NADP Proceedings 2000-01

# NADP 2000

## Ten Years after the Clean Air Act Amendments: Adirondacks in the Balance

October 17-20, 2000
Saratoga Springs, New York

NATIONAL ATMOSPHERIC DEPOSITION PROGRAM

*Last year, scientists, students, educators, and others interested in National Atmospheric Deposition Program (NADP) data made more than 17,000 on-line data retrievals and viewed nearly 70,000 maps from the NADP Internet site. These data are used to address important questions about the impact of wet deposition of nutrients on eutrophication in coastal estuarine environments; the relationship between wet deposition, the health of unmanaged forests, and the depletion of base cations from forest soils; the impact of pollutant emissions changes on precipitation chemistry; and the rate at which precipitation delivers mercury to remote lakes and streams.*

NADP was organized in 1977 under the leadership of State Agricultural Experiment Stations (SAES) 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 acidic chemicals, nutrients, and base cations. NADP was initially 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, SAES reclassified IR-7 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, NADP agreed to coordinate operation of NAPAP's National Trends Network (NTN). To benefit from shared siting criteria, identical operating procedures, and a shared analytical laboratory, NADP and NTN merged with the designation NADP/NTN. Many sampling sites are supported by the U.S. Geological Survey (USGS), 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 nearly 230 sites in the network, and the network designation has been shortened to NTN.

In the 1990s, NADP expanded to include two additional networks. The Atmospheric Integrated Research Monitoring Network (AIRMoN), which currently has nine sites, joined NADP in October 1992. AIRMoN sites collect samples daily when precipitation occurs. Samples are refrigerated until analysis at the CAL for the same constituents measured in NTN samples. AIRMoN seeks to identify pollutant source/receptor relationships and the effect of emissions changes on precipitation chemistry, combining measurements with atmospheric models. AIRMoN also evaluates new sample collection and preservation methods. Another NADP network, the Mercury Deposition Network (MDN), currently has nearly 50 sites and joined NADP in 1996. MDN sites collect one-week, wet-only deposition samples that are sent to a laboratory specializing in mercury measurements. Frontier Geosciences, Inc. analyzes all samples for total mercury and some samples for methyl mercury. MDN collects data on the wet deposition of mercury to surface waters, forested watersheds, and other receptors. Nearly 40 states have advisories against consuming fish from certain lakes because of high mercury concentrations in fish tissues. MDN data enable researchers to investigate the importance of the atmospheric deposition of mercury as a cause of this problem.

A number of federal agencies support NADP: U.S. Geological Survey; Cooperative State Research, Education, and Extension Service; Environmental Protection Agency; National Oceanic and Atmospheric Administration; National Park Service; U.S. Department of Agriculture - Forest Service; Bureau of Land Management; U.S. Fish & Wildlife Service; and Tennessee Valley Authority. Additional support is provided by various other federal agencies, State Agricultural Experiment Stations, state agencies, universities, and public and private research organizations.

**For further information, contact:**

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

**NADP Home Page:** ***http://nadp.sws.uiuc.edu***
**e-mail:** **nadp@sws.uiuc.edu**
**Phone:** **217/333-2213**
**Fax:** **217/244-0220**

The Illinois State Water Survey is an Affiliated Agency of the University of Illinois and a Division of the Illinois Department of Natural Resources

*Cover photo credits: Norway spruce by Gerry Hawkes reprinted with permission. See http://www.biketrack.com/more.htm. All other cover photos and background are copyrighted by Nova Development and its licensors.* *Designer: Wheeler Arts*

# NADP TECHNICAL COMMITTEE MEETING

## Proceedings

Saratoga Springs, New York
October 17-20, 2000

Technical Program Chair
Richard S. Artz
NOAA - Air Resources Lab
Silver Spring, MD 20910

Prepared by

Kathryn E. Douglas and Pamela S. Bedient
NADP Program Office
Illinois State Water Survey
2204 Griffith Dr.
Champaign, IL 61820

October 2000

# In Memoriam

NADP lost a devoted advocate, scientist, and colleague this summer with the death of David Bigelow on 11 June. Dave died at a hospital in Fort Collins, Colorado, of complications from lymphatic leukemia. He was 50 and had been with the Natural Resource Ecology Laboratory at Colorado State University for 30 years.

Dave joined the National Atmospheric Deposition Program as the network began operations in 1978. He worked with NADP Coordinator Jim Gibson, managing the data and ensuring data quality. He developed a data management and dissemination system that placed NADP at the forefront of providing high-quality data to scientists and schoolchildren alike. Dave authored or co-authored our current site selection and installation manual, several versions of our quality assurance plan, several versions of our site operations manual, and numerous data summaries, reports, and journal articles.

Many of us remember Dave for lively discussions at NADP meetings. Dave was a vigorous advocate for the program and dedicated to its success. Most of all, Dave was a friend, who was always ready to serve and help others. He is survived by his wife, Cynthia, and children, Dennis and Caroline.

# CONTENTS

*Page*

# NADP TECHNICAL COMMITTEE MEETING AGENDA

# NADP Technical Committee Meeting
# Saratoga Springs, New York
# October 17-20, 2000

| **TUESDAY, October 17th** | | **Room Location** |
|---|---|---|
| | Registration Desk Open All Day<br>(poster set-up after 12 noon) | Lobby |
| 7:00 a.m. to 9:00 a.m. | Executive Committee Meeting | Place |
| 9:00 a.m. to 9:30 a.m. | Break | |
| 9:30 a.m. to 10:00 a.m. | Welcome and Introductions - Jim Lynch | Daily Double (Rear) |
| | Subcommittee Agenda Topics | |
| | Network Operations<br>Jane Rothert | Daily Double (Rear) |
| | Data Management and Analysis<br>Bob Brunette | Exacta |
| | Environmental Effects<br>Ellen Porter/John Sherwell | Quinella |
| 10:00 a.m. to 12 noon | Joint Subcommittee Meetings | |
| 12 noon to 1:00 p.m. | Lunch (on your own) | |
| 1:00 p.m. to 2:40 p.m. | Individual Subcommittee Meetings | |
| 2:40 p.m. to 3:00 p.m. | Break | |
| 3:00 p.m. to 5:00 p.m. | Technical Committee Annual Business Meeting | Daily Double (Rear) |
| | Executive Committee Report - Jim Lynch | |
| | Service Awards | |
| | Program Advisors | |
| | NRSP-3/SAES - Wayne Banwart | |
| | CSREES - Dan Jones | |
| | NAPAP - Mike Uhart | |
| | NTN - Mark Nilles | |
| | AIRMoN - Rick Artz | |
| | MDN - Clyde Sweet | |
| | NADP Reports<br>Program Office - Van Bowersox | |
| | Subcommittee Resolutions<br>Network Operations<br>Data Management and Analysis<br>Environmental Effects | |
| | New Business<br>Election of Officers<br>Selection of Location for 2001 Technical Meeting | |
| 5:00 p.m. | Adjourn | |

| | |
|---|---|
| **WEDNESDAY, October 18th** | **Room Location** |
| 8:00 a.m. - 10:10 a.m. | Daily Double |
| **TECHNICAL SESSION:** | **TEN YEARS AFTER THE 1990 CLEAN AIR ACT AMENDMENTS, PART 1**<br>Session Chair: James A. Lynch, Pennsylvania State University |
| 8:00 - 8:40 | ***Acid Deposition 1990 to 2000: A Temporal and Global Context***<br>Jim Galloway, University of Virginia |
| 8:40 - 9:10 | ***Leading the Charge: New York's Fight Against Acid Rain***<br>John Cahill, Commissioner, New York State Department of Environmental Conservation |
| 9:10 - 9:40 | ***The Changing Regional Energy and Environmental Research Agenda and Its Relationship to the Clean Air Act***<br>Janet Joseph, New York State Energy Research and Development Authority |
| 9:40 - 10:10 | ***The U.S. Acid Rain Program: Overview and Lessons Learned***<br>Brian McLean, Director, Clean Air Markets Division, U.S. Environmental Protection Agency |
| 10:10 a.m. to 10:30 a.m. | Break |
| 10:30 a.m. - 12:10 p.m. | |
| **TECHNICAL SESSION :** | **TEN YEARS AFTER THE 1990 CLEAN AIR ACT AMENDMENTS, PART 2**<br>Session Chair: Rona Birnbaum, Clean Air Markets Division, U.S. Environmental Protection Agency |
| 10:30 - 10:50 | ***Changes in Atmospheric Deposition Following Phase I of Title IV of the Clean Air Act Amendments of 1990.*** James A. Lynch, Pennsylvania State University; V. C. Bowersox, Illinois State Water Survey; and J. W . Grimm, Environmental Resources Research Institute |
| 10:50 - 11:10 | ***Tracking the Effects of the Clean Air Act Using Streamwater, Soil Solution, and Groundwater Chemistry in Forested Watersheds of the Northeastern U.S.***<br>Peter S. Murdoch, U.S. Geological Survey |
| 11:10 - 11:30 | ***Persistence of Episodic Stream Acidification in the Northeastern United States.*** G. B. Lawrence, U.S. Geological Survey; Mark David, NRES, University of Illinois |
| 11:30 - 11:50 | ***Adirondack Lakes Survey Corporation Long-Term Monitoring Project.*** W. A. Kretser and K. M. Roy, Adirondack Lakes Survey Corporation |
| 11:50 - 12:10 | ***Application of a Biogeochemical Model to Assess Historical and Future Changes in Atmospheric Deposition in the Northeast.*** Charles Driscoll and Solomon Gbondo-Tugbawa, Syracuse University; Myron J. Mitchell, SUNY at Syracuse |
| 12:10 p.m. to 1:30 p.m. | Lunch (on your own) |
| 1:30 p.m. - 3:30 p.m. | |
| **TECHNICAL SESSION :** | **TEN YEARS AFTER THE 1990 CLEAN AIR ACT AMENDMENTS, PART 3**<br>Session Chair: Kristi Morris, U.S. Fish and Wildlife Service, Air Quality Branch |
| 1:30 - 1:50 | ***Contributions of Nitrogen-fixing Shrubs to the Nitrogen Economy of Adirondack Wetlands.*** Dudley J. Raynal, Todd. M. Hurd, and Brian D. Kiernan, SUNY at Syracuse |

| | |
|---|---|
| **WEDNESDAY, October 18th** | **Room Location** |
| | Daily Double |
| **TECHNICAL SESSION :** | **TEN YEARS AFTER THE 1990 CLEAN AIR ACT AMENDMENTS, PART 3 (CONTINUED)** |
| 1:50 - 2:10 | ***Status of Recovery in Acid-Sensitive Streams in the Catskill Mountains of New York.*** Douglas A. Burns, U.S. Geological Survey |
| 2:10 - 2:30 | ***Sugar Maple Health in the Northeastern United States: Cation Nutrition and Defoliation Stress.*** Richard A. Hallett, S. W. Bailey, S. B. Horsley, R. P. Long, USDA FS; T. J. Hall, Pennsylvania DCNR |
| 2:30 - 2:50 | ***Seedling Growth and Mortality Responses to Experimental Additions of Calcium and Aluminum in a Northern Hardwood Forest.*** Richard K. Kobe, Michigan State University; Gene E. Likens, Institute of Ecosystem Studies; Chris Eagar, USDA FS |
| 2:50 - 3:10 | ***Acid Deposition Effects to Forests and Streams in the Southern Appalachian Mountains.*** Patricia F. Brewer, SAMI Technical Coordinator; Timothy J. Sullivan, E&S Environmental Chemistry, Inc.; Jack Cosby, University of Virginia; Ron Munson, Tetra Tech, Inc. |
| 3:10 - 3:30 | ***Controls on Nitrogen Retention in Forested Watersheds.*** Gary M. Lovett and Kathleen C. Weathers, Institute of Ecosystem Studies, Millbrook, NY; Mary A. Arthur, University of Kentucky, Lexington, KY |
| 3:30 p.m. - 3:50 p.m. | Break |
| 3:50 p.m. - 5:30 p.m. | |
| **TECHNICAL SESSION :** | **TEN YEARS AFTER THE 1990 CLEAN AIR ACT AMENDMENTS, PART 4**<br>Session Chair: Mark Nilles, U.S.Geological Survey |
| 3:50 - 4:10 | ***Results from the Mountain Acid Deposition Program.*** Selma Isil, Harding Environmental Science & Engineering |
| 4:10 - 4:30 | ***Assessing the Impact of the Acid Deposition Control Program in the Presence of Natural Variability.*** S. T. Rao, Kevin Civerolo, and Elvira Brankov, New York State Department of Environmental Conservation; I. G. Zurbenko, University at Albany |
| 4:30 - 4:50 | ***Assessing the Results of Title IV: Are Further Emission Reductions Necessary?*** Richard Haeuber, US EPA - Clean Air Markets Division |
| 4:50 - 5:10 | ***From Obstacle to Opportunity: How Acid Rain Emissions Trading is Delivering Cleaner Air.*** Andrew Aulisi, Joseph Goffman, and Daniel Dudek, Environmental Defense |
| 5:10 - 5:30 | ***New York State Acid Deposition Monitoring Network Description, Data, and Differences from NADP.*** Paul Sierzenga and Garry Boyton, New York State Department of Environmental Conservation |

| | |
|---|---|
| **WEDNESDAY, October 18th** | **Room Location** |
| 6:00 p.m. | Place |

### POSTER SESSION AND SOCIAL MIXER

***New Electrode Methodology for pH Measurement in Precipitation Samples.*** Sue Bachman, Tracie Patten, and Tom Bergerhouse, Central Analytical Laboratory, Illinois State Water Survey

***Analytical and Field Considerations in the Design of an Atmospheric Deposition Sampler.*** John S. Beach, Jr., Vice President, N-CON Systems Co., Inc.

***Acidic Deposition Reduction.*** Edward P. Bennett, Special Projects Coordinator and James E. Close, Environmental Program Specialist 2, Division of Air Resources, New York State Department of Environmental Conservation

***Trace Metals in Wet-Deposition: New Initiative for the Mercury Deposition Network.*** Bob Brunette and Eric Prestbo, Frontier Geosciences; and Clyde Sweet, Illinois State Water Survey

***Potential Effects of Climate Change on Atmospheric Wet Deposition at a Site in Central Pennsylvania.*** Anthony R. Buda and David R. DeWalle, The Pennsylvania State University

***Pre- and Post-Phase I Clean Air Act Amendments Impacts on Precipitation $SO_4^=$ and $H^+$, and Dry Deposition Sulfur Species and Prospects for Recovery of Acid Sensitive Ecosystems.*** Tom Butler, Cornell University; Gene Likens, Cary Arboretum

***Assessment of the Contribution Made by Different Nitrogen Sources to the Total Nitrogen Inputs to Thirty-Four Estuaries on the East and Gulf Coasts of the United States.*** Mark S. Castro, Appalachian Laboratory; Charles T. Driscoll, Department of Civil and Environmental Engineering, Syracuse University; Thomas E. Jordan, Smithsonian Environmental Research Center; William G. Reay, Virginia Institute of Marine Science; Walter R. Boynton, Chesapeake Biological Laboratory; Sybil Seitzinger and Renee V. Styles, Institute of Marine and Coastal Sciences, Rutgers University

***Difficulties in Interpreting Trends in Acid Deposition in the Presence of Natural Variability.*** Kevin Civerolo, Elvira Brankov, S. T. Rao and John Kent, New York State DEC; Igor Zurbenko, University of Albany

***An Analysis of Ecoregion Coverage by Current NADP/NTN Sites.*** Brooke Conley, Colorado School of Mines; Mark Nilles, U.S. Geological Survey

***A Five-Year Statistical Study of AIRMoN Field Blank Samples.*** Brigita Demir, Kaye Surratt, and Jane Rothert, Illinois State Water Survey

***Impacts of Changing Emissions Policies on Stream Water Chemistry in the Mid-Appalachians.*** David R. DeWalle, Bryan R. Swistock, and William E. Sharpe, The Pennsylvania State University

***An Analysis of NADP Site Systems and Performance Survey Data: Summary and Use of 1998-1999 Results for the NTN Network.*** Scotty R. Dossett and Greg Dzurisin, NADP Program Office, Illinois State Water Survey

***Influences of Data Inhomogeneities on Trend Detection and Attribution.*** Christian Hogrefe, University at Albany; Heather L. Wakeley, Dartmouth College; S. Trivikrama Rao, NYSDEC and University at Albany

***Spatial Patterns of Precipitation Quantity and Chemistry in the Adirondack Region of New York.*** Mari Ito and Myron J. Mitchell, SUNY at Syracuse; Charles T. Driscoll, Syracuse University

***Mercury in Adirondack Wetlands, Lakes, and Terrestrial Systems.*** Melissa Kalicin, Margaret Lindeman, and Charles T. Driscoll, Syracuse University; Robert Newton, Smith College; Ron Munson, Tetra Tech; Walt Kretser, Adirondack Lake Survey Corp; Joseph Yavitt, Cornell University

***Trends in Atmospheric Deposition Compared to Regional and Local Pollutant Emissions at a Rural Site in Southeastern New York, USA.*** Victoria R. Kelly, Gary M. Lovett, and Kathleen C. Weathers, Institute of Ecosystem Studies

***Atmospheric Mercury Emissions from Municipal Solid Waste Landfills.*** S. Lindberg, H. Zhang, and G. Southworth, Oak Ridge National Laboratory; D. Reinhart, University of Central Florida; P. McCreanor, Mercer University; D. Wallschlager, Frontier Geosciences; J. Price, Florida Department of Environmental Protection

**WEDNESDAY October 18th** **Room Location**

**Poster Session and Social Mixer (Continued)** Place

***Comparison of Non-Linear Regression and Autoregressive Moving Average (ARMA) Models for Precipitation Chemistry from East Central Florida.*** B. C. Madsen and D. M. Nickerson, University of Central Florida; T.W. Dreschel and L.A. Maull, Dynamac Corporation

***Effects of Reduced Acid Deposition to a First- and Third-Order Mid-Atlantic Coastal Plain Stream.*** Jacqueline L. Mann, Michael E. O'Connell, and Karen L Prestegaard, Department of Geology, University of Maryland

***Analysis of pH in Wet Deposition in North-Eastern Puerto Rico.*** R. Mendez-Tejeda, J. Penalbert-Ramos, and M. Rodriquez-Rosario, University of Puerto Rico at Carolina

***Air Quality in the National Wildlife Refuge System.*** Kristi H. Morris, U.S. Fish and Wildlife Service, Air Quality Branch

***The Kempton Mine Complex Restoration Initiative.*** Paul Petzrick and John Sherwell**,** Maryland Department of Natural Resources

***Influences on Wetlands and Lakes in the Adirondack Park of New York State: A Catalog of Existing and New GIS Data Layers for the 400,000 Hectare Oswegatchie/Black River Watershed.*** Karen M. Roy, NYS Adirondack Park Agency, SUNY Plattsburgh, Adirondack Lakes Survey Corp.

