Network (NTN) and Atmospheric Integrated Research Monitoring Network (AIRMoN) samples collected in 2009. This data set will provide additional information on spatio-temporal patterns of nitrogen in deposition, and determine the feasibility of operating a national-scale network to measure TDN.

An intensive sample preservation study was conducted in summer 2009 to evaluate three different sampling methods: Samples were collected following standard NTN weekly collection protocols, AIRMoN daily collection protocols, and using a refrigerated collector where samples were retrieved daily. The results from the preservation study were reported at the 2009 NADP annual meeting, and indicated that TDN can be reliably measured in NADP samples, and that an organic fraction can be differentiated from the inorganic fraction. The purpose of the present study is to evaluate spatial and temporal trends in TDN, especially the organic nitrogen fraction (ON), across NTN sites.

Samples were collected during 2009 from 55 NTN sites across the continental U.S., broadly classified into five categories: Coastal, Low Elevation Inland, High Elevation Inland, and Agricultural. Existing NTN sample protocols were followed: A aliquot was filtered at the CAL, and samples were analyzed for ammonium and TDN by flow injection analysis (FIA) colorimetery and nitrate by ion chromatography (IC). The FIA and IC analyses were coordinated in time to ensure comparability of measurements. TDN measurements were also conducted on unfiltered aliquots from seven NTN sites through 2009.

A total of 2,101 NTN filtered samples were collected and analyzed in 2009. The median organic nitrogen fraction was 9.8%, with an interquartile range of 5.1 – 19.6%. The organic nitrogen fraction varied seasonally as follows: January – March, 8.3% (TDN = 0.359 mg-N/L, ON = 0.28 mg-N/L); April – June, 7.5% (TDN = 0.536 mg-N/L, ON = 0.032 mg-N/L); July – September, 10.4% (TDN = 0.523 mg-N/L, ON = 0.043 mg-N/L); and October – December, 13.4% (TDN = 0.252 mg-N/L, ON = 0.027 mg-N/L).

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Whole-watershed Mercury Balance in a Sierra Nevada Ecosystem

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Little data is available on mercury (Hg) dynamics at high-elevation mountain sites. A whole-watershed approach was used to quantify major fluxes and pools of Hg in Sagehen basin, a closed basin in the Sierra Nevada Mountains in California (NADP site CA50). Over a period spanning 9 months (January-September 2009), we estimated wet deposition inputs to the watershed at 3.8 μg m^{-2}. Dry deposition added additional Hg in the range of 0.30-2.45 μg m^{-2} during this time period, and was the dominant deposition process during summer time. Seasonal snowpack accounted for only half of the Hg deposited by wet deposition. We suggest that photo-induced reduction of Hg(II) in snow and subsequent volatilization was responsible for this loss. Thus, snowpacks in the Sierra Nevada Mountains likely reduce the effective atmospheric mercury flux via wet deposition due to significant re-emission fluxes prior to snowmelt. As such, wet Hg deposition could be of lesser importance as a Hg source in snow-dominated systems. Finally, stream runoff collected at the outlet of the watershed could account for only 6% of total Hg wet deposition suggesting that a large fraction of mercury deposition was sequestered in the ecosystems, specifically in the soils.

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Chamber Validation of Passive Ammonia Samplers

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The NADP is evaluating several passive sampler types as part of its Ammonia Monitoring Network (AMoN) special study. Three different passive sampler types were tested concurrently in an environmental chamber: Radiello (Sigma-Aldrich), Ogawa (Ogawa & Company), and Adapted Low-cost Passive High Absorption (ALPHA, United Kingdom Centre for Ecology & Hydrology). All samplers were prepared at the NADP"s Central Analytical Laboratory (CAL), and shipped together with a travel blank to the U.S. EPA"s National Risk Management Research Laboratory in RTP. After exposure, samplers were returned to the CAL, where they were extracted and analyzed.

The environmental testing chamber is a 0.035 m³ Teflon-lined Plexiglas enclosure, approximately 61 cm long by 30.5 cm wide by 19 cm high. Samplers are suspended from a grid on the chamber ceiling in a random configuration. Circulation fans are used to ensure well-mixed conditions. Test gases are supplied using standard gas cylinders with the concentrations verified using closed circuit FTIR or impingers. Empirical factors were calculated for each sampler type as the ratio of measured concentrations (calculated using the manufacturer"s supplied method) to the standard gas concentration.

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Determination of Bromide by Ion Chromatography in NADP/NTN Samples and Background Levels in Central Analytical Laboratory Weekly Blank Samples

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Bromide is released into the environment via natural and anthropogenic processes. Brominated flame retardants are used in the production of polymers because they increase the fire resistance of a wide variety of products produced from polymers. Methyl bromide is a fumigant applied before plant growth as well as post 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. Users must meet criteria set by the EPA for critical use before purchasing and applying methyl bromide. Although there are regulations in place, there is a concern about the amount of bromide present in the atmosphere.

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.

The Central Analytical Laboratory (CAL) has continued to measure bromide in blank samples, which are monitored weekly, to evaluate the cleanliness of buckets, lids, bottles and bags used to collect, transport, and contain NADP/NTN samples. Detection limits and background levels will be updated based on results obtained through 2009 and 2010. The blank data are compared to typical concentrations observed in NTN samples to evaluate the ability of the CAL to measure long-term bromide ion trends in precipitation.

Use of Passive Samplers and Surrogate Surfaces to Understand Regional Trends in Hg Concentrations and Deposition

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Newly developed passive samplers and surrogate surfaces for characterizing trends in GOM concentrations and potential dry deposition were deployed over a year (July 2009 to August 2010) at three sites in Florida. A passive sample under development for GEM was also deployed.

This project provided an opportunity to test the samplers within the realm of a large research project where atmospheric Hg concentrations and deposition were being measured by other groups. Data collected at these sites is being used to aid in establishing a statewide TMDL for mercury.

Sampling locations were on the east coast near Ft. Lauderdale- operated by Broward County Environmental Protection Department; on the west coast near Tampa-operated by the Environmental Protection Commission of Hillsborough County; and on the panhandle near Pensacola operated by ARA, Inc. as part of the SEARCH network. Site operators deployed samplers on weekly and bi-weekly steps. The samplers were shipped on a monthly schedule.

The general performance of the samplers is being evaluated and the data assessed. Regional trends in deposition and GOM concentrations were observed across the state.

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The Identification of Deposition "Hotspots," an Enhancement to the Critical Loads Approach

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Critical loads are a product of Eulerian modeling. They apply to grid cell averages. Given sufficient computer power, these grid cells can be made as small as one likes. However, weather forecasting and mesoscale meteorological experience indicates that there is a lower limit, below which increasingly fine detail does not improve the predictions. In fact, and depending on the circumstances, the consequences may be in the opposite direction. The net result is that critical loads for areas less than about 10 km^2 will be hard to defend. An alternative approach that shows considerable initial promise is to employ Lagrangian methods. Instead of using grid size averages to describe average exposure regimes, consider instead those areas most likely to be adversely affected by deposition. Such areas can be identified using existing data bases in a GIS framework. Once such "hotspots" are identified, straightforward Lagrangian methods can be used to assess the relative contributions due to potentially offending sources, such as power plants or other industrial complexes. The methods involved have been tested for the case of western Maryland – Garratt and Alleghany Counties. Maps showing expected hotspots have been constructed. A related question appears well worth consideration: Does the ability to identify such hotspots permit a new monitoring focus on those biomes most at risk?

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The Mountain Acid Deposition Program: Comparison of Sulfate and Nitrate Trends in Cloud Water versus Precipitation

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The Clean Air Status and Trends Network (CASTNET) was established by the Environmental Protection Agency (EPA) in 1991 to provide an effective monitoring and assessment network for determining the status and trends in air quality and pollutant deposition, as well as relationships among emissions, air quality, deposition, and ecological effects. The Mountain Acid Deposition Program (MADPro) was initiated in 1993 as part of the research necessary to support CASTNET"s objectives. MACTEC Engineering and Consulting, Inc. (MACTEC) operates both CASTNET and MADPro on behalf of EPA and other agencies.

MADPro"s two main objectives are to develop cloud water measurement systems to be used in a network-monitoring environment and to update the cloud water concentration and deposition data collected in the Appalachian Mountains during the National Acid Precipitation Assessment Program (NAPAP) in the 1980s. MADPro measurements were conducted from 1994 through 1999 during the warm season (May through October) at three mountaintop sampling stations. These sampling stations were located at Whiteface Mountain, NY; Clingmans Dome, TN; and Whitetop Mountain, VA. A mobile manual sampling station also was operated at two locations in the Catskill Mountains in New York during 1995, 1997, and 1998. Measurements during the 2000 and 2001 sampling seasons were collected from two sites: Whiteface Mountain, NY and Clingmans Dome, TN. Since 2001, the EPA, National Park Service (NPS) and the Tennessee Valley Authority (TVA) have exclusively operated only the Clingmans Dome, TN site while the State of New York has been operating the Whiteface Mountain, NY site.

This poster summarizes and compares sulfate and nitrate mean seasonal concentrations and deposition estimates from the MADPro Clingmans Dome site (CLD303) and the National Acid Deposition Program (NADP) Elkmont, TN site (TN11) from 2000 through 2009. There have been significant changes in the last few years in air quality in the Smoky Mountains in part because of emissions reductions enacted by TVA. This comparison assesses the seasonal patterns and recent changes in air quality by examining both the cloud and wet components of total deposition. Both concentrations in cloud water and precipitation and deposition estimates are analyzed to determine correlations between the data sets.

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Precipitation Chemistry Observed at Five Island Stations in East Asia

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The precipitation chemistry observed at five island stations in East Asia, including Gosan (126.27°E, 33.48°N, 72 m asl), Cheju Island, Korea; Cape Hedo (128.2°E, 26.8°N, 60 m asl), Okinawa, Japan; Peng-Jia Islet (122.07°E, 25.63°N, 101.7 m asl), Matsu Island (119.92°E, 26.17°N, 97.842 m asl), and Kinmen Island (118.29°E, 24.41°N, 47.88m asl), Taiwan, will be compared. Gosan, Cape Hedo and Peng-Jia Islet are considered as remote and background stations (group A), while, the other two stations are very close to China (group B). This work will elucidate the geographical distribution of chemical composition of rainwater in East Asian oceanic region, and further to assess wet deposition fluxes of sulfate and nitrate in these stations. These datasets will be also characterized based on their corresponding source regions. The daily sampling period at Gosan, Cape Hedo and Peng-Jia Islet were from January 2003 to December 2007; for Matsu Island and Kinmen Island, it was from April 2005 to December 2008. Principal ions of group A in rainwater were seasalt ions, such as Cl^- and Na^+, accounting for more than 50%, and followed by SO_4^{2-}. In group B, seasalt ions are still the principal ions in Matsu Island, followed by SO_4^{2-} (16%) and H^+ (12%), while in Kinmen Island, the principal ions were SO_4^{2-} (20%) and H^+ (16%). For all five island stations, rain events containing higher SO_4^{2-} were found to be associated with northeast monsoon and frontal systems, which are capable of transporting atmospheric pollutants to the sites via long-range transport. The stations in two groups have various chemical compositions with respect to different source regions. It was also shown the influences of long-range transport on group A, in which has very limited local emissions. Among five stations, Matsu Island had the lowest average pH of 4.5 and the highest nss-SO_4^{2-} of 63 □eq l^{-1}, and it also had the highest frequency (84%) of acid rain (which is defined as pH < 5.0). The highest average pH of 4.95 was found at Cape Hedo, which had the lowest nss-SO_4^{2-} of 38 □eq l^{-1}. The ratio of nss-SO_4^{2-} / NO_3^-, somewhat reflecting the influences of long-range transport, was of 1.66 at Gosan, 1.93 at Cape Hedo, 1.41 at Peng-Jia Islet, 1.56 at Matsu Island, and 1.96, the highest ratio at Kinmen, respectively. More detailed statistic analyses will be also presented.

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Solving National, Regional and Local Air Quality Questions Using the US Forest Service Forest Inventory Analysis/Forest Health Monitoring Program Lichen Indicator

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US Forest Service Forest Inventory Analysis (FIA) Lichen Indicator protocols and data are increasingly used to address forest health information needs across international, national, regional and local scales. At the international scale, a pilot project to evaluate air quality and climate status/ trends in Mexico City will determine whether the FIA Lichen Indicator protocol can be nationally adopted in Mexico. Additionally, the close correlation between FIA lichen community data and atmospheric nitrogen deposition, a strongly eutrophying pollutant, is supporting lower European N critical loads for forests and tundra. At the national level, the indicator is being used to set eco-region specific nitrogen critical loads across all US forested ecosystems; the continued production of gradient models is aiding this process. At regional scales, the Lichen Indicator is providing FS managers with highly systematic evidence of ecological impacts to forest biota from air pollution; map products are delineating areas of concern. At local scales, FIA methods and data are being used to map and assess agricultural air pollution in Yosemite NP, gas drilling emissions on Bridger Wilderness, cruise ship emissions in southeastern Alaska, ammonia deposition in Hells Canyon with regard to cultural resources, and to estimate nitrogen deposition in southern California.

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Finisher Hog Production in the Southeastern United States: Ancillary Measurements Derived from the National Air Emissions Monitoring Study (NAEMS)

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Measurements of emissions of gases and fine particulate matter from swine animal feeding operations (AFOs) in the southeastern US have typically been confined to relatively short periods (days to several weeks) and have generally focused on the waste lagoons. Access to swine animal housing units and other ancillary information has often been limited. The National Air Emissions Monitoring Study (NAEMS) project provided a unique opportunity to characterize emissions from swine housing units for an extended period of time (~ 2 years), and allowed access to ancillary measurements regarding nutrient flows (feed amounts and composition), manure dynamics, animal inventories, water usage and farm management. Presented here is a summary of the observations made for a NAEMS finisher site (NC3B) selected as being representative of swine production in the southeastern US. Finisher hogs are raised in rotations (~ 140 days) with a target market weight of 123 kg/hog. Among the population in a barn during a rotation (700-800 hogs) the actual growth rate varies with a series of "grade-outs" of market-weight hogs starting ~ 110 days from initial load-in. Derivation of the standing live-weight in the barns during a rotation therefore requires use of a growth model and summation over several different "populations" of hogs within a single barn. Up to 5 different feed formulations are fed during a rotation with %N content ranging from (3.4 to 2.2% N). Across 4 complete rotations, N consumed was ~50 g N per hog per day. Of this amount, we estimate ~ 70% is excreted as fecal matter and urine. The TAN (NH_3 + NH_4^+) content of the shallow pits is consistently higher (~1885 ±389.27 mg TAN L^{-1}) than that found in the anaerobic lagoon (802 ±72.78 mg TAN L^{-1}), except immediately after recharge following pit-pull (pH of the two liquids was similar). The presence of a recalcitrant layer of sludge in the shallow pits (depths ranging from 5-10 cm, total N content =) complicates attempts to construct a N mass balance for the barns, and may represent a source of N and S that elevates pit liquid content in addition to daily additions from fecal matter and urine from the hogs. The ancillary information collected during the NAEMS project will provide critical information in order to facilitate the development and test the predictions of process-based models of emissions from shallow-pit hog barns typically used on AFOs in the southeastern United States.

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Long-Term Variation in Speciated Mercury at Marine, Coastal, and Inland Sites in New England

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A comprehensive analysis was conducted using long-term continuous measurements of elemental gaseous mercury (Hg°), reactive mercury (RGM), and particulate phase mercury (Hg^P) at a coastal (Thompson Farm, denoted as TF), marine (Appledore Island, denoted as AI), and elevated inland (Pac Monadnock, denoted as PM) monitoring sites of the University of New Hampshire AIRMAP Observatory Network. Diurnal, seasonal, annual, and interannual variability in Hg°, RGM, and Hg^P from the three distinctly different environments were characterized and compared. Relationships between mercury of all forms and climate variables (e.g., temperature, wind speed, humidity, solar radiation, and precipitation) were examined. To identify source types of mercury correlations between mercury of all forms and tracers of different sources (e.g., CO, NOy, SO2, VOCs) were carefully examined for all seasons. The most pronounced diurnal, seasonal, annual variability in Hg° was found at TF and AI whereas at PM such variability was relatively dampened due to its being located in the free troposphere. It should be noted that the diurnal cycles of Hg° at TF and AI were of opposite phase in summer - daily maximum occurred in the afternoon at TF and at night on AI. This implies strong sinks of Hg° during daytime in the marine boundary layer, which is consistent with Hg° oxidation by halogen radicals in the marine environment reported previously. Annual maximum RGM levels were observed in spring at TF and AI, while most of RGM mixing ratios at PM were below the limit of detection. Mixing ratios of Hg^P at AI and TF were close in magnitude to RGM levels and were mostly below 1 ppqv, and annual maximum Hg^P mixing ratios occurred in winter and minimum in fall. Correlations between Hg°/RGM/Hg^P and climate variables were largely obscure although a tendency of higher levels of RGM and Hg^P was observed in spring and summer under sunny, dry, and warm conditions. Hg°-CO relationship was well defined for winters 2003 – 2008 at TF and changed to be rather scattered in winters 2009 and 2010. Higher levels of RGM were found together with enhancement in CO, NO_y, and SO_2 in plumes at TF and AI, whereas no similar relationships were observed for Hg^P.

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Tree Species‟ Fruit Production Respond Differently along Soil Resource Gradients in Northern Hardwood Forests

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Fruit production is critical to tree species composition, presenting one of the first bottlenecks to regeneration. Reproductive output may not only be affected by the size of the individual but also by abiotic and biotic factors. Among these factors is the soil nutrient environment, which is changed by anthropogenic nutrient addition, such as nitrogen (N) deposition, having the potential to alter reproductive output. The goal of this study is to investigate how soil nutrients, along with characteristics of individual trees and their neighbors, influence fruit production among 11 northern hardwood forest species. To examine these factors, I visually measured fruit production in the crowns of approximately 1700 trees located across a natural fertility/productivity gradient in northwest lower Michigan over two growing seasons. This method allows for a measure of fruit production on individual trees prior to fruit dispersal and predation, more closely approximating reproductive effort than seed rain or seedling density. Influences on fruit production were tested by calibrating individual-based models of fruit production as functions of tree size, neighborhood crowding, local conspecific dominance, and soil resource availability (N, base cations, and phosphorus). The smallest diameter at which fruit production occurred varied by species, ranging from 10.2 cm in *Acer rubrum* to 28.6 cm in *Fraxinus americana*, but was not related to species shade tolerance or soil fertility association. For the seven species with substantial reproductive activity, diameter was a significant predictor of individual two-year fruit production, with the relationship being strongest in *Fagus grandifolia*. However, a great deal of the variation in fruit production remained unexplained, and many individuals did not reach the production level that would be predicted by diameter. In *Quercus rubra* and *Q. velutina*, which were treated together since they naturally hybridize, conspecific relative basal area, soil nitrate, N mineralization rate, and soil ammonium were positively correlated with fruit production, suggesting that pollination efficiency and N soil resources are important for reproduction. In four other species fruit production was weakly correlated with at least one soil resource, but no species were correlated with neighborhood density (the number of trees within 5 m of each individual). These results demonstrate that soil resources, especially N, are more strongly associated with fruit production in certain tree species. Because species have different fruit production responses across a soil fertility gradient, changing nutrient levels due to N deposition may cause different responses among species, potentially altering forest community composition.