***Modeling Atmospheric Nitrogen Deposition and Transport in theChesapeake Bay Watershed: A GIS Approach.*** Scott A. Sheeder and James A. Lynch, Ph.D.,School of Forest Resources, the Pennsylvania State University; Jeffrey W. Grimm, Environmental Resource Research Institute**,** The Pennsylvania State University

***New York State Acid Deposition Monitoring Network Description, Data, and Differences from NADP.*** Paul Sierzenga and Garry Boyton, Bureau of Air Quality Surveillance, New York State Department of Environmental Conservation

***Fish Population Assessment and Spring Water Chemistry in Adirondack Headwater Streams.*** Howard A. Simonin, James R. Colquhoun, Eric A. Paul, John Symula, and Howard J. Dean, New York State Department of Environmental Conservation

***Calcium and Sodium Dryfall at NADP/NTN Sites.*** Gary J. Stensland, Illinois State Water Survey; Steven Lindberg, Oak Ridge National Laboratory

***What a Difference Ten Years Has Made in Ammonium in Rain and Snow in the United States - The Changing Landscape of Ammonia Sources and Deposition.*** Gary J. Stensland, Bob Larson, Van C. Bowersox, and Roger D. Claybrooke, Illinois State Water Survey

***A Meteorological Explanation for Differences Between Precipitation and Sulfate Data Collected from Two Neighboring NTN Sites in Central Pennsylvania.*** Mark A. Taylor and Dennis Lamb, Pennsylvania State University

***Atmospheric Deposition Changes Across New York State and Adjacent New England Following Implementation of the 1990 Clean Air Act.*** Jack T. Tessier, SUNY at Syracuse; Raymond D. Masters, Huntington Wildlife Forest; Dudley J. Raynal, SUNY at Syracuse

***A Comparison Between Coastal and Inland Deposition Using Three AIRMON monitoring sites: PA 15, DE02, MD15.*** Julie Thomas, Air Quality Liaison to the Chesapeake Bay Program

***Atmospheric Deposition of Trace Metals in the San Francisco Bay Area.*** Pam Tsai, San Francisco Estuary Institute; Eric Hansen, City of San Jose Environmental Services Department; Rainer Hoenicke, San Francisco Estuary Institute

***Effects of the Acid Rain Program Emission Reductions on Ambient Particulate Matter Measurements in Maryland.*** Kenneth Walsh, Science Applications International Corporation; John Sherwell, Maryland Power Plant Research Program

***Atmospheric Deposition to Mountainous Terrain: Scaling-Up to the Landscape.*** K. C. Weathers and G. M. Lovett, Institute of Ecosystem Studies; S. E. Lindberg, Oak Ridge National Laboratory; S. M. Simkin and D.N. Lewis, Institute of Ecosystem Studies

|  |  |
|---|---|
| **THURSDAY, October 19th** | **Room Location** |
| 8:00 a.m. - 10:00 a.m. | Daily Double |
| **TECHNICAL SESSION :** | **COASTAL EUTROPHICATION**<br>Session Chair: Susan Johnson, Minnesota Pollution Control Agency |
| 8:00 - 8:20 | ***Atmospheric Nitrogen Inputs to the Delaware Inland Bays: The Importance of Ammonia.*** Joseph R. Scudlark and Megan J. Roadman, University of Delaware |
| 8:20 - 8:40 | ***New Faces, New Places: The Growing Air Deposition Community along the Coasts.*** Tamara Saltman, U.S. Environmental Protection Agency |
| 8:40 - 9:00 | ***Wet Deposition of Atmospheric CNP on a Delmarva Coastal Plain Basin.*** T. R. Fisher and G. Radcliffe, University of Maryland; E. J. Rochelle-Newall, Observatoire Océanologique |
| 9:00 - 9:20 | ***Anthropogenic Nitrogen Inputs to Thirty-Four Watersheds on the Atlantic and Gulf Coasts of the United States.*** Mark S. Castro, Appalachian Laboratory, Frostburg State; Charles T. Driscoll, Syracuse University; Thomas E. Jordan, Smithsonian Environmental Research Center; William G. Reay, Virginia Institute of Marine Science; Walter R. Boynton, Chesapeake Biological Laboratory; Sybil Seitzinger and Renee V. Styles, Institute of Marine and Coastal Sciences, Rutgers University |
| 9:20 - 9:40 | ***Use of Thymol as a Biocide to Eliminate the Loss of Ammonium from Weekly Deposition Sampling Buckets.*** David Whitall and Hans Paerl, University of North Carolina at Chapel Hill |
| 9:40 - 10:00 | ***Ten Years of Aquatic Monitoring.*** William G. Hagar and James J. Norman, University of Massachusetts Boston |
| 10:00 a.m. to 10:20 a.m. | Break |
| 10:20 a.m. - 11:40 a.m. |  |
| **TECHNICAL SESSION:** | **AIR TOXICS AND THE ENVIRONMENT, PART 1**<br>Session Chair: Alan Van Arsdale, U.S. Environmental Protection Agency |
| 10:20 - 10:40 | ***Single-Storm Event Mercury Deposition near a Combustion Point Source.*** Eric M. Prestbo and Julie Calhoun, Frontier Geosciences; Rob Mason, University of Maryland; John Sherwell, Maryland DNR |
| 10:40 - 11:00 | ***Mercury and Trace Metal Deposition at Urban and Rural Sites in Maryland.*** Robert Mason, Nicole Lawson, and Guey-Rong Sheu, Chesapeake Biological Laboratory, University of Maryland |
| 11:00 - 11:20 | ***Trends in Wet Deposition of Mercury, 1995-1999.*** Clyde W. Sweet, Illinois State Water Survey; Eric Prestbo and Robert Brunette, Frontier Geosciences |
| 11:20 - 11:40 | ***Mercury Deposition to the Lake Champlain Watershed: Cloud Water, Cloud Throughfall, and Precipitation Measurements on Mt. Mansfield, VT.*** Elizabeth G. Malcolm and Gerald J. Keeler, University of Michigan Air Quality Laboratory; Sean T. Lawson and Timothy D. Sherbatskoy, School of Natural Resources, University of Vermont |

Daily Double

**TECHNICAL SESSION:** **AIR TOXICS AND THE ENVIRONMENT, PART 1 (CONTINUED)**

11:40 - 12:10 ***A New Look at Missing Sinks and Sources in the Global Mercury Cycle.*** S. E. Lindberg, S. Brooks, T. Meyers, H. Zhang, and L. Chambers, Oak Ridge National Laboratory and National Oceanic and Atmospheric Administration

12:10 p.m. - 1:10 p.m. Lunch (on your own)

1:10 p.m. - 2:30 p.m.

**TECHNICAL SESSION:** **AIR TOXICS AND THE ENVIRONMENT, PART 2**
Session Chair: Richard Artz, National Oceanic and Atmospheric Administration

1:10 - 1:30 ***Bioindication of Atmospheric Heavy Metal Deposition in the Blue Ridge Using the Moss Thuidium Delicatulum.*** Jonathan S. Schilling and Mary E. Lehman, Longwood College

1:30 - 1:50 ***Research on Potential Effects of Mercury on Behavioral Changes of Piscivorous Birds, with Emphasis on the Common Loon (Gavia immer), in the Northeastern United States and Eastern Canada.*** Andrew Major, USFWS; David Evers, BioDiversity Reserach Institute, Freeport, ME; Neil Burges, Canadian Wildlife Service-Atlantic Division

1:50 - 2:10 ***Assessing Hg and Methyl-Hg Burdens in VT and NH Lakes and Historical Trends in Hg Deposition To VT and NH Lake Sediments.*** Neil Kamman, VT Department of Environmental Conservation; Dr. Charles T. Driscoll, Department of Civil and Environmental Engineering, Syracuse University; Dr. Daniel Engstrom, St. Croix Watershed Research Station, Science Museum of Minnesota; David Evers, Biodiversity Research Institute; Robert Estabrook, NH Department of Environmental Services; Peter Lorey, Department of Civil and Environmental Engineering, Syracuse University

2:10 - 2:30 ***The National Dioxin Air Monitoring Network (NDAMN): Results of the First Year of Atmospheric Measurements of CDDs, CDFs and Dioxin-like PCBs in Rural and Agricultural Areas of the United States: June 1998 – June 1999.*** David H. Cleverly, National Center for Environmental Assessment; Dwain Winters, US EPA; Joseph Ferrario, US EPA; John Schaum, National Center for Environmental Assessment; Aubry Dupuy and Christian Byrne, US EPA

2:30 p.m. to 2:50 p.m. Break

2:50 p.m. - 4:30 p.m.

**TECHNICAL SESSION:** **ATMOSPHERIC DEPOSITION MONITORING AND ASSESSMENT**
Session Chair: Dennis Lamb, Pennsylvania State University

2:50 - 3:10 ***Changes in High-elevation Lake Chemistry in the Western United States, 1985-99.*** David W. Clow and M. Alisa Mast, U.S. Geological Survey

**THURSDAY, October 19th** **Room Location**

Daily Double

**TECHNICAL SESSION:** **ATMOSPHERIC DEPOSITION MONITORING AND ASSESSMENT (CONTINUED)**

3:10 - 3:30 ***Composition and Changes in Atmospheric Deposition at a Forested Site Near Atlanta, Georgia, from 1985 to 1999.*** Norman E. Peters, USGS; Tilden P. Meyers, NOAA/ATDD

3:30 - 3:50 ***Chemical Indicators of Sulfur Wet Deposition: Sensitivity to Nitrogen Oxides and Hydrocarbons.*** Ariel F. Stein and Dennis Lamb, Department of Meteorology, Penn State University

3:50 - 4:10 ***Atmospheric Deposition to Complex Landscapes: HRDM - A Strategy for Coupling Deposition Models to a High-Resolution GIS.*** Eric K. Miller, Ecosystems Research Group and Environmental Studies Program, Dartmouth College

4:10 - 4:30 ***Retention of Atmospherically-deposited Inorganic N in Soil Solution: Climatic Differences in the Contributions of Wet and Dry Deposition.*** R. H. Grant and K. L. Scheeringa, Purdue University.

4:30 - 4:50 ***Month-to-month Variation in Precipitation Ion Concentrations at NADP/NTN Sites.*** Gary J. Stensland, Illinois State Water Survey

4:50 - 5:10 ***An Exploration of Data Accompanied by Comment Codes From the Clean Air Status and Trends (CASTNET) Network.*** Luther Smith, ManTech Environmental Technology

5:10 - 5:30 ***The Scoop on Total Nitrogen Deposition: A Look at Status and Trends in the Northeast***. Gary Lear, U.S. Environmental Protection Agency and David Schmeltz, U.S. Environmental Protection Agency

## FRIDAY, October 20th

8:30 a.m. - 3:00 p.m. Field Trip to Huntington Forest, Adirondack Mountains

### Background Information on the Huntington Forest, Adirondack Mountains, New York

Charles T. Driscoll
Department of Civil and Environmental Engineering
Syracuse University
Syracuse, NY 13422

The 6,000 hectare Huntington Forest (HF) is located in the Town of Newcomb, western Essex County and in the Town of Long Lake, eastern Hamilton County, New York, (latitude: 44° 00' North, longitude: 74° 13' West). The HF has a mean annual temperature of 4.4°C and mean annual precipitation is 1010 mm. The HF lies near the geographic center of the Adirondack Park and is within the Hudson River drainage. The topography is mountainous and elevations range from 457 m to 823 m. Vegetation consists of northern hardwoods (72%), mixed hardwood-conifer (18%), and conifer (10%). The property also contains five lakes: Catlin (area=217 ha; max. depth=17 m), Rich (160 ha; 18 m), Wolf (58 ha; 14 m), Arbutus (49 ha; 8 m) and Deer (38 ha; 3 m). The HF is part of the Adirondack Ecological Center (AEC, http://www.esf.edu/aec/). The site is maintained as an experimental forest for studies of forest ecology, wildlife management and silviculture.

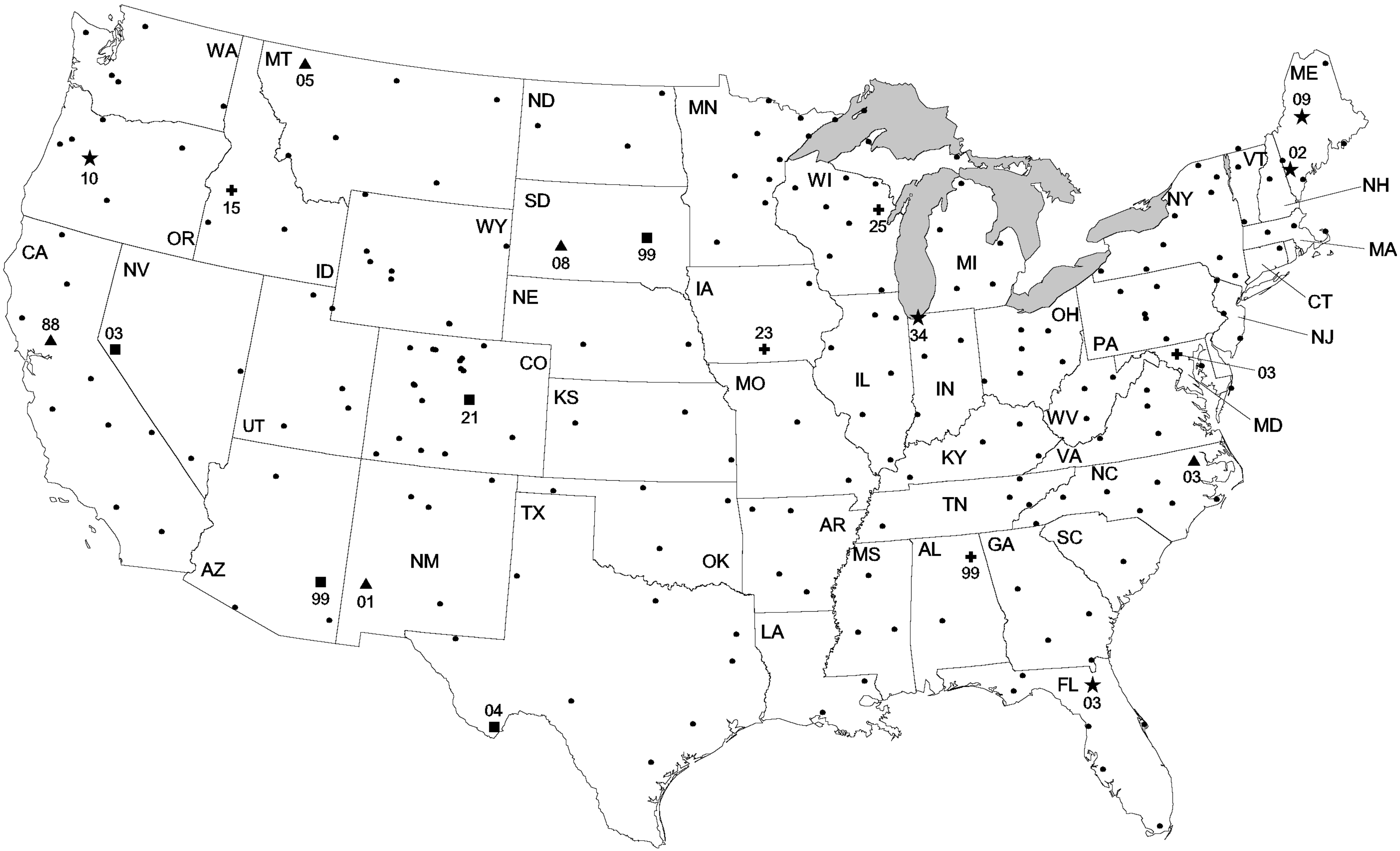
Upper forest slopes are dominated by *Fagus grandifolia*, *Betula alleghaniensis* and *Acer saccharum* with occasional *Picea rubens.* Cool riparian sites and lake shores support *Tsuga canadensis*, *Abies balsamea, Picea rubens and Betula alleghaniensis.* Plantations of *Pinus strobus* and *P. resinosa* are found. Diverse wetland systems are dominated by shrubs and emergent graminoids, characteristic of the Adirondack region, are prevalent. Upland watershed soils are generally <1 m in depth and include Becket-Mundall series sandy loams (coarse-loamy, mixed, frigid typic Haplorthods) while Greenwood Mucky peats are found in valley bottom wetlands. Groundwater occurs predominantly in deep near-stream peats (1-3 m depth), pockets of glacial till in valley-bottoms (0-2 m) and limited zones of glacial outwash deposits.