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Feasibility Analysis of Certifying Ozone Generators as Level 4 Transfer Standards

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During 2009 and 2010, MACTEC investigated the feasibility of certifying a Thermo Scientific 49i ozone analyzer‟s internal ozone generator as an onsite Level 4 Transfer Standard as described in 40 CFR Part 58 by correlating generator lamp voltage to output concentration. The primary advantage of this design includes deployment of a single monitor including both the certified generator and the site photometer, allowing lower up front deployment costs. Each generator was certified by running a six point audit against a certified Level 3 ozone detector on six different days within a two week period and periodic re-certification audits at least semi-annually once installed in a field location. This study examined two methods for operating the ozone generators and results from a field evaluation. The first method used a pressure regulator and a critical orifice to control air flow through the generation chamber. This method was found to have a direct dependence on the ambient atmospheric pressure and could only be considered at sites with similar altitude to the original certification location. The second method utilized a pressure regulator and critical orifice to control the mass flow rate and a flow controller to control the volumetric flow rate of the air leaving the generation chamber. By doing so, both the initial oxygen mass concentration and residence time in the generation chamber could be controlled. This method did not depend on atmospheric pressure and could be evaluated for use at any location. Both methods were ultimately limited by the overall stability of the ozone generator‟s ultraviolet lamp over long periods of field deployment and were shown to be less stable than using a separate certified ozone detector as the onsite transfer standard.

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Critical Loads Map of Atmospheric Nitrogen in the Rocky Mountains, USA

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Critical loads are the amount of deposition of a given pollutant that an ecosystem can receive below which ecological effects are thought not to occur. In this study, maps are being created for high-elevation areas in the Rocky Mountains showing (a) current atmospheric deposition rates of nitrogen (N), (b) critical loads of N, and (c) exceedances of critical loads of N. Deposition maps were developed at 400m resolution using gridded precipitation data and spatially interpolated chemical concentrations in snow and rain. Critical loads maps are being created based on chemical thresholds corresponding to observed ecological effects, and estimated ecosystem sensitivities calculated from basin characteristics.

Diatom species assemblages are being used as an indicator of ecosystem health to establish critical loads of N. Chemical thresholds (concentrations) will be identified for surface waters by using a combination of in-situ growth experiments and observed spatial patterns in surface-water chemistry and diatom species assemblages across a nitrogen deposition gradient.

Ecosystem sensitivity was estimated using a multiple-linear regression approach in which observed surface water nitrate concentrations at 530 sites were regressed against estimates of inorganic N deposition and basin characteristics (topography, soil type and amount, bedrock geology) to develop predictive models of surface water chemistry. Modeling results ($r^2 = 0.5$, $p < 0.01$) indicated that the significant explanatory variables included percent slope, soil permeability, and vegetation type (including barren land, shrub, and grassland) and were used to predict high-elevation surface water nitrate concentrations across the Rocky Mountains.

Chemical threshold concentrations will be substituted into an inverted form of the model equations and applied to estimate critical loads for each stream reach within a basin, from which critical loads maps will be created. Deposition maps will be overlaid on the critical loads maps to identify areas where critical loads are being exceeded, or where they may do so in the future.

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Surface Water Quality Trends from the TIME/LTM Programs

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Surface water chemistry provides direct indicators of the potential effects of anthropogenic impacts, such as acidic deposition and climate change, on the overall health of aquatic ecosystems. Long-term surface water monitoring networks provide a host of environmental data that can be used, in conjunction with other networks, to assess how water bodies respond to stressors and if they are potentially at risk (e.g., receiving pollutant deposition beyond its critical load). Two EPA-administered monitoring programs provide information on the effects of acidic deposition on headwater aquatic systems: the Temporally Integrated Monitoring of Ecosystems (TIME) program and the Long-Term Monitoring (LTM) program. These programs were designed to track the effectiveness of the 1990 Clean Air Act Amendments (CAAA) in reducing the acidity of surface waters in: New England, the Adirondack Mountains, the Northern Appalachian Plateau, and the Ridge and Blue Ridge Provinces. LTM water quality trends from 1990 to 2008 indicate significant decreasing concentrations of sulfate in most monitored sites in the Northern Appalachian Plateau, Adirondack Mountains, and New England regions, but in only 21% of streams monitored in the Ridge and Blue Ridge Provinces. Most sites exhibited constant or only slightly declining nitrate concentrations over the same time period. Acid Neutralizing Capacity (ANC) levels improved at over 50% of sites in the Adirondacks and Northern Appalachian Plateau, but few sites showed increases in New England and the Ridge and Blue Ridge Provinces. The ANC of northeastern U.S. TIME lakes was also evaluated from 1991 to 1994 and 2006 to 2008. The percentage of lakes with ANC values below 50 µeg/L, lakes of acute or elevated concern, dropped by about 7%. Critical loads were calculated for TIME lakes in the Adirondack Mountains and TIME streams in the Ridge and Blue Ridge Provinces. For the period from 1989 to 1991, before implementation of the CAAA, 45% of lakes and 41% of these streams received levels of combined sulfur and nitrogen deposition that exceeded the critical load. For the 2006 to 2008 period, 30% of lakes and 31% of streams were in exceedance. Information from long-term monitoring has shown that emission reductions have resulted in improved environmental conditions and increased ecosystem protection. However, despite some ecological recovery, lakes and streams in these regions remain at risk due to current acid deposition levels. The TIME/LTM programs, along with other monitoring networks, will continue to monitor surface water trends for effects of acid deposition and other anthropogenic impacts.

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Quantifying Spatial and Temporal Variability in Atmospheric Ammonia with In Situ and Space-Based Observations

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Ammonia plays an important role in many biogeochemical processes, yet atmospheric mixing ratios are not well known. The emissions sources are uncertain and it is difficult to measure NH_3 in situ. Recently, methods have been developed for retrieving NH_3 from space-based observations, yet they have not been compared to in situ measurements. We have conducted a field campaign including co-located surface measurements and satellite special observations from the Tropospheric Emission Spectrometer (TES). Our study includes 25 surface monitoring sites spanning 350 km across eastern North Carolina, a region with large seasonal and spatial variability in NH_3 sources and sinks. From the TES spectra, we retrieve a NH_3 representative volume mixing ratio (RVMR), and we restrict our analysis to times when the region of the atmosphere observed by TES is representative of the surface measurement. After refining the retrieval, we find that that the TES NH_3 RVMR captures the seasonal and spatial variability found in eastern North Carolina. Both surface measurements and TES NH_3 show a strong correspondence with the number of livestock facilities within 10 km of the observation. Furthermore, we find that TES NH_3 RVMR captures the month-to-month variability present in the surface observations. The high correspondence with in situ measurements and vast spatial coverage make TES NH_3 RVMR a valuable tool for understanding regional and global NH_3 fluxes.

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Going Green at Bondville Environmental and Atmospheric Research Site (BEARS)

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In April 2010, the AIRMoN, NTN, & MDN collectors as well as the OTT Pluvio electronic raingage at NADP site IL11 (Bondville) went off the grid. An Air X 400 Watt wind turbine on a 10 meter tower was installed with the help of Midstate Renewable Energy Services. Along with a battery bank of four, 6 Volt Deep Cycle Trojan 105 batteries, the system has performed for three months without a failure. In fact, the renewable energy source may prove to be more reliable than the local utility. A solar panel will be added in summer 2010 to create a hybrid power system. The installation was a learning process and helped to provide invaluable experience that can be shared with other NADP sites interested in going green. This poster will show photos of the installation process, a breakdown of materials and labor, as well as a record of the voltages both before and after leaving the grid.

The Ammonia CASTNET CSN Study (ACCS) – Overview and Test Phase Results

Christopher Rogers[1], Kevin Mishoe[2], Michael Smith[2], Marcus Stewart[2] and H. Kemp Howell[2]

The primary purpose of the Ammonia CASTNET CSN Study (ACCS) is to conduct a reactive nitrogen (Nr) inter-comparison study at five CASTNET sites for one year. Currently, the traditional CASTNET 3-stage filter pack captures particulate ammonium (NH_4^+) and nitrate (NO_3^-) on the first (Teflon) filter. The goals of the ACCS are to:

1. Assess the precision, accuracy, and bias of passive ammonia samplers,
2. Test a traditional CASTNET filter pack with an additional fourth stage filter impregnated with phosphorus acid (H_3PO_3) to collect atmospheric NH_3 and any volatilized NH_4^+,
3. Characterize Met One SuperSASS mini-parallel plate denuders for NH_3 collection, and
4. Compare Met One SuperSASS ion module species collection with traditional CASTNET 3-stage filter pack species collection.