The HF has participated in the National Atmospheric Deposition Program (NADP) since Oct. 31, 1978 (http://nadp.sws.uiuc.edu/nadpdata/siteinfo.asp?id=NY20&net=NADP). The HF has also been a site in various regional biogeochemical studies including the Integrated Forest Study (IFS), the Adirondack Manipulation and Modeling Project (AMMP) and the Adirondack Long-Term Monitoring (ALTM) Lake Project. The Huntington Forest was also the site of a soil warming experiment using buried heating cables. Adjacent to the Arbutus Watershed is a 38-m walk-up tower equipped with meteorological instruments and filter packs for sampling air chemistry that is monitored by NOAA. Eddy correlation measurements of $O_3$ and $SO_2$ have been made using this tower.

The Arbutus Lake Watershed has been gauged at the lake outlet since October 1991 with a V-notch weir. The 130 ha Archer Creek Catchment drains into Arbutus Lake. This catchment has been monitored since 1994 using a H-flume equipped with automated discharge logging and sample collection system. Water chemistry samples are taken weekly except during storm events when more frequent sampling is done. Detailed stream and wetland maps have been produced, and this information is part of a GIS database of the site. In addition, transects of piezometers, water table wells, soil tension lysimeters and throughfall collectors, have been installed for characterizing solute chemistry. A hillslope/wetland/stream ecotone in the catchment has been intensively instrumented since 1994. Biogeochemical studies at the HF have evaluated a broad range of biogeochemical constituents including Al, S, and N. For further information consult http://www.esf.edu/hss/Biogeo1.htm

# NADP OPERATOR AWARDS

# NADP/NTN Site Operator Service Awards - 2000



| Site/Sitename | Operator Name | Wet Start | Agency |
|---|---|---|---|
| **5 Years of Service** | | | |
| AZ99 – Oliver Knoll | Philip Madsen | 8/25/81 | USGS-WRD |
| CO21 – Manitou | Steve Tapia | 10/17/78 | USFS |
| NV03 – Smith Valley | Laurie Bonner | 8/7/85 | USGS-WRD |
| SD99 – Huron Well Field | Frank Amundson | 11/29/83 | USGS-WRD |
| TX04 – Big Bend National Park-K-Bar | John Forsythe | 4/10/80 | NPS-ARD |
| **10 Years of Service** | | | |
| CA88 – Davis | Mike Mata | 9/4/78 | USGS-WRD |
| MT05 – Glacier National Park-Fire Weather Station | Lindy Key | 6/30/80 | NPS-ARD |
| NC03 – Lewiston | Margaret Pierce | 10/31/78 | North Carolina State University |
| NM01 – Gila Cliff Dwellings National Monument | Daniel Galindo | 7/29/85 | EPA/NM ED-AQB |
| SD08 – Cottonwood | Ron Haigh | 10/11/83 | NOAA-ARL |
| **15 Years of Service** | | | |
| AL99 – Sand Mountain Ag Experiment Station | James Hugh Burns | 10/2/84 | TVA |
| IA23 – McNay Memorial Research Center | Jim Secor | 9/11/84 | USGS-WRD |
| ID15 – Smiths Ferry | Mary Owen | 10/9/84 | USGS-WRD |
| MD03 – White Rock Substation | Robert Dalton | 10/3/84 | Baltimore Gas & Electric Co. |
| WI25 – Suring | James Trochta | 1/23/85 | Wisconsin DNR |
| **20 Years of Service** | | | |
| FL03 – Bradford Forest | Larry Korhnak | 10/10/78 | St. John’s River Management District |
| IN34 – Indiana Dunes National Lakeshore | Lou Brenan | 7/15/80 | NPS-ARD |
| ME02 – Bridgton | Peter Lowell | 9/30/80 | ME DEP |
| ME09 – Greenville Station | Llew Wortman | 11/20/79 | SAES-University of Maine |
| OR10 – HJ Andrews Experimental Forest | John Moreau | 5/13/80 | USFS |

## TECHNICAL SESSION: TEN YEARS AFTER THE 1990 CLEAN AIR ACT AMENDMENTS, PART 1

Session Chair: James A. Lynch, Pennsylvania State University

## Acid Deposition 1990 to 2000: A Temporal and Global Context

Dr. James N. Galloway
Environmental Sciences
University of Virginia
Charlottesville, VA 22903

The purpose of Title IV of the 1990 Clean Air Act Amendments is to reduce the adverse impacts of acid deposition through reductions in annual emissions of sulfur dioxide and nitrogen oxides. This overview presentation assesses the success of the 1990 CAAA for regions of the USA in the context of the degree of human alteration of the S and N cycles. In addition, the presentation will present emerging issues relative to acid deposition for both the U.S.A and other regions of the world.

**Biographical Information:**

Dr. James N. Galloway earned his BA from Whittier College in 1966 with a double major in Chemistry and Biology. He was awarded his Ph.D. from the University of California, San Diego in Chemistry in 1972 for his research on the fate of trace metals in a coastal ocean. For two years, he was a professional potter in Lexington, Virginia. In 1974, he was appointed as a Postdoctoral Fellow at Cornell University, and in 1976 joined the University faculty as an Assistant Professor. He is currently Professor and Chair of the Department of Environmental Sciences, an interdisciplinary department whose purpose is to advance understanding of the environment through interdisciplinary scientific research and education. Jim's research is in the area of biogeochemistry and includes works on the natural and anthropogenic controls on chemical cycles at the watershed, regional, and global scales. He is the author of over a hundred scientific papers. Jim is internationally recognized for his work on acid deposition effects on soils, waters, and forests; watershed biogeochemistry; and the influence of Asia on the global environment. Jim and his wife Nancy, an artist, are eager gardeners, and have two grown children–Joshua and Anna.

# Leading the Charge: New York's Fight Against Acid Rain

John P. Cahill
Commissioner of the New York State Department of Environmental Conservation

## Biographical Information:

John P. Cahill is commissioner of the New York State Department of Environmental Conservation (DEC), overseeing an agency of 3,900 employees dedicated to conserving, improving and protecting the State's environment and natural resources.

Governor George E. Pataki nominated Cahill to the position on June 6, 1997 and the State Senate unanimously confirmed the nomination on June 24, 1997. Cahill joined DEC in 1995 as general counsel and was named acting commissioner a year later. Governor Pataki also appointed Cahill in 1995 to serve as vice chairman of the New York State Emergency Financial Control Board for the City of Yonkers.

Prior to joining DEC, John was a partner in the New York City law firm of Plunkett & Jaffee, P.C., where his practice focused on environmental and municipal issues.

Since becoming Commissioner, John has spearheaded Governor Pataki's efforts to make New York a national leader in environmental protection and natural resource management. Since 1995, New York State has preserved more than 300,000 acres of open space, required the most protective measures on utilities and automakers to insure the cleanest air quality possible and invested millions of dollars to enhance public access and enjoyment of the State's vast natural resources.

John also oversees implementation of the $1.75 billion 1996 Clean Water/Clean Air Bond Act, a major environmental initiative championed by Governor Pataki and endorsed by New York's voters in November 1996. The Bond Act provides unprecedented resources for important environmental projects which improve our environment, protect public health and conserve our unique natural resources. In less than four years since its passage, almost 1400 projects have been approved.

John has been recognized by numerous organizations for his efforts. The Adirondack Council presented him with the 1999 Conservationist of the Year Award for his efforts in the Adirondack Park and the National Audubon Society has presented him with the William B. Hoyt Award for his statewide conservation efforts. John has long been active in his community, serving on the boards of several civic organizations. He is one of the most sought-after speakers at Pace University School of Law and has been a presenter at academic and other events sponsored by the School's Environmental Law Program.

John earned a law degree in 1985, and a master's degree in environmental law in 1992, from Pace Law School. He graduated from Fordham University with a bachelor's degree in economics. He is a member in good standing of the American Bar Association (the Natural Resources, Energy and Environmental Law Section, and the Urban, State and Local Government Section); the New York State Bar Association (the Environmental Law and Municipal Law sections); and the Westchester County Bar Association (the Municipal Law Section).

John and his wife, Kim, have four children. He is an avid runner and triathlete.

## The Changing Regional Energy and Environmental Research Agenda and Its Relationship to the Clean Air Act

Janet Joseph
Program Manager for Environmental Research
New York State Energy Research and Development Authority

### Biographical Information:

Janet Joseph is the Program Manager for Environmental Research at the New York State Energy Research and Development Authority (NYSERDA). Janet has held a variety of technical and policy positions at NYSERDA over the past 10 years, from Manager of Planning to Program Manager of Buildings R&D. Prior to joining NYSERDA, Janet was a research scientist at Battelle Pacific Northwest Laboratories. Janet has also worked as an environmental consultant for Booz-Allen and Hamilton in Washington, D.C. Janet has a Master's degree in Environmental Chemistry from the University of Maryland.

# The U.S. Acid Rain Program: Overview and Lessons Learned

Brian McLean
Director, Clean Air Markets Division
U.S. Environmental Protection Agency

When established under the 1990 Clean Air Act Amendments, the Acid Rain Program was a departure from traditional air pollution control programs. This presentation will highlight the provisions that made Title IV unique in its approach to the regulation of air emissions. The costs of the acid rain program are much lower than predicted at the time of the 1990 Amendments, but have the goals of Title IV been met? Where have sulfate depositions occurred and what are the concomitant health benefits? The presentation will also address the elements necessary to create an effective cap and trade program and the challenges of extending the cap and trade approach to other pollutants, such as reducing ozone transport.

---

1200 Pennsylvania Avenue, NW
Mail Code: 6204J
Washington, DC 20460
Contact:
Al Dahlberg (202) 564-9790
dahlberg.albert@epa.gov

## TECHNICAL SESSION: TEN YEARS AFTER THE 1990 CLEAN AIR ACT AMENDMENTS, PART 2

Session Chair: Rona Birnbaum, Clean Air Markets Division, U.S. Environmental Protection Agency

# Changes in Atmospheric Deposition Following Phase I of Title IV of the Clean Air Act Amendments of 1990

J. A. Lynch*, V. C. Bowersox†, and J. W . Grimm‡

Phase I of Title IV of the Clean Air Act Amendments of 1990 (CAAA) was implemented on 1 January 1995. On that date limitations were imposed on sulfur dioxide emissions from 110 coal-fired electric utility plants Sulfur dioxide emissions at these plants dropped an average 2.78 million tons (38%) from 1995 through 1999, when compared to 1993 emissions from these plants. As a result of these reductions, sulfate concentrations decreased over a large portion of the eastern USA including portions of the Ohio River Valley, the Mid-Atlantic region and New England, the regions specifically targeted by Phase I for reductions in acidic deposition. Nitrate concentrations were essentially unchanged during this period except for a small section of the Ohio River Valley and northern New England where small reductions were measured. Reductions in hydrogen ion concentrations were greater and even more extensive than the net reductions in acid anion concentrations. These differences can be explained by a significant increase in base cation concentrations over a large portion of the eastern USA during the post-Phase I period. Higher base cation concentrations increase the acid neutralizing capacity of precipitation resulting in lower hydrogen ion concentrations.

Reductions in wet $SO_4^{2-}$ deposition were generally consistent with observed reductions in $SO_4^{2-}$ concentrations; however, deviations in precipitation volumes between the pre- and post-Phase I periods did result in some sites recording significantly lower post-Phase I concentrations but non-significant wet deposition patterns; at some sites, deposition actually increased. Deviations in precipitation within and between regions also influenced the magnitude and spatial distribution of the observed changes in wet $SO_4^{2-}$ deposition. Clearly, deviations in the amount and distribution of precipitation need to be considered along with concentration changes in evaluating the CAAA effectiveness. This is particularly important in the acid sensitive mountainous regions of the eastern USA that are subject to considerable fluctuations in precipitation volumes and subsequently acidic wet deposition.

An analysis of wet sulfur deposition versus total sulfur emissions for each state located in the eastern half of the country indicates that, in general, states with high emission sources have the lowest deposition/emissions ratios and vice versa. Those state with the lowest ratios (<0.2) were generally located in the Mid-west (IL, IN, OH) and Mid-Atlantic (PA, MD, NJ) regions. The states with the highest ratios (>0.5) were located in either the central portion of the country (SD, NE, KS, OK) were emissions are low or in New England (ME, VT, RI) where deposition is relatively high. Vermont receives nearly 6 times more sulfur deposition than it emits to the atmosphere. On a mass bases for all states in the eastern half of the country, wet deposition accounts for approximately 35% of the total sulfur emissions from those states.

---

*Pennsylvania State University, School of Forest Resources, University Park, PA 16802, U.S.A.
†Illinois State Water Survey, National Atmospheric Deposition Program, Champaign, IL 61820, U.S.A.;
‡Environmental Resources Research Institute, University Park, PA 16802, U.S.A.

# Tracking the Effects of the Clean Air Act Using Streamwater, Soil Solution, and Groundwater Chemistry in Forested Watersheds of the Northeastern U.S.

Peter S. Murdoch
U.S. Geological Survey
Troy, New York

The U.S. Geological Survey has been continuously monitoring flow and seasonally monitoring water quality in 3 medium-scale watersheds (40-60 square miles) in the Northeastern United States since the mid-1960's. During the past three years more frequent water quality monitoring (biweekly and during stormflows) has been established at these stations. The stations are located in north-central Pennsylvania, southeastern New York, and northwestern Maine, and thus lie along a gradient of decreasing sulfate and nitrate deposition from southwest to northeast across the region. Additionally, samples of soil solution and groundwater were collected within the New York watershed during the 1990's. Patterns of stream nitrate and sulfate concentrations are consistent with the regional deposition pattern. Sulfate concentrations have decreased at the Neversink River (southeast New York) and the Wild River (western Maine) during the period of record, and most notably when emissions decreased in 1995, but sulfate concentrations in Young Woman's Creek show no trend. No trend in sulfate concentrations is evident in any of the streams since 1995 through spring of 2000.

Stream acidification and recovery are dependent upon the interactions of atmospheric deposition with the surrounding landscape. As the acidity of atmospheric deposition decreases, stream acid neutralizing capacity (ANC) can only recover if first preceded by recovery in soil chemistry. Soil solutions and shallow groundwater may be important early and long-term indicators of watershed recovery as a result of declines in emissions. Data from 8 years of soil solution and groundwater monitoring in Neversink watershed indicate decreases in sulfate concentrations consistent with emission and stream concentration decreases. Sulfate concentrations increase with increased depth in the soil profile below hardwood forest stands, but decrease with depth below hemlock stands. Sulfate in soil solutions under hemlock stands are greater than under hardwoods due to the greater scavenging efficiency of hemlock foliage that increases atmospheric deposition. Soil solution ANC and calcium concentrations do not show any trends that would indicate an incipient recovery in nearby streamwaters. Groundwater and C-horizon water quality is less-responsive than streamwater to individual hydrologic events, and thus provides a less-noisy record for deciphering chemical trends. Deep groundwater in the Neversink watershed may not have exhibited any reductions in sulfate concentrations during the 1990's based on preliminary assessments.

# Persistence of Episodic Stream Acidification in the Northeastern United States

G.B. Lawrence* and Mark David†

Through data collected by the US EPA Episodic Response Program, episodic acidification of streams was well documented by the early 1990's in the northeastern United States. Ongoing research since that time has enhanced our knowledge of the processes involved and the extent of effects. As a result of the direct link between soil and stream water during periods of high soil water flux, inorganic Al concentrations in stream water reach levels that are toxic to fish. Mobilization of inorganic Al in the soil does not occur, however, if base cation availability is sufficient to neutralize inputs of acidity. Despite decreases in acid rain levels, acid anion leaching remains high because nitrogen and sulfur that have accumulated in soils over past decades can be readily oxidized and released. Depletion of the available pool of base cations in the soil over past decades has also reduced the ability of soils to neutralize acidity. These factors have resulted in acidification episodes that have continued through the end of the 20th century. In a first-order stream in the Adirondack Mountains of New York, the sum of base cations minus the sum of acid anions dropped from +164 to –53 microequivalents per liter, pH decreased from 6.34 to 4.17, and inorganic Al concentrations increased by a factor of 10, over a 3-hour period on September 16, 1999. Ineffective neutralization was also observed in seven small watersheds in the Northeast, where the degree of episodic stream acidification was negatively correlated with exchangeable Ca concentrations in the forest floor, but was unrelated to Ca concentrations in the mineral soil.

---

*U.S. Geological Survey, Troy, New York, 12180; phone 518/285-5664; email: glawrenc@usgs.gov
†NRES, University of Illinois, W-503 Turner Hall, 1102 South Goodwin Avenue, Urbana, IL 61801, Phone 217/333-4308, email: m-david@uiuc.edu

# Adirondack Lakes Survey Corporation Long-Term Monitoring Project

W. A. Kretser and K. M. Roy
Adirondack Lakes Survey Corporation

Chemical long-term monitoring of Adirondack Lakes has been on-going since 1982 in an effort to examine spatial and temporal trends. In 1982, 17 lakes were selected for continuous long-term chemical monitoring as a continuation of the US EPA Regional Integrated Lake Watershed Acidification Study (RILWAS). In 1992, this program was expanded by the Adirondack Lakes Survey Corporation to include 52 waters that were more representative of the lake classes found in the Adirondack region. The 17 year record for 16 of the original lakes in this study show a relatively steady rate of decline of $SO_4^{2-}$ concentrations reflecting reductions in atmospheric deposition. Temporal patterns for $N0_3^-$ have not followed the same pattern. From 1982 through 1990, $N0_3^-$ concentrations were generally increasing but began to decline in 1991 with a slight increase from 1992 to 2000 for several of these waters. Preliminary analyses (1992-2000) for the expanded Long-Term Monitoring program also appear to show a steady decline in $SO_4^{2-}$ concentrations (96%) while $N0_3^-$ levels for 26 waters (50%) is increasing. Since 1992, concentrations of base cations have also been decreasing steadily with 49 of 52 waters showing declines. During the spring snow melt period, increases in $N0_3^-$ are evident in nearly all monitoring waters. The magnitude and duration of spring snowmelt pulses are directly related to annual local climatic factors and may be biologically relevant in high snowpack, high runoff years. The 1995 winter was very mild with little snowpack and spring runoff and resulted in approximately half the number of episodically acidified waters found in all other years of the study. Significant chemical differences are also noted among lake categories with thin till and mounded seepage lakes being the most sensitive to acidification processes. Since 1992, 96% of the thin-till class waters have shown decreases in $SO_4^{2-}$ while 44% of these waters are showing increases in $N0_3^-$ concentrations. Since 1997, Geographic Information System(GIS) analysis has been conducted in two major watersheds, the Oswegatchie-Black and the Upper Hudson, providing detailed watershed mapping for 33 LTM waters. Key watershed coverages including wetland types, forest cover, major landscape disturbances (blow downs and fires) have been interpreted. Preliminary efforts to incorporate precipitation data with GIS spatial models shows improved estimates of annual runoff and lake water retention times. Comparisons of New York State deposition data and lake chemistry data are being developed. These GIS products plus more detailed monitoring data are expected to improve future modeling efforts.

# Application of a Biogeochemical Model to Assess Historical and Future Changes in Atmospheric Deposition in the Northeast

Charles T. Driscoll[1, 2], Solomon Gbondo-Tugbawa[1]and Myron J. Mitchell[3]

There is considerable interest in assessments of the response of forest watersheds to changes in inputs of atmospheric deposition. An integrated biogeochemical model, PnET-BGC, was developed to quantify the response of soil and drainage water chemistry to changes in atmospheric deposition and investigate inputs and dynamics of S in the northeastern U.S. The model was applied to a northern hardwood forest at the Hubbard Brook Experimental Forest, New Hampshire. Watershed studies across the northeastern U.S. have shown that stream losses of $SO_4^{2-}$ exceed atmospheric S deposition. Understanding the processes responsible for this additional source of S is critical to understanding ecosystem response to $SO_2$ emission controls. Model simulation using measured dry-to-bulk deposition ratio of 0.21 resulted in an underprediction of soil S pools and stream water $SO_4^{2-}$ concentrations, but the depiction of biotic process (e.g. plant uptake, mineralization) in the model reduced the discrepancy in stream $SO_4^{2-}$ concentration between measured and model predicted value by about 50% compared previous simulations which consider only abiotic processes. Model calculations suggest that an additional source of S, in the form of unmeasured dry deposition or weathering of S minerals is needed to explain the S budget for the site. Long-term simulations showed that elevated anthropogenic S deposition has increased stream $SO_4^{2-}$ concentrations, and the incorporation of S in adsorbed $SO_4^{2-}$ and organic S soil pools. Following the implementation of the 1970 Amendment to the Clean Air Act, decreases in S deposition resulted in the net release of S from these soil pools. Simulation of stable S isotopes showed that fractionation associated with the mineralization of soil organic S might explain the depletion in $^{34}S$ observed between throughfall and stream water. However there is a need for further research on the rate of weathering of various minerals and the isotopic composition of these minerals in order to fully assess the discrepancy in the watershed S mass balance. The results of forecasts of the future response to anticipated decreases in S deposition are highly dependent on the additional source of S to the watershed.

---

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

[2] e-mail: ctdrisco@mailbox.syr.edu, phone: (315)-443-3434, fax: (315) 443-1243.

[3] State University of New York College of Environmental Science and Forestry,
Syracuse, NY 13210-2788, e -mail: mitchell@mailbox.syr.edu, phone: (315) 470-6765, fax: (315) 470-6996

# TECHNICAL SESSION: TEN YEARS AFTER THE 1990 CLEAN AIR ACT AMENDMENTS, PART 3

Session Chair: Kristi Morris, U.S. Fish and Wildlife Service, Air Quality Branch

## Contributions of Nitrogen-fixing Shrubs to the Nitrogen Economy of Adirondack Wetlands

Dudley J. Raynal[1, 2], Todd. M. Hurd[3], and Brian D. Kiernan[1]

Because the Adirondack Mountain region receives elevated levels of atmospheric deposition, concerns over nitrogen pollution have prompted numerous studies linking nitrogen deposition to acidification of surface waters, potential nitrogen saturation, and other ecological effects in the area. Empirical investigations and modeling studies have accounted for many of the sources and sinks of nitrogen in surface waters of the Adirondacks, though few have evaluated the importance of internal biological fixation of atmospheric nitrogen. Wetlands are generally considered important sinks for inorganic nitrogen, but many wetlands contain abundant nitrogen-fixing plant species and thus may be sources of nitrogen. For example, using *in situ* field assays and natural abundance $^{15}N$ analyses, we have measured nitrogen fixation rates of 37 to 43 kg $ha^{-1}yr^{-1}$ by the common wetland shrub, speckled alder (*Alnus incana* ssp. *rugosa*). Total (wet plus dry) deposition of inorganic nitrogen in the Adirondacks ranges from 10-12 kg $ha^{-1}$ $yr^{-1}$. Thus the potential for alder and other nitrogen-fixing shrubs to impact the biogeochemistry of Adirondack wetlands is substantial. This presentation will characterize ongoing studies of the abundance and role of nitrogen-fixing shrubs on the nitrogen dynamics of Adirondack wetland ecosystems.

---

[1] State University of New York, College of Environmental Science and Forestry, Syracuse, NY 13210
[2] 315-470-6782; djr@mailbox.syr.edu
[3] Present address: Department of Biology, Shippensburg University, Shippensburg, PA 17257

# Status of Recovery in Acid-Sensitive Streams in the Catskill Mountains of New York

Douglas A. Burns

The Catskill Mountains of southeastern New York receive among the highest rates of acidic deposition in the Northeast, and the region contains many streams that are sensitive to acidic deposition. Precipitation and stream chemistry has been continuously monitored in the region since 1984. Precipitation at the NADP/NTN site at Biscuit Brook had a volume weighted mean pH of 4.53 in 1999, and the pH has increased about 0.2 units since 1984. The mineral acid content of precipitation in 1999 consisted of about 54% sulfuric acid, 37% nitric acid, and 9% hydrochloric acid. The relative proportion of sulfuric acid in precipitation has declined significantly from 1984 to 1999, because sulfate concentrations have decreased steadily through this period. By contrast, nitrate concentrations in precipitation were relatively constant from 1984-90, but have decreased by about 5 µmol/L during the 1990's. Despite declines of about 25% in the rate of acid deposition in the Catskills since 1984, monitored streams in the region have not shown signs of recovery. Acid-neutralizing capacity (ANC) values have not increased during the 1990's at three monitored streams with a range of baseflow ANC values from about –50 meq/L to 100 meq/L. The lack of recovery in Catskill streams can be attributed primarily to two factors: (1) continued elevated concentrations of nitrate in stream water that have not decreased to the same extent as sulfate concentrations, and (2) long-term decreases in exchangeable calcium (and to a lesser extent magnesium) in watershed soils. Acid-neutralizing capacity is not likely to increase significantly in Catskill streams until the rate of acid-anion leaching decreases sufficiently to allow recovery of soil base status. Additionally, continued variations in stream nitrate concentrations that are unrelated to the rate of atmospheric nitrogen deposition may delay stream recovery.

---

U.S. Geological Survey
425 Jordan Rd.
Troy, NY 12180-8349
(518) 285-5662
daburns@usgs.gov

## Sugar Maple Health in the Northeastern United States: Cation Nutrition and Defoliation Stress

R. A. Hallett*, S. W. Bailey, S. B. Horsley,
R. P. Long, USDA FS, and T. J. Hall, PA DCNR

Unusual mortality of sugar maple has been occurring across northern Pennsylvania since the early to mid-1980's. In New Hampshire and Vermont, the incidence of sugar maple decline-disease is low. We rated sugar maple health on 46 stands in Pennsylvania and New York and 33 stands in New Hampshire and Vermont. Health data were correlated with foliar chemistry data. Foliar Ca and Mg concentrations are higher in healthier stands region wide. Conversely foliar Mn concentrations are higher in less healthy stands region wide. Stands on the Allegheny Plateau stressed by multiple defoliations in the last decade and low foliar Ca and Mg have high mortality. Foliar N concentrations had no statistically significant relationship with sugar maple health.

The results of this study suggest that knowledge of foliar Ca and Mg concentrations in sugar maple canopies can yield information about stand health.

---

*Corresponding author: Richard Hallett, USDA Forest Service, P.O. Box 640, Durham, NH 03824, 603 868-7657;
e-mail: rah@unh.edu

# Seedling Growth and Mortality Responses to Experimental Additions of Calcium and Aluminum in a Northern Hardwood Forest.

Richard K.Kobe[1], Gene E. Likens[2], and Chris Eagar[3].

To assess forest compositional responses to ecosystem losses of calcium and increased aluminum mobilization, we characterized growth and mortality responses of seedlings of five dominant tree species to soil amendments of $CaCl_2$ and $AlCl_3$. At the Hubbard Brook Experimental Forest in New Hampshire, seedlings of sugar maple, American beech, yellow birch, balsam fir, and red spruce were transplanted into experimental field plots (controls, Ca and Al amendments), which were stratified across a gradient of light availability from <1% to approximately 35% full sun. Seedlings of maple exhibited significantly higher and spruce and beech marginally higher mortality in the aluminum-amended plots than in the calcium-amended or control plots. Models of mortality as a function of growth showed similar trends. Based on fitted models of diameter growth as a function of light availability, beech, maple, fir, and birch showed the highest growth under calcium and the lowest under aluminum amendments, but only maple showed statistically significant effects. The integration of significant results into a model of forest community dynamics shows that the subtle effects of lower Ca:Al ratios on only seedling population dynamics can lead to a substantial decrease in sugar maple density and basal area in forested ecosystems.

---

[1] Michigan State University, Department of Forestry, East Lansing, MI 48824
[2] Institute of Ecosystem Studies, Millbrook, NY 12545
[3] USDA Forest Service – NE Research Station, Durham, NH 03824

# Acid Deposition Effects to Forests and Streams in the Southern Appalachian Mountains

Patricia F. Brewer[1], Timothy J. Sullivan[2], Jack Cosby[3], and Ron Munson[4]

The Southern Appalachian Mountains Initiative (SAMI) is a voluntary partnership led by eight southern states with participation by EPA, National Park Service, U.S. Forest Service, industries, environmental groups, academia, and public representatives. SAMI was established to recommend air emissions management strategies to protect natural resources in the Southern Appalachian Mountains, with particular focus on national parks and wilderness areas. SAMI's integrated assessment is focusing simultaneously on ozone, visibility impairment, and acid deposition. SAMI's acid deposition assessment is employing two watershed response models, the Model of Acidification of Groundwater in Catchments (MAGIC) and the Nutrient Cycling Model (NuCM), to evaluate aquatic and forest responses to future levels of sulfur and nitrogen deposition.

A combination of NADP monitoring data and atmospheric model results are being used to represent deposition changes between 1995 and 2040 in response to emissions changes. NADP data for 1991 - 1995, combined with available information on rainfall volumes, have been used to spatially interpolate annual average deposition in the Southern Appalachian Mountains (Lynch, et. Al.) for the five year period. An episodic atmospheric model, the Urban to Regional Multiscale (URM) model, is being used to project deposition in 1995, 2010, and 2040 as a function of SAMI emissions management strategies. Episode results are being scaled to derive annual average deposition for 1995 to 2040 for the 12 x 12 km grid over the Southern Appalachian Mountains. The modeled changes in annual average deposition are being used to adjust NADP monitoring data to represent implementation of SAMI strategies. For each stream or forest, spatially and temporally adjusted monitoring data will be used to define deposition inputs for the MAGIC and NuCM models.

Initial analyses indicate that reductions in sulfate and nitrate deposition of 50-70 and 40 percent, respectively, from 1990 levels may be needed to prevent further acidification of high-risk watersheds. The watershed models are currently being calibrated for 120 streams and 12 forested watersheds. Deposition strategies will be finalized in January 2001 and resource responses to SAMI strategies will be reported in June 2001.

---

[1] SAMI Technical Coordinator, Interchange Building, 59 Woodfin Place, Asheville, NC 28801
[2] E&S Environmental Chemistry, Inc., P. O. Box 609, Corvallis, OR 97339
[3] Department of Environmental Sciences, Clark Hall, University of Virginia, Charlottesville, VA 22903
[4] Tetra Tech, Inc., 2696 N University Ave Suite 255, Provo, Utah 84604

# Controls on Nitrogen Retention in Forested Watersheds

Gary M. Lovett[1], Kathleen C. Weathers[1], and Mary A. Arthur[2]

As deposition of sulfur decreases in the eastern U.S., nitrogen (N) takes on an increasingly important role in surface water pollution. Our understanding of the factors regulating N retention and loss from watersheds is incomplete, and consequently our model predictions of surface water response to changing nitrogen emissions are suspect. In the Catskill Mountains of New York State, we have observed a wide range in the stream water N export from small forested watersheds. The differences in N export correspond to differences in N retention, ranging from about 50% to >90% of atmospheric N deposition. The differences in N export do not appear to be related to differences in atmospheric deposition, topographic features, or groundwater inflow to streams. We observe that N export is lowest, and N retention is highest, in watersheds dominated by oak forests. Comparison of N cycling in single-species stands of major tree species in the Catskills shows a near absence of nitrate production in oak stands. We hypothesize that the chemical properties of the organic matter developed under oaks inhibits the production of nitrate, thus greatly decreasing N leaching and increasing N retention. Tree species composition may play a major role in controlling N retention and loss in forested watersheds.

---

[1] Institute of Ecosystem Studies, Millbrook, NY 12545
[2] University of Kentucky, Lexington, KY

# TECHNICAL SESSION: TEN YEARS AFTER THE 1990 CLEAN AIR ACT AMENDMENTS, PART 4

Session Chair: Mark Nilles, U.S. Geological Survey

# Results from the Mountain Acid Deposition Program

Selma Isil
Harding Environmental Science & Engineering

The Mountain Acid Deposition Program (MADPro) was initiated in 1993 as part of the research necessary to support the objectives of the Clean Air Status and Trends Network (CASTNet). The main objectives of MADPro were to develop automated cloudwater measurement systems and to update the cloudwater concentration and deposition data collected in the Appalachian Mountains during the National Acid Precipitation Assessment Program (NAPAP) in the 1980s. Measurements were conducted from 1994 through 1999 during the warm season at three 'permanent' mountaintop sampling stations: Whiteface Mountain, New York; Clingman's Dome, North Carolina; and Whitetop Mountain, Virginia.

Cloudwater concentrations of major ions ($SO_4^{2-}$, $NO_3^-$, $NH_4^+$, and $H^+$) for Whiteface and Whitetop Mountains did not show any statistically significant trends. In contrast, Clingman's Dome demonstrated a statistically significant upward trend in seasonal $SO_4^{2-}$, $NO_3^-$, and $H^+$ values.