Duplicate annular denuder systems (ADS) will be used as the reference method. Site selection was based on proximity to predicted or known ammonia emissions sources, site operator capability, and collocation with the National Atmospheric Deposition Program (NADP) Ammonia Monitoring Network (AMoN). Current AMoN sites are measuring NH_3 concentrations at a 2-week interval as an average of results obtained from triplicate Radiello passive samplers. Other sampling types will be run for two 1-week periods every six weeks.

Prior to the start of field sampling on August 31, several test studies were conducted at the Gainesville, FL MACTEC facility. Two problems were encountered during testing. First, the initial ADS design featured a nylon filter for the collection of particles, which proved to be inadequate as there was evidence of particle breakthrough. A Teflon filter was added to the ADS for the collection of particles, and results improved. The second problem involved the 4-stage filter pack. Expected results were not obtained. No NH_3 was collected by the H_3PO_3 impregnated filter. It appears that in high humidity environments use of a 4-stage filter pack is not viable. The NH_3 may react with SO_2 collected by a hydrated potassium-carbonate (K_2CO_3) impregnated filter prior to encountering the H_3PO_3 impregnated filter. Because of this issue, 4-stage CASTNET-style filter packs will not be included during the first several ACCS sampling periods. Additional testing of other configurations will be performed, and it is hoped that a modified CASTNET filter pack will join the study by its midpoint.

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Linking Air Emissions and Water Quality: Mercury TMDLs in Maryland

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All of the fresh water impoundments in Maryland are under fish consumption advisories for mercury. As a consequence of this fish burden these impoundments are subject to remediation actions under the Clean Water Act Total Maximum Daily Load [TMDL] requirements. All of the mercury inputs into these systems are atmospherically derived and consequently developing a TMDL program to address this problem requires an understanding of the emissions sources and their contribution to loading in the affected water bodies. The State has developed a mercury deposition modeling system[1] and this poster will discuss its application in the development of the mercury TMDL programs. The modeling system has a Lagrangian formulation and so allows a categorical source-receptor relationship to be established for each of the air emission sources in the airshed and the receptor water bodies in the State.

1 Sherwell, J., M. Garrison, A. Yegnan, A. Baines. 2006. Application of the CALPUFF Modeling System for Mercury Assessments in Maryland. In Proceedings 99th Annual Meeting of the Air and Waste Management Association, Paper No. 429, Air and Waste Management Association, Pittsburgh, PA.

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Wet Deposition Monitoring Network of Mercury in Taiwan

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Taiwan is located in the downwind region of the East Asian continent, which is the largest anthropogenic mercury (Hg) source region globally. Modeling simulations suggested that Taiwan could receive high Hg input via wet deposition. Therefore, a national Hg wet deposition monitoring network, consisting of 12 sampling sites, was established along with the existing acid deposition monitoring network to collect rainwater for total Hg analysis since 2009. The objective of this network is to build a national database of total Hg concentration in precipitation and the associated wet depositional fluxes. The data will later be used to develop information on spatial and seasonal trends in Hg wet deposition and to evaluate the contribution of regional/long-range transport. Weekly rainwater samples were collected using automated wet-only precipitation collection systems. Acid-cleaned glass funnels were used for rainwater collections and samples were collected into acid-cleaned 1L Teflon bottles. Samples were retrieved and sampling trains were changed every Tuesday morning. Total Hg was quantified by dual amalgamation CVAFS after BrCl oxidation, NH_2OH•HCl neutralization, and $SnCl_2$ reduction. Total Hg concentrations of all the rainwater samples ranged from 2.1 to 82.2 ng L^{-1} in 2009. The volume-weighted mean (VWM) total Hg concentrations of all the sampling sites ranged between 7.6 and 17.2 ng L^{-1}, comparable to the 2008 values (2.1-18.7 ng L^{-1}) reported by NADP/MDN. Eight of the 12 sampling sites had VWM Hg concentrations higher than 10 ng L^{-1}. In general, rainwater Hg concentrations were lower in northern Taiwan sites, likely due to the dilution effect caused by higher rainfall amount. Annual wet depositional Hg fluxes ranged between 12.3 and 37.0 μg m^{-2} in 2009, somewhat higher than the 2008 MDN values (1.9-25.0 μg m^{-2}). Higher wet depositional Hg fluxes were observed in northern Taiwan sites. The geographical distribution of wet depositional Hg flux mimicked the distribution of accumulative rainfall amount, indicating precipitation depth is the primary factor in determining the magnitude of the wet depositional Hg flux.

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Analysis of the Physiological Effects of Ozone and Nitric Acid on Two Cultivars of Tobacco and Snapbean with Differing Sensitivities to Ozone

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Damage done to plants due to air pollution deposition decreases overall productivity and reduces the profitability and sustainability of crops near urban centers. Increasing population and urbanization in areas surrounding agriculture makes an understanding of possible pollutant effects increasingly important. Physiological effects of two photochemical pollutants, ozone (O_3) and nitric acid (HNO_3), were examined on *Phaseolus vulgaris* (snapbean) and *Nicotiana tobaccum* (tobacco), crops with cultivars known to differ in sensitivity to O_3. Measurements based on photosynthetic gas exchange, including, photosynthetic CO_2 assimilation (A), stomatal conductance to water vapor (g_s) and mesophyll conductance of CO_2 (g_m), were used to determine the extent of the damage to plants under fumigation. Fluorescence effects were also measured using quantum yield (F_v/F_m). This study brought to light several important factors related to plant biology and pollution deposition. Cultivar and species differences were noted, especially when comparing A_{max} and F_v/F_m. In agreement with other studies, O_3 was shown to reduce biomass, g_s, and A_{max}. In contrast to O_3, the physiological effects of HNO_3 were previously unknown. This study demonstrated that HNO_3 exposure increased g_m, whereas g_s and A_{max} were not affected. Increased g_m in response to HNO_3 exposure may be tied to other physiological processes that depend on conductance of CO_2 through the mesophyll, such as photosynthetic gas exchange and Rubisco activity.

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Assessment of Particulate Mercury Measured with the Tekran System

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A seasonal study was conducted to ascertain cycling of speciated atmospheric mercury in the marine and continental atmospheric boundary layers. A component of this work focused on assessing the accuracy of the automated Tekran system for measuring Hg^P. Our results suggest that the filter-based Hg^P has minimal positive artifact from uptake of RGM during sampling. In coastal New Hampshire, where RGM is at its highest mixing ratios in springtime, periodic artifact from RGM uptake could occur. However, comparison of the Tekran and filter Hg^P values during a period of elevated RGM showed no difference in the measured mixing ratios suggesting that the artifact is essentially immeasurable. The largest discrepancy in measured mixing ratios of filter and Tekran Hg^P always were associated with the highest levels of filter Hg^P. Peaks in filter Hg^P occurred in all seasons and there was corresponding enhancements in selected hydrocarbons, halocarbons, and oxygenated compounds. Most of these cases also had enrichments in HCN and CH_3CN, indicative of a biomass burning contribution. Since there were no reported wildfires in the backward trajectory determined source regions, we concluded that in winter this must include contributions from regional wood stove and fireplace emissions. In other seasons a variety of anthropogenic sources may be involved, including vehicle emissions, coal combustion, and other combustion types. Almost every peak in filter Hg^P showed a potential biomass contribution as indicated by tracer compounds. In comparison, the Tekran exhibited little response to these events. Furthermore, we found no consistent disparity in the two methods caused by aerosol size distribution factors. In summer and winter the Tekran yielded minimal correlation with the filter measurements. In springtime they tracked each other much more closely, with the Tekran still providing lower mixing ratios. We conclude that until the discrepancies are understood better between the filter and Tekran methodologies, the filterbase Hg^P may provide more accurate measurement of Hg^P for research applications in chemical cycling studies.

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Comparison of precipitation-depth measurements for Belfort Model 5-780, ETI Noah-IV, and OTT Pluvio-N rain gages for the National Atmospheric Deposition Program

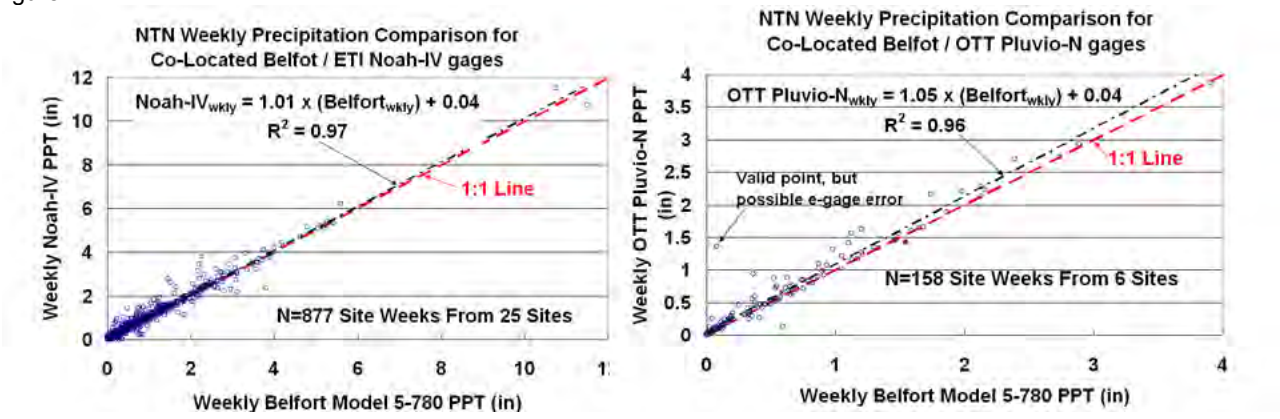
Gregory A. Wetherbee[1], Mark F. Rhodes[2] and RoseAnn Martin[1]

Precipitation-depth data were obtained by co-located mechanical Belfort Model 5-780[a] (Belfort) and electronic ETI Noah-IV[a] and OTT Pluvio-N[a] (e-gage) precipitation gages at National Atmospheric Deposition Program (NADP)/National Trends Network (NTN) sites. At present, approximately 50 percent of the NADP Belfort precipitation rain gages have been retrofit with e-gages. Quantification of potential bias in e-gage records is crucial for accurate reporting of atmospheric wet deposition.