Cloudwater deposition estimates were made by applying the cloudwater deposition computer model, CLOUD (Lovett, 1984), parameterized with site-specific cloudwater chemistry and meteorological data. Monthly cloudwater depositions were highly variable with depositions typically peaking in July or August. Seasonal depositions were highest for Whiteface Mountain because of the higher wind speeds and LWC experienced at this site. No trend was evident in the deposition data.

Dry, wet and cloud depositions were calculated on a monthly basis for June through September for 1994 through 1998. Between 80 and 90 percent of S deposition occurred via cloud exposure at all three sites, and 90 to 95 percent of $NH_4^+$ deposition occurred via cloud deposition at the southern sites. Cloud deposition also accounted for 70 to 87 percent of the total $H^+$ loading at all three sites. Dry deposition was a very minor contributor to the total S and $NH_4^+$ loading, but contributed between 22 and 28 percent of N deposition and approximately 15 to 16 percent of $H^+$ deposition at the southern sites.

Total deposition values from MADPro sites are also compared to total deposition values from nearby low-elevation CASTNet sites.

# Assessing the Impact of the Acid Deposition Control Program in the Presence of Natural Variability

Kevin Civerolo[1], Elvira Brankov[1], S. T. Rao[1,2]*, and I. G. Zurbenko[2]

Policy makers are interested in assessing the effectiveness of regulatory programs that have been implemented in improving environmental quality. For example, a goal of the acidic deposition control program in the United States has been to link specific emissions control policies, such as those mandated under the Title IV of the Clean Air Act Amendments (CAAA) of 1990, to improvements in air and water quality. Recently, several researchers have reported trends in time series of pollutant data in an effort to evaluate the effectiveness of the CAAA in reducing the acidic deposition problem. It is well known that pollutant concentrations are highly influenced by natural variations such as those induced by synoptic-scale weather fluctuations, intra-seasonal forcing (Madden-Julian Oscillation), year-to-year variations in the seasonal amplitude, 2-5 year oscillation (ElNino-Southern Oscillation), and other climatic variations. Analysis of pollutant concentration time series reveals the presence of spatial and temporal inhomegenities in the acid deposition data induced by the differences in the data collection, reduction, and reporting practices. These natural variations and artifacts in pollutant data can significantly affect the trend estimates. Using observations at a few sites, this paper illustrates that linear trend estimates in concentrations of $SO_4^=$ and $NO_3^-$ can be biased in the presence of such complex features in the pollutant time series data. We present a methodology to discern breaks or discontinuities in the time series of pollutant concentrations stemming from emission reductions in the presence of meteorological/climatological variability. Also, we discuss an approach to perform an integrated analysis of both photochemical modeling results and observations of air quality and acid deposition that would enable policy makers to evaluate the impact of the emission reductions and refine pollutant control strategies.

***Key Words:*** *Acid precipitation; Trend detection/attribution; Time series analysis, Discontinuities*

---

[1] New York State Department of Environmental Conservation, Albany, NY

[2] Department of Biometry and Statistics, University at Albany, Rensselaer, NY

*Corresponding author: Dr. S. T. Rao, Office of Science and Technology, New York State Department of Environmental Conservation, 50 Wolf Road, Albany, New York 12233-3259

# Assessing the Results of Title IV: Are Further Emission Reductions Necessary?

Richard Haeuber

The new millennium marks the ten year anniversary of the creation of Title IV and the completion of the first phase of the Acid Rain Program (1995-1999). Various recent workshops, analyses, and government reports used the completion of Title IV Phase I implementation as an opportunity to assess whether the emission reductions goals and programs established under Title IV (both Phase I and II) are sufficient to achieve the environmental and human health objectives envisioned by Congress and the public in 1990. Recent questioning of the sufficiency of Title IV also has spawned various legislative proposals for further emission reductions. This presentation first examines the projected achievements of a fully implemented Title IV with regard to $SO_2$ and $NO_X$ emissions, deposition of sulfur and nitrogen, particulate matter, and visibility. Modeling results based on a $SO_2$ and $NO_X$ emission reduction scenario are then used to assess the potential environmental and human health impacts of further emission reductions.

---

U.S. Environmental Protection Agency
Clean Air Markets Division (6204J)
Ariel Rios Building
1200 Pennsylvania Ave., N.W.
Washington, D.C. 20460
202-564-2667
202-565-2140 (fax)
haeuber.richard@epa.gov

# From Obstacle to Opportunity:
# How Acid Rain Emissions Trading is Delivering Cleaner Air

Joseph Goffman[1], Andrew Aulisi*[2], Daniel Dudek[3]

The report has two related subjects. The first four parts of the report analyze the emissions performance and economic results of the EPA's sulfur dioxide ($SO_2$) emissions trading program. The fifth part discusses design issues in "cap and trade" regulatory programs in relation to the Kyoto Protocol on climate change. The review of the $SO_2$ program highlights its notable success from both an economic and an environmental perspective, with particular emphasis on the following results: (1) power plants reduced $SO_2$ emissions 22% below the levels required as compared to the restricted number of base allocations initially allotted to them by Congress, resulting in 7.3 million tons of extra emissions reductions; (2) when taking into account all Phase I emissions allowances issued under the program, including allowances for certain technologies and auction allowances, actual emissions were 30% lower than the level that was legally permitted; (3) the extra reductions have occurred in the absence of any federal or state action to restrict the saving or transfer of allowances; (4) the cost of $SO_2$ reductions, as reflected indirectly in the price of traded $SO_2$ emissions allowances, is far below the cost predicted during the initial debates on the program; and (5) reductions in sulfate deposition have been observed in sensitive geographic areas affected by atmospheric transport of sulfur. The conclusion of the report enumerates a set of environmental policy challenges characterized by the imperative of achieving substantial reductions in air pollution quickly and inexpensively.

---

[1] Phone: (202) 387-3500 jgoffman@environmentaldefense.org
[2] Phone: (212) 616-1230 aaulisi@environmentladefense.org
[3] Phone: (212) 505-2100 ddudek@environmentaldefense.org
*Corresponding author:
Environmental Defense†
257 Park Avenue South
New York, NY 10010
†a national, New York-based nonprofit organization

# New York State Acid Deposition Monitoring Network Description
# Data and Differences from NADP

Paul Sierzenga and Garry Boyton
Bureau of Air Quality Surveillance
New York State Department of Environmental Conservation

The New York State Department of Environmental Conservation began an acid deposition monitoring network in 1986 which currently consists of twenty sites throughout all of New York State. These are located in the major urban areas as well as the sensitive rural areas of the Adirondack and Catskill Mountains. This is a long term monitoring effort intended to identify trends and generate relevant information for policy makers. Laboratory analysis of the samples is performed by NYSDEC staff using DIONEX$^{tm}$ ion chromatography.

This oral presentation will describe the New York State network and analysis procedures highlighting differences with the NADP network. Some of the data trends will also be presented while a more complete data trend analysis of all the sampling locations will be provided in the poster session.

## TECHNICAL SESSION : COASTAL EUTROPHICATION

Session Chair: Susan Johnson, Minnesota Pollution Control Agency

# Atmospheric Nitrogen Inputs to the Delaware Inland Bays: The Importance of Ammonia

Joseph R. Scudlark[1] and Megan J. Roadman
Graduate College of Marine Studies
University of Delaware
Lewes, DE 19958

A recent assessment of nitrogen loading to Delaware's Inland Bays (presented at last fall's NADP Technical Committee Meeting) indicates that atmospheric deposition provides 15-25% of the total N input to these eutrophic estuaries. Almost half of the atmospheric DIN wet flux is in reduced form ($NH_4^+$), which for aquatic organisms is the most readily available form of this nutrient. Particularly conspicuous is the 60% increase in precipitation $NH_4^+$ concentration over the past 20 years noted at Lewes, DE, which parallels a similar increase in chicken production on the Delmarva peninsula over this period (which now stands at nearly 530 million birds annually). To further examine the relationship between local $NH_3$ emissions and deposition, gaseous $NH_3$ concentrations have been monitored at 13 sampling sites across the Inland Bays watershed using passive sampling devices. Mean concentrations range from $<1$ µg/m$^3$ at an isolated forested site, to $>5$ µg/m$^3$ at a location $\approx$150 m from a poultry house; at the latter site, airborne concentrations $>15$ µg/m$^3$ have been detected in individual samples. Initial data indicate a strong concentration gradient across the watershed, which is consistent with the spatial distribution of poultry houses (as determined by GIS analysis of aerial photographs). Highest $NH_3$ concentrations generally occur during spring and summer, when fertilizer application is greatest and seasonally elevated temperatures induce increased rates of microbial activity and volatilization from soils and animal wastes. A comparison of precipitation chemistry between our NADP/AIRMoN site (DE02) and a satellite site established in the southwestern Inland Bays watershed indicates that on a local/regional scale, precipitation composition generally reflects the gradient in airborne $NH_3$ concentration.

---

[1] scudlark@udel.edu

## New Faces, New Places: The Growing Air Deposition Community Along the Coasts

Tamara Saltman

There is a new constituency for atmospheric deposition data. Coastal watershed managers are becoming increasingly aware that atmospheric deposition of nitrogen, and sometimes toxics such as mercury and PAHs, are a significant source of pollution loading in many coastal waters. While there is much we do not know about the exact role of atmospherically-deposited pollutants in coastal ecosystems, we know it is not possible to ignore it any longer. NADP has begun to address the need for basic deposition data by accepting some coastal sites into the network. However, more needs to be done both on the monitoring and the research sides to meet the needs of coastal data users. The presentation will outline the basics of what we already know about coastal atmospheric deposition, discuss some of the policy issues surrounding the issue, and present data and research needs that NADP may have a role in meeting.

---

U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
(202) 564-8982
saltman.tamara@epa.gov

# Wet Deposition of Atmospheric CNP on a Delmarva Coastal Plain Basin

E. J. Rochelle-Newall[2], T. R. Fisher[1,3], G. Radcliffe[1]

Using NADP protocols, samples were collected for 2 years from two sites in or near the Choptank River basin. We measured $PO_4$, TP, $NH_4$, $NO_3$, TN, DOC, and CDOM (chromophoric dissolved organic matter), some of which are not routinely monitored by NADP. All concentrations were inversely related to rainfall amounts, and all statistics were volume-weighted. TN averaged 43 µM, ~75% of which was inorganic. TP concentrations were low, averaging 0.1 µM, of which ~50% was $PO_4$. DOC averaged 66 µM, and CDOM was 1.3 NFlU, both lower than previously reported for this region,. By repeatedly subsampling a rain event maintained in an Aerochem sampler over a week, we found that there were no losses of TN, although ~50% of the DON was converted to $NH_4$. However, ~90% of both $PO_4$ and TDP were removed, probably by biological processes. These results indicate that the NADP protocol underestimates deposition of P and DON and overestimates $NH_4$ deposition. Furthermore, previous reports using older methods appear to have overestimated deposition of both DOC and CDOM. Compared to terrestrial diffuse and point sources of N and P to the Choptank estuary, atmospheric deposition was <5% of the total inputs.

---

[1] Horn Point Laboratory, Center for Environmental Science, University of Maryland, Cambridge, MD, USA.

[2] Observatoire Océanologique, Villefranche-sur-mer, France.

[3] E-mail: fisher@hpl.umces.edu; Fax: 410-221-8490

# Anthropogenic Nitrogen Inputs to Thirty-Four Watersheds on the Atlantic and Gulf Coasts of the United States

Mark S. Castro[1]*, Charles T. Driscoll[2],
Thomas E.Jordan[3], William G. Reay[4],
Walter R. Boynton[5], Sybil Seitzinger[6] and Renee V. Styles[6]

We quantified the anthropogenic nitrogen (N) inputs to the watersheds of 34 estuaries on the East and Gulf coasts of the United States and the point and non-point source N inputs into these estuaries. Total anthropogenic N inputs to the watersheds of these estuaries ranged from 6 kg N $ha^{-1}$ $yr^{-1}$ for St. Catherines-Sapelo Island Sounds to 71 kg N $ha^{-1}$ $yr^{-1}$ for the Tampa Bay, and averaged 28 kg N $ha^{-1}$ $yr^{-1}$ over all 34 watersheds. Nitrogen fertilization was the dominant anthropogenic N input to these watersheds (38%), followed by atmospheric nitrate deposition (21%), net food import (18%), nitrogen fixation (13%), and net feed import (10%). Nitrogen inputs to the 34 study estuaries ranged from 5 kg N $ha^{-1}$ $yr^{-1}$ for Casco Bay, Maine to 51 kg N $ha^{-1}$ $yr^{-1}$ for Massachusetts Bay. Total N inputs to 15 of the 34 estuaries were dominated by urban N sources (point sources, septic system and non-point source runoff); point sources accounted for 39% to 88% of the total N inputs to these urban dominated estuaries. Total N inputs to 18 of the 34 estuaries were dominated by agricultural N sources; N fertilization was the dominant source (46%), followed by manure (32%) and N fixation by crops (15%). Atmospheric deposition (runoff from watershed plus direct deposition to the surface of the estuary) accounted for 8 to 61% of the total N inputs these 34 estuaries. Only three estuaries (Barnegat Bay 58%, St. Catherines-Sapelo 47%, and Terrebonne-Timbalier 61%) had atmospheric contribution greater than 30% of the total N inputs. Atmospheric deposition was the dominant N input to Barnegat Bay because effluent from wastewater treatment plants are discharged offshore and bypasses the estuary. Atmospheric N inputs to St. Catherines-Sapelo Island Sounds and Terrebonne-Timbalier Bays were dominated by direct deposition to the surface of the estuary, which accounted for 37% and 85% of the total atmospheric N input to these estuaries, respectively.

---

[1] Appalachian Laboratory, 301 Braddock Road, Frostburg, Maryland 21532, phone: (301) 689-7163, FAX (301) 689-7200, e-mail: castro@al.umces.edu
[2] Department of Civil and Environmental Engineering, Syracuse University, Syracuse, NY 13422
[3] Smithsonian Environmental Research Center, 647 Contees Wharf Road, Edgewater, Maryland 21037
[4] Virginia Institute of Marine Science, Gloucester Point, Virginia, 23062
[5] Chesapeake Biological Laboratory, Solomons, Maryland 20688
[6] Institute of Marine and Coastal Sciences, Rutgers University, Brunswick, New Jersey, 08901
*Corresponding author

# Use of Thymol as a Biocide to Eliminate the Loss of Ammonium from Weekly Deposition Sampling Buckets

David Whitall[1]* and Hans Paerl[2]

Previous studies have demonstrated differences in the measured deposition ions $H^+$, $NH_4^+$, $NO_3^-$ and $SO_4^{2-}$ ions when a weekly wet deposition sampling program is compared to a daily or event based sampling program. Undersampling has been reported for the weekly sampling regime for $H^+$, $NH_4^+$, $NO_3^-$ and $SO_4^{2-}$. These ions are important to ecologists and environmental managers from an acidity ($H^+$, $NO_3^-$ and $SO_4^{2-}$) perspective and for nutrient budgets/eutrophication issues in the cases of $NO_3^-$ and $NH_4^+$. These differences have been attributed to biological alterations of the ions in the sample bucket. Thymol ($C_{10}H_{14}O$) has been effectively used as a biocide to prevent changes in $NO_3^-$ and $NH_4^+$ concentrations in the sample bucket as part of a watershed level study in the Neuse River basin in eastern North Carolina. In laboratory studies, $NH_4^+$ losses were reduced by 22% and $NO_3^-$ losses were reduced by 3%; in both cases using thymol made nutrient losses statistically negligible. The advantages of thymol over other preservatives (such as HgO and formalin) are that it can be added as a solid, it is relatively less toxic to humans than other biocides and it is compatible with Lachat Autoanalyzer techniques for $NH_4^+$ and $NO_3^-$.

---

[1, 2] University of North Carolina at Chapel Hill, Institute of Marine Sciences. Morehead City, NC 28557
*Corresponding author: 3431 Arendell St. Morehead City, NC 28557; 252-726-6841x135; psu-fan@email.unc.edu.

# Ten Years of Aquatic Monitoring

William G. Hagar[1] and James J. Norman[2]
Biology Department
University of Massachusetts Boston
Boston, MA 02125

Instrumentation for monitoring acid precipitation has improved over the last ten years to provide reliable results for evaluating aquatic systems. Our laboratory group has improved computer-based monitoring systems to reduce the power consumption by the devices and improve their reliability. Initially, we used the RCA Corporation Model 1802 computer for remote data logging and operational control (Hagar, W.G. and R. Volpicelli (1990), "Cordless Phone Data Logger", Patent Number 4,914,686). We then moved to modified Radio Shack Model 100 computer connected to a portable pH meter. The new modification allowed for continuous on site monitoring of pH and temperature in freshwater ponds for longer time periods (Stallsmith et al.(1996), "The Effect of Acid Episodes on Lepomis Sunfish Recruitment and growth in Two Ponds of Different Buffering Capacity in Massachusetts" Freshwater Biology 36: 730- 740). Nowadays, there are packaged devices that include pH and other sensors along with a data logging system for continuous measurements. Our laboratory group uses some of these devices for pH monitoring, but also uses a modified data collection system. Our new system includes an upgrade to palm top technology to connect the monitoring pH system to the laboratory. We will share this new technology as well as give an overview of aquatic deposition for the last ten years.

---

[1] william.hagar@umb.edu
[2] jjnorman@cs.umb.edu

# TECHNICAL SESSION: AIR TOXICS AND THE ENVIRONMENT, PART 1

Session Chair: Alan Van Arsdale, U.S. Environmental Protection Agency

# Single-storm Event Mercury Deposition near a Combustion Point Source

Eric M. Prestbo[1], Julie Calhoun, Rob Mason[2] and John Sherwell[3]

The US EPA is expected to make a ruling at the end of the year 2000 on whether utility coal combustion sources should be regulated for mercury emissions. This is due to the "plausible link" between utility coal emissions and Hg input to sensitive aquatic ecosystems through air transport, chemical transformation and finally, deposition. However, in the 1997 EPA Mercury Report to Congress, the EPA acknowledges that the linkage is not quantitative due to lack of adequate Hg data near Hg sources. The purpose of the study presented here is to begin to fill this known data gap. In a previous study, simulated plumes were generated and the fate and transport properties of mercury were determined with a static plume dilution chamber (SPDC). Using simulated rainwater input, the more water-soluble gaseous Hg(II) fraction in the SPDC plume was readily washed out. We present here a complimentary ground-based study to determine the deposition rates of Hg within 3 kilometers of a combustion point source. The study was designed to sample an individual rain event, both upwind and downwind of the point source to gauge the direct local Hg impact. Samplers were deployed just hours prior to a rain event, based on predicted incoming storms with the desired wind direction. A total of 21 sampling sites were located around the point source, with 3 samples in the upwind location. There were also 3 locations where throughfall samples were collected under vegetation to provide a measure of integrated deposition. The total Hg in deposition data was supported by capture of data from the internet including NEXRAD radar images, wind speed, wind direction and NOAA HYSPLIT back trajectories. Also, for some rain events, trace metal and major ion data was measured. The first phase of the data interpretation will be presented as a descriptive analysis of the deposition and meteorological data generated for each storm.

---

[1] Frontier Geosciences, 414 Pontius Avenue N., Seattle WA 98109 (ericp@frontier.wa.com)

[2] Chesapeake Biological Lab, University of Maryland System, Solomons, MD 20688

[3] Maryland Power Plant Research Program, Maryland DNR, Annapolis, Maryland

# Mercury and Trace Metal Deposition at Urban and Rural Sites in Maryland

Robert Mason, Nicole Lawson and Guey-Rong Sheu
Chesapeake Biological Laboratory
University of Maryland
Solomons, MD, 20688

The atmosphere is an important source of mercury (Hg) and other trace metals to aquatic systems. However, while there has been a recent focus and heightened examination of Hg in wet deposition in locations throughout the USA through the Mercury Deposition Network (MDN), there has not been the same emphasis on the atmospheric inputs of other trace metals. Nor has the importance of urban areas as sources been addressed by MDN as it was not structured with that intent. The MDN results nevertheless clearly show an west-east trend in increasing total Hg concentration in precipitation with states such as Maryland (MD), the Carolinas and Florida having the highest concentrations. By comparison, concentrations are lower in the northeast, and the lowest concentrations are found on the west coast. Our studies in and around Baltimore, MD have demonstrated that Hg deposition is enhanced by local sources within the urban landscape, and this is also true for a number of trace metals. Furthermore, Hg concentrations correlate with those of other metals, suggesting particular urban sources. These correlations are less evident at the more rural locations. Using both our data and that of others, the paper will discuss our results for Hg and contrast the urban/rural signal of Hg with that of the other important trace metals such as cadmium, copper, lead, and zinc.

# Trends in Wet Deposition of Mercury, 1995-1999

Clyde W.Sweet[1], Eric Prestbo[2], and Robert Brunette[2]

Mercury Deposition Network (MDN) operates sites in the United States and Canada to monitor total mercury in wet deposition. Weekly data from 43 locations are reported for the years 1995-1999. The median mercury concentration for 4500 samples collected in MDN during this period is 9.7 ng/L. Volume-weighted total mercury concentrations are lowest in New England (6 ng/L) and the Canadian Maritime provinces and highest in Florida (12 ng/L). Wet deposition of mercury depends on both the concentration in the rain and the total rainfall amount. Wet deposition of mercury ranges from over 20 $mg/m^2/yr$ in south Florida to about 4 $mg/m^2/yr$ at remote sites in the western U.S. Mercury deposition is strongly seasonal in eastern North America. In the summer, the average mercury concentration in rain is about double that found in the winter. The average wet deposition of mercury is more than 3 times higher is summer than in winter. In the upper Midwest (8 sites in Minnesota and Wisconsin), there was a significant increasing trend in mercury concentration and deposition of about 9% per year between 1995 and 1999. There was no significant change in annual rainfall amount in this region during the same period. No significant increasing or decreasing trend in either mercury concentration, mercury deposition, or annual rainfall amount was found in other regions or in eastern North America as a whole.

---

[1] Illinois State Water Survey, Champaign, IL
[2] Frontier Geosciences, Seattle, WA

# Mercury Deposition to the Lake Champlain Watershed: Cloud Water, Cloud Throughfall and Precipitation Measurements on Mt. Mansfield, VT

Elizabeth G. Malcolm[1], Gerald J. Keeler[1, 2],
Sean T. Lawson[3], Timothy D. Sherbatskoy[3]

The lack of high quality measurements of Hg in cloud water led to the design of a new collector for sequential sampling of cloud and fog water using clean techniques. Cloud water was collected during nine non-precipitating cloud events on Mt. Mansfield, VT between August 10 and October 16, 1998. Mercury cloud water concentrations ranged from 7.5 to 71.8 ng/L with a mean of 22.8 ng/L. During four of the events, cloud throughfall measurements were made under a red spruce-balsam fir canopy. Event precipitation samples were collected during the cloud sampling period in Underhill, Vermont near the base of Mt. Mansfield. Mercury deposition for the study period was estimated to be approximately twice as high from cloud water at the summit versus that of precipitation at the lower elevation site. Meteorological analysis and trace metal data suggest that highest Hg cloud water concentrations were associated with transport form the Mid-Atlantic and Ohio River Valley, and lowest concentrations with transport from the north of Mt. Mansfield out of Canada. The data from the cloud study period will be discussed in the context of the longest event precipitation record in the world collected at the Underhill, Vermont site.

---

[1] University of Michigan Air Quality Laboratory, 109 S. Observatory St., Ann Arbor, MI 48109
[2] Email: jkeeler@umich.edu (734) 936-1836
[3] School of Natural Resources, University of Vermont, Burlington, VT 05405-0088

# A New Look at Missing Sinks and Sources in the Global Mercury Cycle

S. E. Lindberg, S. Brooks, T. Meyers, H. Zhang, and L. Chambers
Oak Ridge National Laboratory and National Oceanic and Atmospheric Administration

In the past decade many new sources of diffuse mercury emissions have been measured. These sources significantly increase the estimates of global Hg emissions, and suggest there may be missing Hg sinks in global models. Mercury levels in Arctic wildlife are elevated above normal levels, but there are few known Arctic Hg sources, and long range transport of Hg° must be considered. The discovery of mercury depletion events (MDE, similar to ozone depletion) at Alert, NWT suggests a mechanism for Hg accumulation from the global pool. One hypothesis is that Hg° is transformed into a reactive gaseous mercury (RGM) species which deposits locally. This species has never been measured in the Arctic, and MDE's must be confirmed at other Arctic sites.

We have measured total gaseous Hg at Barrow, AK, since September 1998, with an automated analyzer. The initial data provide the first confirmation of MDE's at this more southerly, Arctic site. MDE events begin soon after Polar sunrise, and persist until snowmelt. During MDE Hg exhibits a strong correlation with ozone, suggesting a links with the reactions that destroy tropospheric ozone. We have developed a simple model using local meteorological data which closely simulates the patterns of depletion events, and suggest that turbulence and temperature are important factors. There are a number of potential reaction pathways with Hg and Br to explain the depletion events, which suggest that during these events Hg° is oxidized to RGM. The model predicts a Hg deposition rate much higher than measured in the eastern U.S. To test our hypotheses, we are measuring RGM prior to and following polar sunrise during winter 2000, and plan to measure Hg speciation and evasion in snowmelt during polar summer.

## TECHNICAL SESSION: AIR TOXICS AND THE ENVIRONMENT, PART 2

Session Chair: Richard Artz, National Oceanic and Atmospheric Administration

# Bioindication of Atmospheric Heavy Metal Deposition in the Blue Ridge Using the Moss *Thuidium Delicatulum*

Jonathan S. Schilling[1] and Mary E. Lehman[2]
Natural Sciences - Longwood College
Farmville, VA 23909

Reliable bioindication of atmospheric heavy metals in the southern Appalachians using an ectohydric moss has been limited by the availability of species used in analogous studies. In this study, heavy metal concentrations were quantified in the tissue of fern moss *Thuidium delicatulum* (Hedw.) in the central Blue Ridge of Virginia. The objectives of the project were to evaluate the suitability of fern moss for moss-monitoring studies in the southern Appalachians, to compare local metal concentrations, and to test the effects of several geographical and environmental variables on deposition.

Fern moss was sampled over four mountains in Virginia using a sampling protocol applicable to a deciduous forest. Extraction of moss tissue followed the standard protocol of the German moss-monitoring method, and analysis was performed by graphite furnace-AAS.

---

[1] University of Maine
Hitchner Hall - c/o Jody Jellison
Department of Biological Sciences
Orono, Maine 04469
(207) 866-4057
Jonathan.Schilling@umit.maine.edu
[2] (804) 395-2658

# Research on Potential Effects of Mercury on Behavioral Changes of Piscivorous Birds, With Emphasis on the Common Loon (*Gavia Immer*), in the Northeastern United States and Eastern Canada

Andrew Major[1], David Evers[2], and Neil Burges[3]

Studies on the possible causes of the reported decline of the Common Loon (*Gavia immer*) have been undertaken by U.S. and Canadian scientists in eastern North America. Since 1993 a consortium of investigators have studied territorial pairs and non-nesting birds in Northeastern U.S. and the Eastern Canadian Maritime Provinces to determine the possible links between mercury in freshwater ecosystems and biomagnification of mercury in these piscivorous birds.

*G. immer* is monogamous and shows territorial fidelity, returning to the same nesting site or home range year after year. This makes them ideal subjects for long-term studies of the potential effects of persistent biological toxic elements and compounds on fish-eating bird populations. Field studies of Canadian and Northeastern U.S. loons during the breeding season and during overwintering, indicate that elevated concentrations of mercury in blood may play a role in the reproductive success of loon pairs.

The research protocols which have been developed for the Common Loon have been recently applied to other piscivorous birds, including Belted King Fisher (*Ceryle alcyon*) and Common Merganser (*Mergus merganser*). The foraging and breeding territories of these birds, as is the case with loons, also overlap areas where geochemical and lake morphology patterns present high risk levels of mercury exposure.

---

[1] USFWS, New England Field Office, Concord, NH
[2] BioDiversity Reserach Institute, Freeport, ME
[3] Canadian Wildlife Service-Atlantic Division

# Assessing Hg and Methyl-Hg Burdens in VT and NH Lakes, and Historical Trends in Hg Deposition to VT and NH Lake Sediments

Neil Kamman[1] *, Dr. Charles T. Driscoll[2], Dr. Daniel Engstrom[3],
David Evers[4], Robert Estabrook[5], and Peter Lorey[6]

In 1998, US EPA funded a Regional Environmental Monitoring and Assessment Program effort to assess total and methylmercury concentrations in multiple matrices of a large spatially-randomized sample of VT and NH lakes. The experimental design of the study is such that results can be applied to the entire population of lakes across VT and NH which are 8 hectares in size and larger.

The project carries four distinct components: 1) Measurement of Hg, methyl-Hg, and relevant physico-chemical parameters in epilimnetic and hypolimnetic waters, and profundal sediments, of 90 lakes; 2) Measurement of Hg in macrozooplankton and yellow perch of 45 lakes; 3) Measurement of Hg and relevant biomarkers related to Hg contamination of loons and other piscivores in up to 45 lakes; and 4) Paleolimnological investigations of recent (<200 yBP) Hg deposition to 13 undisturbed lakes across the study region. This project overview includes initial findings from the physico-chemical and biological studies, and detailed paleolimnological findings.

The paleolimnological investigations have shown that HgT flux rates ranged from between 6 and 22 *u*g•m$^{-2}$•yr$^{-1}$ at the core bases, to between 20 and 82 *u*g•m$^{-2}$•yr$^{-1}$ at modern times. These values are in agreement with results from Midwestern and Adirondack lake sets. In the present lake set, there exists a synchronous increase in flux rates to all lakes, corresponding approximately to the 1850 core strata. In all but two lakes, Hg fluxes are presently declining significantly, and this reversal began in all cases by the 1980 core strata. We attribute these declines to reductions in atmospheric Hg contributions.

The historical direct atmospheric Hg contribution to the study lake set was estimated by the method of Swain and Engstrom at 9.3 *u*g•m$^{-2}$•yr$^{-1}$, and the modern direct contribution at 19.7 *u*g•m$^{-2}$•yr$^{-1}$. This latter value is within the range of atmospheric wet-Hg deposition reported from a site at Underhill, VT over the past several years, but is significantly lower than estimated wet+dry deposition. Watershed Hg retention for historic and present times was estimated by the method of Lorey and Driscoll.

Our paleolimnological findings present additional evidence that Hg fluxes to northeastern lake waters are presently in decline, but that they remain quite elevated in relation to baseline contributions. Further, the present study-set provides a baseline against which future declined in atmospheric Hg deposition can be evaluated.

---

[1] VT Department of Environmental Conservation, 103 S. Main St. 10N, Waterbury, VT 05671-0408 Phone: 802 241-3795 E-mail: neil.kamman@state.vt.us

[2] Department of Civil and Environmental Engineering, Syracuse University

[3] St. Croix Watershed Research Station, Science Museum of Minnesota

[4] Biodiversity Research Institute

[5] NH Department of Environmental Services

[6] Department of Civil and Environmental Engineering, Syracuse University

*Corresponding author

# The National Dioxin Air Monitoring Network (NDAMN): Results of the First Year of Atmospheric Measurements of CDDs, CDFs, and Dioxin-like PCBs in Rural and Agricultural Areas of the United States: June 1998 – June 1999

David H. Cleverly[1], Dwain Winters[2], Joseph Ferrario[3], John Schaum[1],
Aubry Dupuy[3], and Christian Byrne[3]

The U.S. EPA has established a National Dioxin Air Monitoring Network (NDAMN) to determine the temporal and geographical variability of atmospheric CDDs, CDFs and dioxin-like PCBs at rural locations throughout the United States. Consisting of 29 sampling stations, NDAMN has three primary purposes: (1) To provide measurements of background atmospheric levels of dioxin-like compounds in different geographic regions of the U.S.; (2) To determine the atmospheric levels of dioxin-like compounds in agricultural areas where livestock, poultry and animal feed crops are grown; and (3) To provide data to evaluate results from long-range transport and deposition air models. NDAMN has been implemented in phases, with the first phase consisting of 9 monitoring stations. NDAMN is being implemented in phases. Phase 1 consists of an array of 10 monitors at 9 sites. A duplicate sampler (station 2) is colocated at site 1. Each station consists of a PS-1 PUF sampler. The sampling medium has two components: a quartz fiber filter (QFF) to collect and retain particulate matter ($\geq$ 0.1 microns); and a polyurethane foam plug (PUF) to collect and retain gaseous phase compounds. In order to achieve a target 0.1 fg $m^{-3}$ level of detection (LOD) necessary to avoid non-detects in air, the sampling moment was 24 days of sampling over a 28-day period, on a weekly schedule of 6 days of continuous operation followed by one day of inactivity. Each week, on the day the sampler was inactive, the QFF was harvested, yielding 4 composite samples per sampling moment. The PUF was harvested once at the end of the sampling moment. Sampling proceeded with a regime of sampling 24 days, every other month. This produced 6 sampling moments over the year: (1) 6/23/98 – 7/21/98; (2) 8/18/98 – 9/15/98; (3) 11/24/98 –12/22/98; (4) 1/26/99 – 2/23/99; (5) 3/23/99 – 4/20/99; and (6) 5/18/99 – 6/15/99. Although not perfectly aligned with seasons, such a scheme did encompass different climatic conditions. Samples were shipped to EPA's Environmental Chemistry Laboratory for extraction, clean-up and analysis with HRGC/HRMS in accordance with EPA Method 1613. The analytes of interest in this monitoring program are the CDDs, CDFs substituted in the 2,3,7,8 positions on the molecule, and the so-called coplanar PCBs (IUPAC PCB-77; PCB-105; PCB-118; PCB-126; PCB-156; PCB-157 and PCB-169). Results from Phase 1 has yielded an overall annual average $TEQ_{df}$–$WHO_{98}$ air concentration of CDDs, CDFs measured at nine rural stations is 12 fg $m^{-3}$. The detailes and air monitoring results of the first phase of NDAMN will be presented.