Data were available for 25 Belfort gages co-located with ETI Noah-IV gages and 6 Belfort gages co-located with OTT Pluvio-N gages during the study period January 1, 2007 to May 12, 2010. The available record for each site varied between 24 to 605 days where both co-located gages provided valid data. Electronic files containing the e-gage records are submitted to the NADP Program Office (PO), where they are verified. For this study, daily precipitation depth obtained from the Belfort charts was compared to corrected e-gage records obtained from the PO.

Weekly sums of the daily data for each site are compared in scatter plots in Figure 1. Slopes for the regression equations comparing data from the gages indicate that weekly Noah-IV precipitation-depths are approximately 1 percent higher than the Belfort depths, and weekly OTT Pluvio-N depths are approximately 5 percent higher than the Belfort depths. Median weekly percent differences are 4.2 percent for the Noah-IV gage and 13 percent for the OTT Pluvio-N gage. Estimated median percent differences for the period of record for each site ranged from -20 percent to 10 percent. Additional work is needed to develop algorithms and/or correction factors for adjustment of historic Belfort gage records to account for any artificial shifts in precipitation-depth and atmospheric deposition trends resulting from NADP e-gage retrofits.

Figure1.



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[a]Use of trade or firm names is for identification purposes only and does imply endorsement by the U.S. government.

Establishing a Collaborative and Multipurpose Long Term National Reference Site Network for Freshwater Streams in the United States

Bill Wilber, Jeff Deacon, Peter Murdoch, Mark Nilles and Mike Norris
U.S. Geological Survey

The U.S. Geological Survey is developing a plan for a collaborative and multi-purpose long-term national reference site network for freshwater streams in the United States to address increasing needs for information on the status and trends in streamflow and water quality of relatively unimpaired watersheds. An organizational structure similar to that of the National Atmospheric Deposition Program would help facilitate interagency collaboration to develop and encourage use of nationally-consistent field and laboratory protocols, procedures for quality assurance and quality control, and data management. A three tiered network design would consist of: 1) 75 to 100 minimally impaired watersheds geographically distributed across Level 2 ecoregions where real-time monitoring of hydrologic, climatic, and landscape variables would occur; 2) periodic synoptic sampling of a larger number of sites to provide higher spatial resolution of stream conditions; and 3) remote sensing and modeling to assist with extrapolation and forecasting. One approach for evaluating a network design involves characterizing the natural setting and anthropogenic disturbances of pre-designated “reference” basins relative to all Hydrologic Unit Code 10 basins within a Level 2 ecoregion. This will allow for placing existing and candidate reference basins in a larger environmental context and provide a mechanism for individual scientists and agencies to evaluate the suitability of different sites for achieving mission-specific goals. Initially this effort will include: an inventory of existing sites and data used by different agencies to characterize reference conditions and an analysis of existing and discontinued monitoring sites to determine where new sampling may be effective for enhancing a national reference site network. Data from this network will quantify reference conditions for a broad suite of chemical and ecological attributes that respond to anthropogenic and climate-related effects on water quality at watershed, regional, and national scales. For example, network data would be used in quantifying long-term trends for select constituents on a regional and national basis; establishing background concentrations for select constituents to guide the establishment of water-quality criteria; providing a benchmark for understanding environmental stressors on aquatic communities; quantifying episodic events with sufficient sampling frequency; and providing access to data for reference water-quality conditions. Increased collaboration among Federal and State agencies is a key mechanism for the success and support of a national reference site network that ultimately serves multiple agency objectives and program goals.

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Investigation of Mercury Deposition and Sources of Mercury Input to Four Western National Parks and One California State Park

Genine Wright[1], Mae Gustin[1] and Peter Weiss-Penzias[2]

A recent project, the Western Airborne Contaminants Assessment Project (WACAP) showed that fish in eight parks of the western U.S. had mercury concentrations that exceeded the threshold for fish eating wildlife (www.nature.nps.gov/air/Studies/air_toxics/wacap.cfm). These observations led to the development of this study focused on investigating air mercury concentrations and potential for dry deposition using newly developed passive samplers and surrogate surfaces. Samples will be collected simultaneously along a transect from the coast of California to the eastern edge of Nevada. Sampling locations are located within the Point Reyes, Yosemite, Sequoia and Great Basin National Park units and at Lick Observatory on Mt. Hamilton, CA. Dry deposition using surrogate surfaces and air Hg speciation are also being measured at Elkhorn Slough.

Investigation of elevational gradients in air concentrations and deposition within select parks during sampling intensives will allow us to better understand the sources of Hg to park ecosystems. Recent work suggests that RGM may be formed in the free troposphere from elemental Hg in the global pool. This Hg would be more available at higher elevation sites.

To better understand changes in atmospheric deposition and air concentrations over time and the potential relationship to current and future climate, Hg concentrations in tree rings will be measured. We will also link our work with sediment core data collected in the past and to better understand potential ecosystem inputs and potential for changing deposition. Modeling with HYSPLIT back trajectories will be done to investigate air masses impacting areas during the weeks of sampling.

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Passive Sampling of Ammonia in Ontario (2007–2010)

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Elevated emissions of atmospheric reactive nitrogen (Nr) have lead to concerns that Nr deposition may result in long-term negative impacts on natural ecosystems e.g., acidification, eutrophication and decreased biodiversity. Atmospheric ammonia (NH_3), is the dominant Nr species emitted in agricultural regions, moreover recent studies have shown significant emissions in urban centres owing to emissions from vehicle exhaust. Atmospheric concentrations of NH_3 are highly variable, both spatially and temporally, owing to its high deposition velocity. Continuous observations of NH_3 are limited, within Ontario there is only one station with ongoing NH_3 monitoring: Centre for Atmospheric Research Experiments (CARE) Environment Canada. Passive samplers have been widely used to capture the spatial variability as they provide a low cost method requiring no power and can be deployed across many sites. In the current study, ambient NH_3 concentrations have been monitored across southern Ontario in regions of intensive agricultural activity, rural background regions and more recently in the urban centre of Toronto using the Willems badge passive sampler. Since August 2007, the samplers have been exposed in triplicate at two week intervals, at approximately 40 sites (continuous at 2: CARE and Dorset). The Willems badge has been evaluated against other passive samplers (Gradko, Radiello® and Ogawa) and shown significant correlation with a modified Thermo 42C trace level chemiluminescence based analyzer (R^2 = 0.86) and an active denuder system (R^2 = 0.71). Ammonia concentrations varied spatially across southern Ontario and temporally throughout the year peaking in the spring in agricultural regions and the summer in urban and background regions; concentrations were the lowest in the winter. At CARE (low intensity agriculture) and Dorset (background), annual average NH_3 concentrations ranged between 0.10 – 4.12 μg m^{-3} and 0.00 – 0.54 μg m^{-3} respectively during 2007 to 2009. The largest range in NH_3 concentrations was observed in intensive agricultural regions with a low of 0.38 μg m^{-3} (February 2008) and peaking at 18.98 μg m^{-3} (May 2008). Ammonia concentrations in Toronto ranged from 1.55 – 4.65 μg m^{-3} (winter – summer, 2010).

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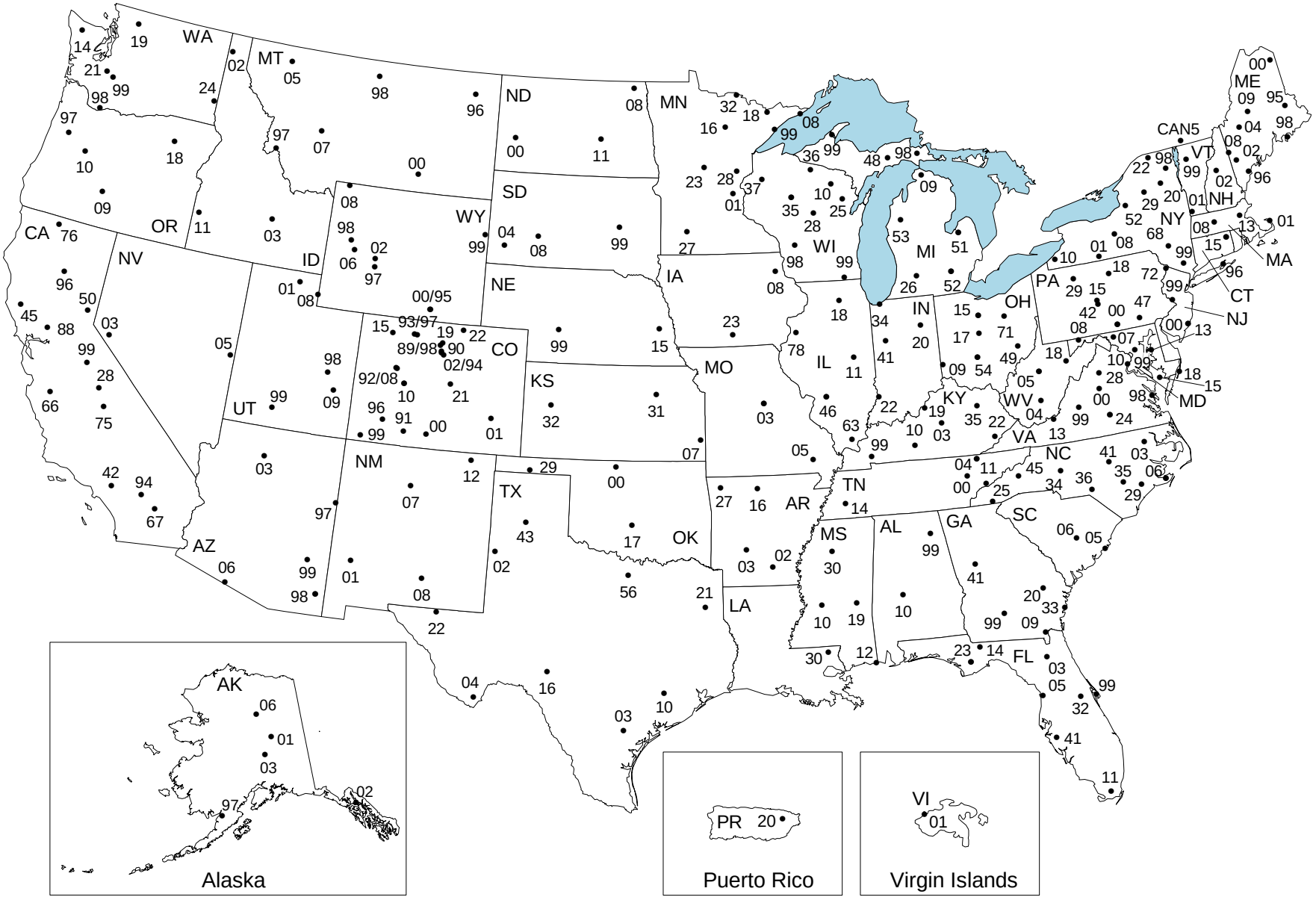
NTN MAP AND SITE LISTINGS

National Atmospheric Deposition Program
National Trends Network



National Atmospheric Deposition Program/National Trends Network Sites

July 31, 2010

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Alabama				
AL10	Black Belt Research & Extension Center		US Geological Survey	08/83
AL99	Sand Mountain Research & Extension Center		Tennessee Valley Authority	10/84
Alaska				
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		US Environmental Protection Agency-CAMD	02/99
AZ99	Oliver Knoll		US Geological Survey	08/81
Arkansas				
AR02	Warren 2WSW		US Geological Survey	05/82
AR03	Caddo Valley		US Geological Survey	12/83
AR16	Buffalo NR - Buffalo Point		National Park Service - Air Resources Division	07/82
AR27	Fayetteville		US Geological Survey	04/80
California				
CA28	Kings River Experimental Watershed		USDA Forest Service/Pacific Southwest Research Station	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		National Park Service - Air Resources Division	09/00
CA75	Sequoia NP - Giant Forest	MDN	National Park Service - Air Resources Division	07/80

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
CA76	Montague		US Geological Survey	06/85
CA88	Davis		US Geological Survey	09/78
CA94	Converse Flats	MDN	Big Bear Municipal Water District/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
Colorado				
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 CO	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
CO90	Niwot Ridge-Southeast		NSF-Institute of Arctic & Alpine Research/University of CO	01/06
CO89	Rocky Mountain National Park-Loch Vail		National Park Service-Rocky Mountain National Park	09/09
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		USGS/Colorado State University	08/83
CO99	Mesa Verde NP - Chapin Mesa	MDN	US Geological Survey	04/81
Connecticut				
CT15	Abington		US Environmental Protection Agency-CAMD	01/99
Florida				
FL03	Bradford Forest		St John's River Water Management District	10/78
FL05	Chassahowitzka NWR	MDN	US Fish & Wildlife Service - Air Quality Branch	08/96
FL11	Everglades NP - Research Center	MDN	National Park Service - Air Resources Division	06/80
FL14	Quincy		US Geological Survey	03/84

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
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		SAES-University of Georgia	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	National Park Service - Air Resources Division	08/80
ID11	Reynolds Creek		US Geological Survey	11/83
Illinois				
IL11	Bondville	AIRMoN/MDN	US Environmental Protection Agency-CAMD	02/79
IL18	Shabbona		SAES-University of Illinois	05/81
IL46	Alhambra		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
IN22	Southwest-Purdue Agricultural Center		US Geological Survey	09/84
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	Farlington Fish Hatchery		US Geological Survey	03/84
KS31	Konza Prairie		SAES-Kansas State University	08/82
KS32	Lake Scott State Park	MDN	US Geological Survey	03/84

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Kentucky				
KY03	Mackville		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	Maine Department of Environmental Protection	04/80
ME02	Bridgton	MDN	EPA/Maine Dept of Environmental Protection	09/80
ME04	Carrabassett Valley	MDN	US Environmental Protection Agency-CAMD	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
Maryland				
MD07	Catoctin Mountain Park		National Park Service - Air Resources Division	05/03
MD08	Piney Reservoir	MDN/AMNet	MD DNR/University of Maryland-Appalachian Lab	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	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
MA13	East		Northeast States for Coordinated Air Use Management	02/82
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

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
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
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	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	Coffeeville		Tennessee Valley Authority	07/84
Missouri				
MO03	Ashland Wildlife Area	MDN	US Geological Survey	10/81
MO05	University Forest		US Geological Survey	10/81
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

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Nebraska				
NE15	Mead	MDN	SAES-University of Nebraska	07/78
NE99	North Platte Agricultural Experiment Station	MDN	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
New Mexico				
NM01	Gila Cliff Dwellings NM		New Mexico Environment Department - AQB	07/85
NM07	Bandelier NM		DOE-Los Alamos National Lab/National Park Service	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 & Forestry	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 Program	11/03
NY98	Whiteface Mountain		US Geological Survey	07/84
NY99	West Point	MDN	US Geological Survey	09/83

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
North Carolina				
NC03	Lewiston		North Carolina State University	10/78
NC06	Beaufort		US Environmental Protection Agency-CAMD	01/99
NC25	Coweeta		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
OH15	Lykens		US Environmental Protection Agency-CAMD	01/99
OH17	Delaware		USDA Forest Service	10/78
OH49	Caldwell		US Geological Survey	09/78
OH54	Deer Creek State Park		US Environmental Protection Agency-CAMD	01/99
OH71	Wooster		US Geological Survey	09/78
Oklahoma				
OK00	Salt Plains NWR		US Geological Survey	12/83
OK17	Great Plains Apiaries		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	MDN	USDA Forest Service	05/80
OR18	Starkey Experimental Forest		US Geological Survey	03/84
OR97	Hyslop Farm		US Environmental Protection Agency-CAMD	04/83