---

[1] National Center for Environmental Assessment (8623D), Office of Research and Development, United States Environmental Protection Agency, 1200 Pennsylvania Ave., NW, Washington, DC 20460

[2] Office of Prevention, Pesticides and Toxic Substances, United States Environmental Protection Agency, 401 M St., SW, Washington, DC 20460

[3] Environmental Chemistry Laboratory, United States Environmental Protection Agency, Stennis Space Center, MS 39520

## TECHNICAL SESSION: ATMOSPHERIC DEPOSITION MONITORING AND ASSESSMENT

Session Chair: Dennis Lamb, Pennsylvania State University

## Changes in High-elevation Lake Chemistry in the Western United States, 1985-99

David W. Clow and M. Alisa Mast
U.S. Geological Survey
Box 25046 MS 415
Denver, Colorado 80225, USA

A chemical survey of 72 high-altitude lakes in 7 national parks in the western United States was conducted during the fall of 1999; the lakes were previously sampled during the fall of 1985 as part of the Western Lake Survey. Changes in lake chemistry were compared to changes in precipitation chemistry between 1985 and 1999. Sulfate and nitrate concentrations in lakes showed a slight decline ($p<0.05$). Sulfate in precipitation showed widespread declines but nitrate and ammonium concentrations in precipitation generally increased. There were no widespread trends in calcium concentrations in either lake water or precipitation. Spatial patterns in sulfate and nitrate concentrations in lakes are similar to those in precipitation (higher in the Rocky Mountains than in the Sierra), reflecting the importance of atmospheric deposition on high-elevation surface waters.

Variations in climatic conditions may confound direct comparisons of changes in lake and precipitation chemistry. It may be possible to partly account for climatic variations using surface-water chemistry models developed at intensively-monitored sites, which is a primary focus of ongoing research.

# Composition and Changes in Atmospheric Deposition at a Forested Site Near Atlanta, Georgia from 1985 to 1999

Norman E. Peters[1] and Tilden P. Meyers[2]

The trends in dry and wet deposition were investigated using data from a weekly sampling network to evaluate deposition processes at the Panola Mountain Research Watershed (PMRW), a forested research site 25 km southeast of Atlanta, Georgia. Atmospheric deposition has been monitored using various methods at PMRW since 1985, as a satellite site of both the Atmospheric Integrated Monitoring Network (AIRMON-dry) and the National Trends Network (NTN). The weekly monitoring consists of deciduous and coniferous throughfall (1995-99), wet-only deposition using NADP/NTN protocols (1985-99), and dry deposition monitoring and computations using micrometeorological methods (1985-1997). These data were compared for overlapping collection periods and analyzed for temporal trends. From 1986-99, the annual wet deposition of S and N averaged 400 and 300 eq $ha^{-1}$ (6.4 and 4.2 kg $ha^{-1}$), respectively. Inferential model estimates of annual dry S and N deposition from 1986-97 averaged 230 and 160 eq $ha^{-1}$ (3.7 and 2.2 kg $ha^{-1}$), respectively. From 1995-99, net S deposition (dry deposition plus canopy interactions) for coniferous and deciduous throughfall (throughfall minus wet-only precipitation) averaged 360 and 170 eq $ha^{-1}$ (5.8 and 2.7 kg $ha^{-1}$), respectively. The inferential model estimates are within this range and the variation in net S deposition for throughfall is attributed to variations in collector efficiency, the type of canopy, and differences in the canopy surface area. The pH of precipitation is acidic, the annual volume-weighted mean (VWM) pH (derived from the VWM $H^+$ concentration) was 4.43 for the entire period and 4.51 from 1995-99. Coniferous throughfall also is acidic having an annual VWM pH of 4.42 from 1995-99. Annual average VWM pH (from $H^+$) concentrations in wet only precipitation increased (statistically significant at $p<0.05$) on average by 0.03 pH units per year from 1985 through 1994 and then decreased by 0.05 pH units per year since 1994. The pH increase was associated with statistically significant decreases in acid anion ($NO_3^-$ and $SO_4^{2-}$) concentrations. Concentrations of base cations ($Mg^{2+}$ and $Ca^{2+}$) also decreased from 1985-94, but the decrease was small compared to that of the acid anions. From 1995-99, the pH increase was associated with an increase in $NO_3^-$ and $SO_4^{2-}$concentrations, although smaller increases also were observed in $Mg^{2+}$ and $Ca^{2+}$ concentrations. The trends in base-cation and acid-anion concentrations of the filters from the AIRMON-dry monitoring system were comparable to the wet-only precipitation concentrations. The recent increase in S and N deposition does not reflect emission reductions associated with the 1 January 1995, implementation of Phase I of Title IV of the 1990 Clean Air Act Amendments. However, the increased deposition may result from increased local emissions associated with urban development in the region.

---

[1] USGS, 3039 Amwiler Rd., Suite 130, Atlanta, GA, 30360-2824; nepeters@usgs.gov

[2] NOAA/ATDD, Oak Ridge, TN 37831-2456; tilden.meyers@noaa.gov

# Chemical Indicators of Sulfur Wet Deposition: Sensitivity to Nitrogen Oxides and Hydrocarbons

Ariel F. Stein and Dennis Lamb
Department of Meteorology
Penn State University

The wet deposition of sulfate in eastern North America is chemically linked to the abundance of oxidants in the lower troposphere and, therefore, also, to the emissions of nitrogen oxides (NOx) and volatile organic compounds (VOC) within the region. The sensitivity of sulfate deposition to future NOx and VOC controls depends in part on the resulting changes in oxidant levels and the competition that naturally exists between clear-air and in-cloud oxidation. This issue is addressed here, through theory and model calculations, using a unique combination of the afternoon concentrations of nitric acid ($HNO_3$), hydrogen peroxide ($H_2O_2$), and ambient sulfate ($SO_4^{2-}$) as "indicator species" of the $SO_4^{2-}$/VOC/NOx sensitivity. The concentrations of these indicator species are calculated from a series of photochemical model simulations with varying rates of NOx and VOC emissions. This study shows that the deposition of sulfate is likely to be VOC-sensitive when the non-dimensional "sulfate indicator" is less than about unity. A higher value of the indicator identifies a NOx-sensitive sulfate regime. The transition between NOx and VOC-sensitive regimes and the sulfate-formation pathways are also analyzed theoretically.

# Atmospheric Deposition to Complex Landscapes: HRDM - A Strategy for Coupling Deposition Models to a High-Resolution GIS

Eric K. Miller

A spatially distributed modeling environment was developed which couples detailed models of atmosphere-landsurface heat, mass and momentum transfer to a high-resolution GIS. The high-resolution distributed model (HRDM) was developed for a series of applications including: estimates of total deposition to lake-watershed ecosystems, regional studies of pollutant accumulation in soils, and regional studies of air pollution effects on ecosystem health, productivity and carbon sequestration. High-resolution models are required to address these issues because tremendous variation in temperature, wind speed and cloud immersion are known to occur within 1 km due to the complex topography of the region. The biophysical characteristics of receptor surfaces also vary substantially at scales less than 1 km. Such local variation in meteorology and receptor surface can result in large (4-5X) and ecologically significant variation in deposition over small distances. The HRDM estimates seasonal and annual deposition at 90- to 30-meter ground resolution subject to the constraints of positional and characterization accuracy of land surface and atmospheric descriptive data. The model includes precipitation, cloud water interception, and dry deposition. The HRDM offers the opportunity to evaluate patterns of total atmospheric deposition in response to landscape factors such as topography and receptor surface type at a scale appropriate for the spatial gradients that exist in the complex mountainous terrain of the northeastern United States.

---

Ecosystems Research Group, Ltd., PO Box 1227, Norwich, VT 05055
Environmental Studies Program, Dartmouth College, Hanover, NH 03755
Phone:802-291-0831 / Email: eric.k.miller@dartmouth.edu

# Retention of Atmospherically-deposited Inorganic N in Soil Solution: Climatic Differences in the Contributions of Wet and Dry Deposition

R.H. Grant and K. L. Scheeringa
Purdue University

Excess nitrogen (N) deposition can be defined as the nitrogen deposited over and above that needed for the sustained 'health' of an ecosystem. This study evaluated the relationship between climate and inorganic N in the soil solution using multi-year records of precipitation and deposition form NADP and CASTNET monitoring stations in the eastern U.S. and simulated water budgets and inorganic N transformations of nitrification and denitrification. Results show that:

1) For most locations in the eastern U.S., soil solution inorganic N from wet and dry deposition equilibrated to levels varying from 1 kg/ha to 15 kg/ha if only nitrification occurs.
2) The timing of dry deposition strongly influenced the proportion of the deposition that remains available in the soil water, with dry deposition during cold periods resulting in reduced nitrification and denitrification in the soil solution but dry deposition during dry periods resulting in no denitrification and little nitrification. Denitrification can deplete essentially all available N due to atmospheric deposition when the soil is near saturation.
3) The impact of denitrification on soil solution N was greater in the warmer, moister climates than the cooler, dry climates, with the denitrification essentially removing all atmospherically-deposited inorganic N in the warm moist climates.

In conclusion, the soil-available inorganic N depends on the presence of denitrifying bacteria, the timing and amount of dry deposition, and the climate.

# Month-to-Month Variation in Precipitation Ion Concentrations at NADP/NTN Sites

Gary J. Stensland
Illinois State Water Suarvey
Champaign, IL

It has been recognized for many years that concentrations of precipitation constituents such as sulfate vary during the year. The variations are the result of variation during the year of source emissions and of meteorological variables such as temperature, wind direction, mixing heights and precipitation type that affect the air concentrations, partitioning between gaseous and particulate species and the precipitation scavenging processes.

The fine temporal and spatial coverage by NADP/NTN allows for a more comprehensive examination of seasonal concentration patterns than has been possible in the past. Because of the long temporal record the data will be grouped and analyzed by month instead of some longer averaging period.

This study summarizes the monthly concentrations at NADP/NTN sites across the 48 contiguous states. Maps of the month at each site of the highest median concentration show the considerable variation across the 48 states and between different ion groups. For example ammonium concentrations are highest for eastern sites during months 4,5, and 6; for central plains sites during months 2,3, and 4; for southwestern sites during month 6; and for northwestern sites during month 8.

Ammonium concentration variation by month will be examined in detail and compared to expected variation in the major ammonia emission sources: livestock, fertilizer losses and emission from crops. The latter has recently been suggested to be the dominant source for the Midwest but this study does not support this hypothesis.

# An Exploration of Data Accompanied by Comment Codes From the Clean Air Status and Trends (CASTNet) Network

Luther Smith
ManTech Environmental Technology
Two Triangle Drive
Research Triangle Park, NC 27709

Ambient gaseous and particulate concentration data from the CASTNet dry deposition monitoring program are examined with respect to whether data from samples containing comment codes may be different than data from samples with no codes. The questions of whether commented samples may yield values that appear to be too high and whether concentrations from samples with wet filters differ from those from uncommented samples are addressed. Data were analyzed for each of the various monitored chemical species on a site-by-site basis. Generally, the results suggest that there are differences between samples that have comments and those that do not.

# The Scoop on Total Nitrogen Deposition: A Look at Status and Trends in the Northeast

Gary Lear and David Schmeltz
U.S. Environmental Protection Agency

The Clean Air Status and Trends Network (CASTNet) is the nation's primary source for atmospheric data on the dry deposition component of total acid deposition. Used in conjunction with NADP, CASTNet provides data to evaluate the effectiveness of national emission control strategies. This is accomplished by characterizing the dry deposition component of total acid deposition and estimating trends and spatial patterns. This presentation features an analysis of CASTNet and NADP data and reports the status and trends of total nitrogen deposition loadings in areas of the northeast.

# POSTER SESSION
# (IN ALPHABETICAL ORDER BY FIRST AUTHOR)

# New Electrode Methodology for pH Measurement in Precipitation Samples

Sue Bachman, Tracie Patten, and Tom Bergerhouse
Central Analytical Laboratory
Illinois State Water Survey
Champaign, Illinois 61820

The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) has been collecting and analyzing precipitation samples for over 20 years. The environmental community values this program for its long term, continuous, and comprehensive sampling and analysis, and its high quality data validation and verification procedures. The Central Analytical Laboratory (CAL) at the Illinois State Water Survey, Champaign, Illinois, is committed to improving its performance of the chemical analyses of precipitation samples. The CAL staff is responsive to the ever changing needs of the program by continually improving the efficiency and accuracy of these measurements.

A vital laboratory consideration is the choice of instrumentation used to perform sample analyses. As technology improves so does the availability of new products and methods. One such method is the manner in which the pH (acidity) of a precipitation sample is measured. Currently, the CAL measures the acidity of precipitation samples received by the processing lab with a Broadly-James epoxy-bodied, double-ceramic-junction electrode. A sample volume of at least 2 milliliters (preferably 4 milliliter) is used to rinse then accurately read each sample. In an effort to pursue suggestions and requests by users and researchers, we began examining other available electrodes. Reducing sample volumes, and rapid, reliable readings for low- ionic strength samples were defined requirements for systems being evaluated.

One such electrode is the *Sentron* series of pH probes, available in several designs for a variety of applications. The standard RED-LINE and the STREAM LINE series are appropriate for our low ionic strength, low volume needs. Each probe's design incorporates the working principle of an ISFET (ion selective field effect transistor). "A chemical principle combined with an electronic driving circuit is used instead of relying on the physical properties of a type of glass"[1]. An imbedded micro sensor responds to the $H^+$ concentration (sensing current between the electrodes) from a small aliquot of sample (50-100 µl). Both a flow type reference probe developed especially for low conductance applications and the drop sample and flat bottomed probe tip developed for small samples were evaluated.

Comparison between the Broadly-James electrode and the *Sentron* probes with precipitation samples and controlled reference solutions were made. Parameters examined included accuracy and precision, speed of analysis, analyst ease of use, and cost. Other considerations reviewed included storage options, ruggedness, cleaning methods and electrode specifications.

---

[1] Sentron pH Meter Argus X, Operations Manual, Reference #E7500174, 02, September 1999

# Analytical and Field Considerations in the Design of an Atmospheric Deposition Sampler

John S. Beach, Jr., Vice President
N-CON Systems Co., Inc.
Crawford, GA 30630

As no analyses can be more accurate than the samples on which they are made, the importance of representative and reliable sample collection is essential. The evolution over the past two decades of analytical requirements and techniques and the breakdown of aging equipment have created the need for a new generation of atmospheric deposition sampling devices.

Design considerations include:

Reliability, in uncovering and covering of the sample collection container(s) at the onset and end of a precipitation event
Minimize splash and sample contamination
Ability to perform in a wide range of temperatures and wind conditions
Ability to collect up to 4 individual samples with different analytical requirements
Simple to install, yet rugged
Simple in field "Plug and Play" maintenance

This paper describes the development of a new atmospheric deposition sampler to meet the stringent criteria of NADP/NTN and other precipitation chemistry networks, based on technical requirements and user "wish lists".

# Acidic Deposition Reduction

Edward P. Bennett, Special Projects Coordinator
James E. Close, Environmental Program Specialist

Title IV of the Clean Air Act of 1990 provided an initial attempt to reduce the impacts of acidic deposition. [We note briefly the results and how it has failed to make significant reductions in acid rain effects in Adirondacks] In addition, the *Acid Deposition Standard Feasibility Study* has pointed to the need for additional reductions of Oxides of Nitrogen ($NO_x$) and Sulfur Dioxide ($SO_2$). Control of these pollutants now extend beyond Title IV, but a holistic approach is needed in order for these regulatory approaches to achieve optimal effectiveness and control of acidic deposition. These regulatory approaches include Title I (Non-compliance with the Ozone Standard), Title IV (Acidic Deposition), New Source Performance Standards, Ambient Air Quality Standards, Utility Deregulation, etc. This poster session considers the current emission reductions achieved under these programs and the synergistic effects of potential reductions under New York State's ongoing efforts, including Governor Pataki's initiative, enforcement actions against Clean Air Act (PSD) violations by coal-fired utilities, national legislation, and Canadian and provincial reduction efforts.

---

Division of Air Resources
New York State Department of Environmental Conservation
Albany, New York 12233-3255

# Trace Metals in Wet-Deposition: New Initiative for the Mercury Deposition Network

Bob Brunette[1, 2] and Eric Prestbo[1] and Clyde Sweet[3]

Trace metals measurements in wet-deposition, in addition to mercury, is a critical component in the determination of the source, transport and input to aquatic and terrestrial ecosystems. Recent legislation such as the Total Maximum Daily Load (TMDL) and Toxic Release Inventory (TRI) has further demonstrated the need to measure trace metals in wet deposition. Thus, the NADP has begun the process of approving trace metals measurements to the program. In 1998, the Mercury Analytical Lab (HAL) began a new initiative to develop this capability for the Mercury Deposition Network (MDN). The focus of this new initiative is to add the US EPA priority trace metals Sb, As, Be, Cd, Cr, Cu, Pb, Ni, Se, Ag, Tl, Zn in addition to Hg. For sites where source-receptor chemical-mass-balance studies are to be done, additional metals such as V, Mn, Fe and Al to name a few, can be added to the list. With the advent of US EPA 1600 Series analytical trace metals techniques, previously difficult trace metals measurements have been improved sufficiently, to more accurately and precisely measure the low concentration ranges (ppt) expected in wet-only deposition. A trace metals clean sample train and modified second chimney of the MDN Aerochem collector was custom designed for this new initiative. The trace metals sample train and MDN Aerochem modifications will be described in detail. As a first step, these new techniques were applied to measure trace metals at a select number of MDN sites throughout the network. In addition, results of a full suite of trace metals measured at MDN Site WA18 over the past two years will be reported. Finally, results from an intensive, event-based trace metal study will be shown.