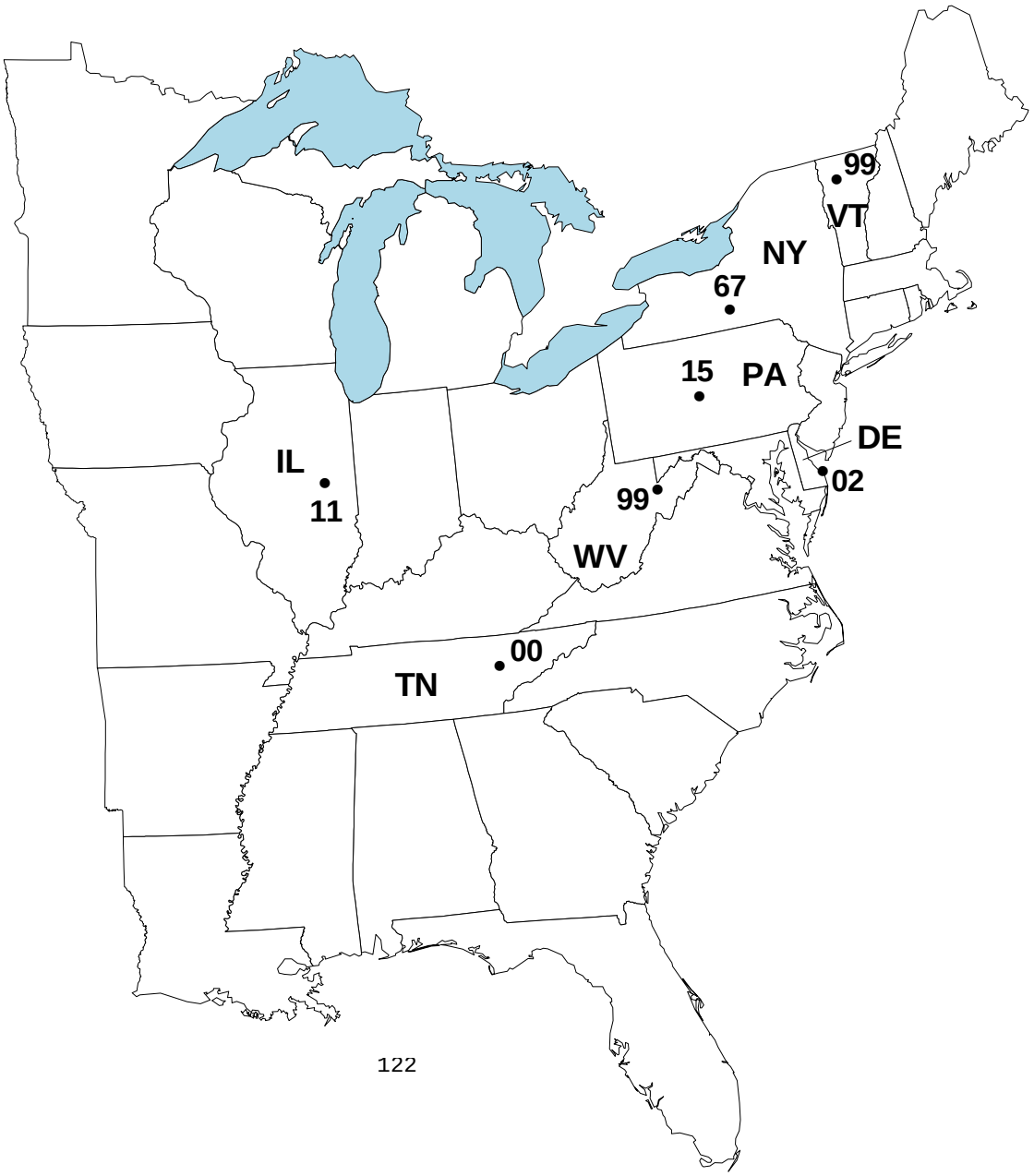
State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Pennsylvania				
PA00	Arendtsville	MDN	US Environmental Protection Agency-CAMD	01/99
PA15	Penn State	AIRMoN	NOAA-Air Resources Lab/Pennsylvania Game Commission	06/83
PA18	Young Woman's Creek		US Geological Survey	04/99
PA29	Kane Experimental Forest	MDN	USDA Forest Service	07/78
PA42	Leading Ridge	MDN	SAES-Pennsylvania State University	04/79
PA47	Millersville	MDN	Pennsylvania Department of Environmental Protection/PSU	11/02
PA72	Milford	MDN	USDA Forest Service	12/83
Puerto Rico				
PR20	El Verde		USDA Forest Service	02/85
South Carolina				
SC05	Cape Romain NWR	MDN	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
TX43	Cañónceta		Texas A&M University/Texas Agrilife Research	07/07
TX56	LBJ National Grasslands		US Geological Survey	09/83

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
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	AIR/MDN/AMN	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		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
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		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		USDA Forest Service	07/78

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Wisconsin				
WI09	Popple River	MDN	Wisconsin Department of Natural Resources	12/86
WI10	Potawatomi		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
WI35	Perkinstown		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

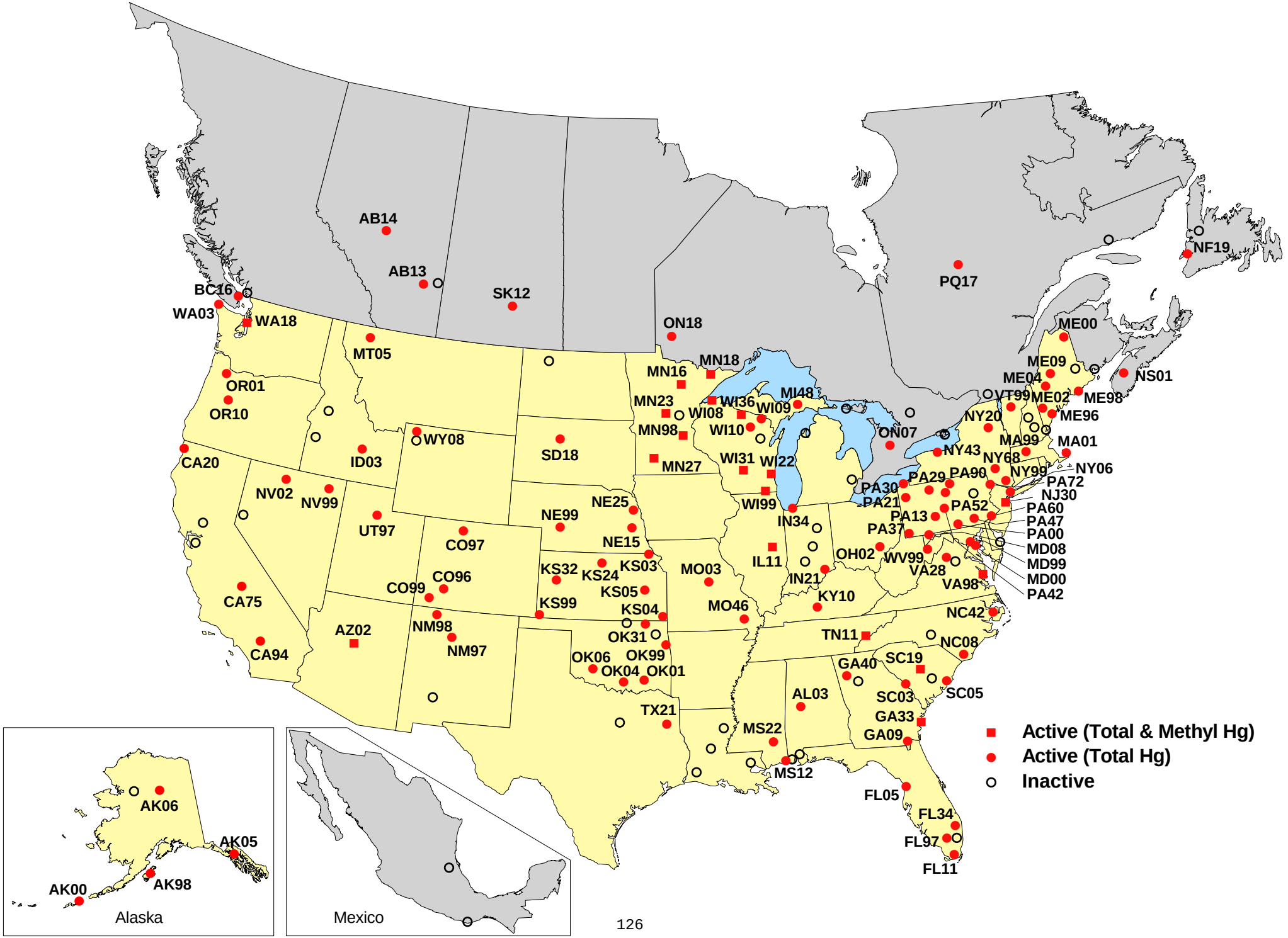
National Atmospheric Deposition Program
Atmospheric Integrated Research Monitoring Network



National Atmospheric Deposition Program/Atmospheric Integrated Research Monitoring Network Sites
July 31, 2010

State Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Delaware				
DE02	Lewes		NOAA-Air Resources Laboratory	09/92
Illinois				
IL11	Bondville	MDN & NTN	NOAA-Air Resources Laboratory	10/92
New York				
NY67	Cornell University		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	NOAA-Air Resources Laboratory	01/93
West Virginia				
WV99	Canaan Valley Institute		NOAA-Air Resources Laboratory	06/00

MDN MAP AND SITE LISTINGS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AB13
SK12
BC16
WA03
WA18
ON18
PQ17
NF19
MT05
MN18
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FL97
FL11
AK06
AK05
AK00
AK98
Alaska
Mexico
Active (Total & Methyl Hg)
Active (Total Hg)
Inactive

National Atmospheric Deposition Program/Mercury Deposition Network Sites
July 31, 2010

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Alabama				
AL03	Centreville		Southern Company/Atmospheric Research and Analysis, Inc	06/00
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	Big Bear Municipal Water District/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
Florida				
FL05	Chassahowitzka NWR	NTN	US Fish & Wildlife Service - Chassahowitzka NWR	07/97
FL11	Everglades NP - Research Center	NTN	South Florida Water Management District/Florida DEP	03/96
FL34	Everglades Nutrient Removal Project		South Florida Water Management District/Florida DEP	07/97
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 NERR	07/07
GA40	Yorkville		Southern Company/Atmospheric Research and Analysis, Inc	06/00
Idaho				
ID03	Craters of the Moon NM	NTN	Idaho Department of Environmental Quality	10/06
Illinois				
IL11	Bondville	AIRMoN/NTN	Illinois State Water Survey/NADP	01/99

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Indiana				
IN21	Clifty Falls State Park		Indiana Department of Environmental Management/USGS	01/01
IN34	Indiana Dunes NL	NTN	Indiana Department of Environmental Management/NPS	10/00
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/EPA	06/97
ME04	Carrabassett Valley	NTN	Penobscot Indian Nation	02/09
ME09	Greenville Station	NTN	Maine Department of Environmental Protection/EPA	09/96
ME96	Casco Bay - Wolfe's Neck Farm	NTN	Maine Department of Environmental Protection/EPA	01/98
ME98	Acadia NP - McFarland Hill	NTN	Maine Dept of Environmental Protection/NPS-Acadia NP/EPA	03/96
Maryland				
MD00	Smithsonian Environmental Res Ctr		MD DNR/Smithsonian Environmental Research Center	12/06
MD08	Piney Reservoir	NTN /AMNet	MD DNR/University of Maryland-Appalachian Lab	06/04
MD99	Beltsville	NTN /AMNet	Maryland Department of Natural Resources	06/04
Massachusetts				
MA01	North Atlantic Coastal Lab	NTN	NPS - Cape Cod National Seashore	07/03
MA99	Amherst		Amherst College	09/09
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 & MNPCA	02/96
MN18	Fernberg	NTN	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		Southern Company/Atmospheric Research and Analysis, Inc	06/00
Missouri				
MO03	Ashland Wildlife Area	NTN	Missouri DNR/US Environmental Protection Agency	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
Nebraska				
NE15	Mead	NTN	Nebraska Department of Environmental Quality	06/07
NE25	Winnebago		Winnebago Tribe of Nebraska	
NE99	North Platte Agricultural Exp Stn	NTN	US Geological Survey	10/08
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		New Mexico Environment Department-Air Quality Bureau	04/09
New York				
NY06	Bronx	AMNet	New York Department of Environmental Conservation	01/08
NY20	Huntington Wildlife	NTN /AMNet	Syracuse University /EPA	12/99
NY43	Rochester	AMNet	New York Department of Environmental Conservation	01/08
NY68	Biscuit Brook	NTN	US Geological Survey	03/04
NY99	West Point	NTN	US Dept of Education/John Jay College-City University of New York	10/06
North Carolina				
NC08	Waccamaw State Park		North Carolina Dept of Environment & Natural Resources	02/96
NC42	Pettigrew State Park		North Carolina Dept of Environment & Natural Resources	02/96
Ohio				
OH02	Athens Super Site	AMNet	Ohio University/EPA	12/04

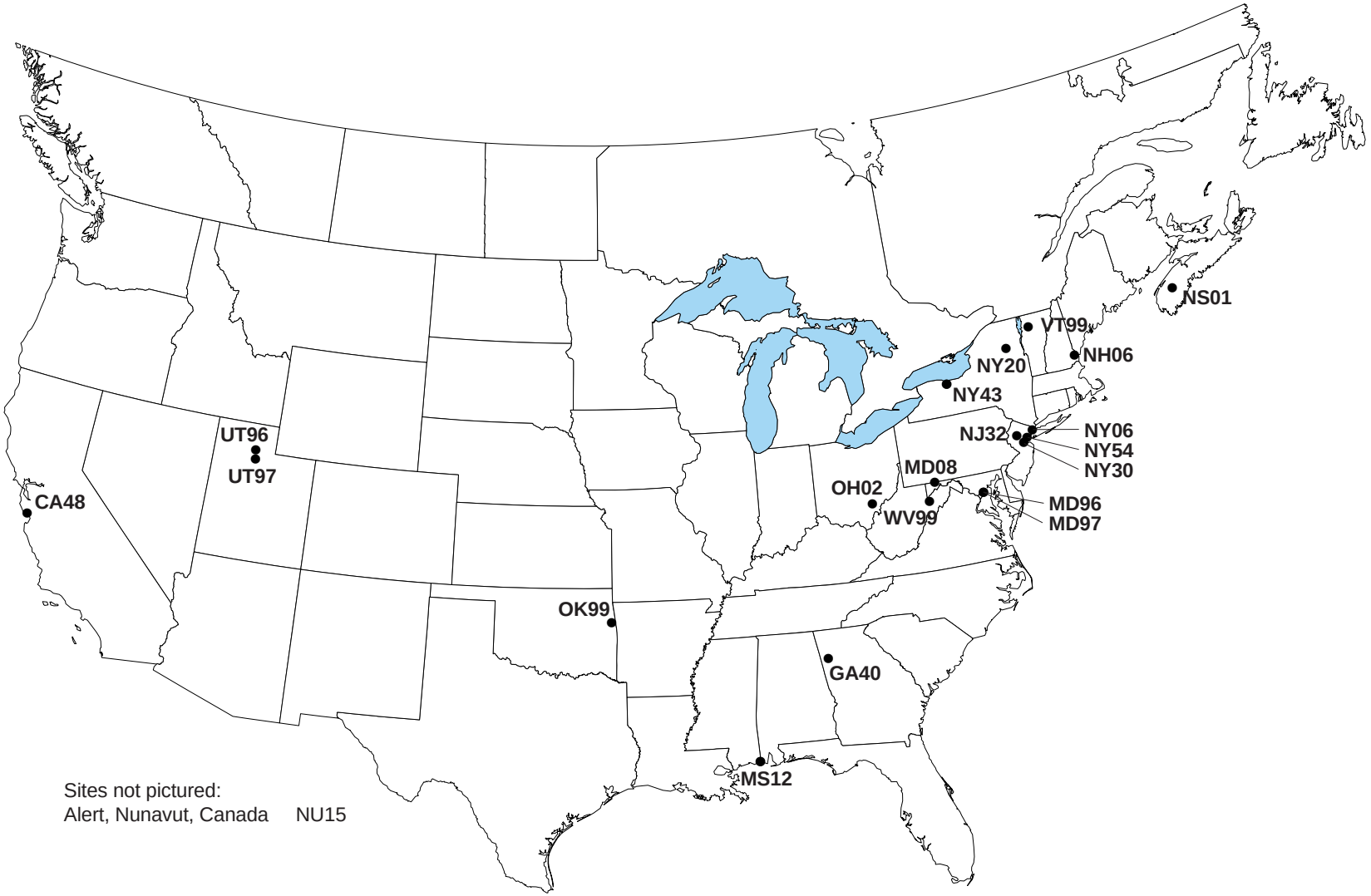
State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Oklahoma				
OK01	McGee Creek		Oklahoma Department of Environmental Quality	10/06
OK04	Lake Murray		Oklahoma Department of Environmental Quality	10/07
OK06	Wichita Mountains NWR		Oklahoma Department of Environmental Quality	11/07
OK31	Copan		Oklahoma Department of Environmental Quality	10/06
OK99	Stilwell	AMNet	Cherokee Nation/EPA	04/03
Oregon				
OR01	Beaverton		Oregon Department of Environmental Quality/EPA	04/03
OR10	H.J. Andrews Experimental Forest		Oregon Department of Environmental Quality/EPA	12/02
Pennsylvania				
PA00	Arendtsville	NTN	PA Dept of Environmental Protection/Penn State University	11/00
PA13	Allegheny Portage Railroad NHS		PA Dept of Environmental Protection/Penn State University	01/97
PA21	Goddard State Park		PA Dept of Environmental Protection/Penn State University	03/10
PA29	Kane Experimental Forest	NTN	PA Dept of Environmental Protection/Penn State University	06/10
PA30	Erie		PA Dept of Environmental Protection/Penn State University	06/00
PA37	Waynesburg		Electrical Power Research Institute	05/99
PA42	Leading Ridge	NTN	PA Dept of Environmental Protection/Penn State University	03/10
PA47	Millersville	NTN	PA Dept of Environmental Protection/Penn State University	11/02
PA52	Little Pine State Park		PA Dept of Environmental Protection/Penn State University	07/07
PA60	Valley Forge		PA Dept of Environmental Protection/Penn State University	11/99
PA72	Milford	NTN	PA Dept of Environmental Protection/Penn State University	09/00
PA90	Hills Creek State Park		PA Dept of Environmental Protection/Penn State University	01/97
South Carolina				
SC03	Savannah River		Washington Savannah River Company	01/01
SC05	Cape Romaine NWR	NTN	US Fish & Wildlife Service - Air Quality Branch	03/04
SC19	Congaree Swamp		South Carolina Dept of Health & Environmental Control	03/96
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

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Vermont				
VT99	Underhill	AIR/NTN/AMN	NOAA/Univ of VT-Rubinstein School of Environ & Natural Resources	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/AMNet	NOAA - Air Resources Lab	06/07
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 Axys Ltd.	07/06
British Columbia				
BC16	Saturna Island		Environment Canada	09/09
Newfoundland				
NF09	Cormak		Environment Canada	05/00
Nova Scotia				
NS01	Kejimkujik NP	AMNet	Environment Canada	07/96
Ontario				
ON07	Egbert		Environment Canada	03/00
ON18	Experimental Lakes Area		Environment Canada	11/09

State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Quebec				
PQ17	Chapais		Environment Canada	11/09
Saskatchewan				
SK12	Bratt's Lake BSRN		Environment Canada	05/01

AMNET MAP AND SITE LISTINGS

National Atmospheric Deposition Program
Atmospheric Mercury Network



National Atmospheric Deposition Program/Atmospheric Mercury Network Sites
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State/Province Site Code	Site Name	Collocation	Sponsoring Agency	Start Date
Maryland				
MD08	Piney Reservoir	MDN/NTN	MD DNR/University of Maryland-Appalachian Lab	01/08
MD98	Beltsville II		NOAA/US Environmental Protection Agency	01/07
MD99	Beltsville	MDN/NTN	NOAA/US Environmental Protection Agency	11/06
Mississippi				
MS12	Grand Bay NERR	MDN/NTN	National Oceanic & Atmospheric Administration	09/06
MS99	Grand Bay NERR II	MDN	National Oceanic & Atmospheric Administration	10/09
New Hampshire				
NH06	Thompson Farm		University of New Hampshire	01/09
New Jersey				
NJ05	Brigantine		State of New Jersey	06/09
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	US Environmental Protection Agency-CAMD	01/07
Oklahoma				
OK99	Stilwell	MDN	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/NTN	National Oceanic & Atmospheric Administration	01/08
West Virginia				
WV99	CVI	MDN	National Oceanic & Atmospheric Administration	01/07

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

PROCEEDING NOTES

Proceeding Notes

Proceeding Notes

Proceeding Notes

Proceeding Notes