---

[1] Frontier Geosciences, 414 Pontius Ave. N., Seattle WA 98109
[2] bobb@frontier.wa.com
[3] Illinois State Water Survey, Champaign, IL

# Potential Effects of Climate Change on Atmospheric Wet Deposition at a Site in Central Pennsylvania

Anthony R. Buda[1, 2] and David R. DeWalle[1]

Changes in regional climate can alter the basic weather conditions that control the transport, chemical transformation, and eventual deposition of atmospheric pollutants. In central Pennsylvania, climate change is projected to increase mean annual temperatures by four degrees Celsius and precipitation amounts by about five percent through 2100. The objective of this research was to determine how changes in temperature and precipitation would affect concentrations and loads of sulfate, nitrate, ammonium, and hydrogen ions in atmospheric wet deposition at NADP Pennsylvania Site 15. Wet deposition data (event-based) were obtained from the MAP3S and the AIRMoN monitoring programs. Multiple linear regression models were used to predict log-normal concentrations using mean temperature on the day of an event and total precipitation amount for an event as predictor variables. Results showed significant positive effects of temperature on concentrations and loads of pollutants in wet deposition for all pollutants except nitrate. Precipitation negatively affected the concentration of pollutants due to dilution, but the reduced concentration did not completely offset the increase in load due to increased amounts of precipitation. Projected climate change through 2100 at this central PA site would increase overall loads of pollutants in wet deposition by 3 to 30 percent.

---

[1] School of Forest Resources, 136 Land and Water Building, The Pennsylvania State University, University Park, PA 16802; (814) 863-0130
[2] arb7@email.psu.edu

# Pre and Post Phase I Clean Air Act Amendments Impacts on Precipitation $SO_4^=$ and $H^+$, and Dry Deposition Sulfur Species and Prospects for Recovery of Acid Sensitive Ecosystems

Tom Butler, Cornell University
Gene Likens, Cary Arboretum

Pre- and Post -Phase I Clean Air Act Amendments emissions changes are reflected in changes of precipitation $SO_4^=$ and $H^+$, as well as in dry deposited sulfur species ($SO_2$ and particulate $SO_4^=$ ) for several regions in the eastern U.S. In most cases, relations between emissions changes and changes in concentrations of acid-forming species show near 1:1 relationships, in areas affected by Phase I $SO_2$ reductions. A notable exception is the southern Appalachian mountain regions which shows the least improvement in wet and dry sulfur species and essentially no improvement in precipitation acidity. This is an acid sensitive area receiving some of the highest deposition rates in the country.

No strong relations have been found between changes in NOx emissions and changes in precipitation $NO_3^-$ and atmospheric concentrations of $HNO_3$ vapor (the major component of N dry deposition). This is most likely due to very limited changes in NOx emissions, despite Phase I implementation.

Hopefully, the subject of ecosystem recovery in the Northeast or the lack thereof, will also be addressed. The bottom line here is that long-term depletion of soil acid neutralizing capacity may delay ecosystem recovery of acid sensitive areas. Thus further emissions reductions will be necessary.

# Assessment of the Contribution Made by Different Nitrogen Sources to the Total Nitrogen Inputs to Thirty-Four Estuaries on the East and Gulf Coasts of the United States

Mark S. Castro[1]*, Charles T. Driscoll[2],
Thomas E.Jordan[3], William G. Reay[4],
Walter R. Boynton[5], Sybil Seitzinger[6] and Renee V. Styles[6]

We quantified the anthropogenic nitrogen (N) inputs to the watersheds of 34 estuaries on the East and Gulf coasts of the United States and the point and non-point source N inputs into these estuaries. Total anthropogenic N inputs to the watersheds of these estuaries ranged from 6 kg N $ha^{-1}$ $yr^{-1}$ for St. Catherines-Sapelo Island Sounds to 71 kg N $ha^{-1}$ $yr^{-1}$ for the Tampa Bay, and averaged 28 kg N $ha^{-1}$ $yr^{-1}$ over all 34 watersheds. Nitrogen fertilization was the dominant anthropogenic N input to these watersheds (38%), followed by atmospheric nitrate deposition (21%), net food import (18%), nitrogen fixation (13%), and net feed import (10%). Nitrogen inputs to the 34 study estuaries ranged from 5 kg N $ha^{-1}$ $yr^{-1}$ for Casco Bay, Maine to 51 kg N $ha^{-1}$ $yr^{-1}$ for Massachusetts Bay. Total N inputs to 15 of the 34 estuaries were dominated by urban N sources (point sources, septic system and non-point source runoff); point sources accounted for 39% to 88% of the total N inputs to these urban dominated estuaries. Total N inputs to 18 of the 34 estuaries were dominated by agricultural N sources; N fertilization was to dominant source (46%), followed by manure (32%) and N fixation by crops (15%). Atmospheric deposition (runoff from watershed plus direct deposition to the surface of the estuary) accounted for 8 to 61% of the total N inputs these 34 estuaries. Only three estuaries (Barnegat Bay 58%, St. Catherines-Sapelo 47%, and Terrebonne-Timbalier 61%) had atmospheric contribution greater than 30% of the total N inputs. Atmospheric deposition was the dominant N input to Barnegat Bay because effluent from wastewater treatment plants are discharged offshore and bypasses the estuary. Atmospheric N inputs to St. Catherines-Sapelo Island Sounds and Terrebonne-Timbalier Bays were dominated by direct deposition to the surface of the estuary, which accounted for 37% and 85% of the total atmospheric N input to these estuaries, respectively.

---

[1] Appalachian Laboratory, 301 Braddock Road, Frostburg, Maryland 21532, phone: (301) 689-7163, FAX (301) 689-7200, e-mail: castro@al.umces.edu
[2] Department of Civil and Environmental Engineering, Syracuse University, Syracuse, NY 13422
[3] Smithsonian Environmental Research Center, 647 Contees Wharf Road, Edgewater, Maryland 21037
[4] Virginia Institute of Marine Science, Gloucester Point, Virginia, 23062
[5] Chesapeake Biological Laboratory, Solomons, Maryland 20688
[6] Institute of Marine and Coastal Sciences, Rutgers University, Brunswick, New Jersey, 08901
*Corresponding author

# Difficulties in Interpreting Trends in Acid Deposition in the Presence of Natural Variability

Kevin Civerolo[1], Elvira Brankov[2], S. T. Rao[2,4], John Kent[3], and Igor Zurbenko[4]

Evaluating trends in acid deposition data is difficult, since such data are strongly affected by meteorological and climatological variations operating on different time scales. Such natural variability leads to widely-varying patterns of acid deposition, even at two nearby receptor sites. Using smoothed precipitation-weighted $SO_4^=$ and $NO_3^-$ data from nearby National Atmospheric Deposition Program (NADP) and New York State Department of Environmental Conservation (DEC) monitors, we show that different data sets can yield different trend estimates. We also present the difficulties in interpreting trend estimates using different methodologies.

---

[1] New York State DEC, Bureau of Air Research, Albany, NY
[2] New York State DEC, Office of Science and Technology, Albany, NY
[3] New York State DEC, Bureau of Air Quality Planning, Albany, NY
[4] University at Albany, Department of Biometry and Statistics, Albany, NY

# An Analysis of Ecoregion Coverage by Current NADP/NTN Sites

Brooke Conley and Mark Nilles

In the early 1980's, the agencies and other organizations developing the National Trends Network (NTN) developed a set of criteria to determine the optimum site locations for the network. One of the major design goals of the NTN was for the network to estimate deposition across the U.S. by locating representative sites in the various ecoregions of the United States. When the NTN was established, approximately 150 sites were included in the network design. Since the networks inception, numerous site closures, site relocations and site additions have occurred and today the network consists of approximately 220 sites. By superimposing the current NADP/NTN site locations onto the recently updated North American Ecoregions map, we can determine ecoregion coverage by NTN sites on both an absolute and equal area basis, thus estimating the relative coverage by NTN sites across the various ecoregions in the U.S.

Despite many changes in the network over the past two decades, at least one NADP/NTN site is located in each ecoregion of the contiguous United States. The ecoregion 221b, which encompasses a significant portion of the upper Mississippi and Ohio River valleys, has the greatest number of sites of any ecoregion with 33 sites. The ecoregions with the lowest number of sites are 261, 262, 313, M131, M132b, M263, and R with 1 site each. Because ecoregions vary considerably in size, ecoregion coverage was normalized to unit area to gain a better understanding of which sites have greater or lesser coverage on a per unit area basis. The ecoregions 251, 314, and M241 have the greatest site coverage on a unit area basis while ecoregions 241 and 252 have the least coverage with NTN sites on a unit area basis. Some of the differences in absolute and unit area coverage are due to other network design criterion which call for increased number of sites in areas of high depositional gradients and additional sites to represent sensitive ecosystems. In order to provide a comprehensive assessment of current network adequacy, additional research is needed which would incorporate all network design criteria, updated network objectives and current site locations.

---

Colorado School of Mines
U.S. Geological Survey
BOX 25046 M.S.
401Denver Federal Center
Denver, CO 80225
Phone:(303) 236-1846(303) 236-1878;
E-mail:bconley@usgs.gov; manilles@usgs.gov

# A Five-Year Statistical Study of AIRMoN Field Blank Samples

Brigita Demir, Kaye Surratt, and Jane Rothert
Illinois State Water Survey
Champaign, Illinois

AIRMoN is the daily wet deposition sampling sub-network of NADP with ten sites currently in the network. The sites chosen for this study were IL11 at Bondville, IL; TN00 at Oak Ridge, TN; NY67 at Ithaca, NY; and DE02 at Lewes, DE which represent the western, southern, northern, and eastern regions of the network. The five-year time interval studied was 1995 through 1999. Four quality assurance (QA) solutions used for field blanks will be investigated. The four QA solutions are DI water, two concentrations of simulated rainwater, and a pH 4.3 nitric acid solution. The sulfate, ammonium, and hydrogen ion concentrations in the first three QA solutions and the nitrate, ammonium, and hydrogen ion concentrations in the fourth QA solution will be compared. The absolute differences of the volume-weighted DF (the portion of solution poured from the sample bottle to the sample collection bucket) and DK (the solution that remains in the sample bottle) field blanks and the effect of time and regional differences on them will be investigated and presented.

# Impacts of Changing Emissions Policies on Stream Water Chemistry in the Mid-Appalachians

David R. DeWalle, Bryan R. Swistock, and William E. Sharpe

The impacts of changes in atmospheric deposition due to the 1991 Clean Air Act Amendments (CAAA) on stream water chemistry were evaluated in five forested watersheds in the Mid-Appalachian region of Pennsylvania. Major reductions in wet deposition of sulfate from the atmosphere have occurred in the region. Concentrations of major anions and cations in stream water corrected for discharge levels were compared between pre-CAAA (1988-95) and post-CAAA (1997-99) periods. No discernible differences in stream concentrations at a given discharge were apparent between periods, with one exception. High sulfate concentrations that occurred at low flows during some dry-weather events in the pre-CAAA were absent in the post-CAAA period. However, pre-CAAA streamflow was intensively sampled during events, while post-CAAA streamflow was only sampled monthly. Lack of high sulfate concentrations during low-flow events may be an early response to atmospheric deposition changes or simply a reflection of differing stream sampling protocols. Regardless, stream chemistry response to air pollution policy changes generally appears to be delayed in the Mid-Appalachian region.

---

School of Forest Resources and Environmental Resources Research Institute
107 Land and Water Building
The Pennsylvania State University
University Park, PA 16802
814-863-3532
drdewalle@psu.edu

# An Analysis of NADP Site Systems and Performance Survey Data: Summary and Use of 1998-1999 Results for the NTN Network

Scotty R. Dossett and Greg Dzurisin
NADP Program Office
Illinois State Water Survey
Champaign, IL

The NADP Systems and Performance Surveys, funded by the United States Environmental Protection Agency, gather data related to several aspects of NTN field site operations. Preliminary results from the first complete round will be presented. Specifically; survey data regarding: 1) local siting criteria; 2) field equipment attributes and performance; and 3) operator procedure are discussed.

During the survey period 196 individual sites were visited and there were 12 (6%) surveys which were incomplete because of weather problems.

Of the sites surveyed 106 (54%) exhibited at least one type of violation of the local siting criteria. The most frequently violated criteria was that objects taller than 1 meter should not be within 5 meters of the collector. In this group the largest single violation was due to raingages being too close to the collector, these accounted for 47% of all cases. Vegetation was found to be greater than 1 meter tall within 5 meters in only 5 cases. The second most violated siting criteria involved the projection of any obstacle over the horizon of the site by greater than a 45 degree angle. Twenty sites had trees which violated this criteria. Maps and plots show the extend and severity of these criteria violations.

Field equipment variability measures involved, sensor gap and heating measurements and motor box opening time and power production tests. In general the goal of network equipment uniformity is being met. Data summaries will be used to illustrate this.

Operator compliance with standard operating procedures was found to be good with the areas of pH electrode agitation and rinsing and conductance cell rinsing techniques receiving the most remedial action. Only 2 sites were noted to have had significant problems with field sample handling procedures.

In addition to the results noted above, the NADP Program Office is working on databases which will allow the easy electronic viewing of a photographic and site sketch suite by quality control personnel and network data users. A prototype of this utility will be shown.

# Influences of Data Inhomogeneities on Trend Detection and Attribution

Christian Hogrefe[1], Heather L. Wakeley[2], and S. Trivikrama Rao[1,3] *

To illustrate the effects of data inhomogeneities on trend detection, we present an analysis of time series of hourly ozone and nitrogen dioxide measurements in Los Angeles for the time period 1981 to 1999. The accuracy of the reported concentrations was changed in 1994 from 0.01 ppm to 0.001 ppm. Our analysis reveals that trend estimates for both pollutants are affected by as much as 2.5 % per year by this data artifact, if trends estimated from the original data are compared to trend estimates from a homogenized data set. Since this value is larger than the expected benefits from implemented control policies (such as the implementation of the reformulated gasoline program in January 1992; the reformulated diesel program in October 1993; and the clean burning fuel program in 1995), it is evident that great care must be taken to perform trend analysis on a homogenized data set. In addition, it is demonstrated that the influences of data inhomogeneities on trend estimates differ based on the metric used. Specifically, we computed trends in hourly 1-hour average concentrations, 8-hour average concentrations, the daily maximum 1-hour average concentrations, and the daily maximum 8-hour average concentrations for both ozone and nitrogen dioxide for both the original and homogenized data set. It is shown that for both ozone and nitrogen dioxide, the effect of data inhomogeneities is largest when trend estimates are based on time series of hourly 1-hour or 8-hour average concentrations and smallest when trend estimates are based on the daily maximum 1-hour average concentrations. However, for time series of nitrogen dioxide concentrations, trend estimates are not as influenced by data inhomogeneities compared to time series of ozone concentrations. In this paper, we demonstrate that trend estimates themselves are very sensitive to the metric considered. We compare trend estimates derived from hourly data with trend estimates derived from the daily maximum concentrations for both Los Angeles and a location in New Jersey. To explain the differences of trend estimates for different metrics, we spectrally decompose the hourly time series and investigate the long-term behavior of intra-day, diurnal and synoptic-scale fluctuations embedded in time series of daily maximum concentrations.

---

[1] Department of Earth and Atmospheric Sciences, University at Albany, Albany, NY 12222
[2] Thayer School of Engineering, Dartmouth College, Hanover, NH, 03755
[3] New York State Department of Environmental Conservation, Albany, NY 12233
*Corresponding author: Dr. S. Trivikrama Rao, Office of Science and Technology, New York State Department of Environmental Conservation, 50 Wolf Road, Albany, NY 12233
Email: strao@dec.state.ny.us; Tel: (518) 457 3200; Fax: (518) 485 8410

# Spatial Patterns of Precipitation Quantity and Chemistry in the Adirondack Region of New York

Mari Ito [1]*, Myron J. Mitchell [2] and Charles T. Driscoll[3]

Empirical relationships were developed for precipitation quantity and concentrations of strong acids in wet deposition in order to estimate wet deposition of strong acids across the Adirondack region of New York. Annual wet deposition of chemical species was more closely related to annual ion concentration than to annual precipitation quantity at the six monitoring stations in the Adirondack Park from 1988 to 1999. This pattern suggests that it is important to consider the variability of ion concentrations in estimating wet deposition across the region. During the period from 1988 to 1999, multiple regression analyses showed that variations in the mean annual precipitation and the mean monthly precipitation (for most months) were largely explained by variations in longitude, latitude, and elevation. A decreasing gradient from the southwest to the northeast was evident for annual and winter precipitation, but did not occur for summer precipitation. The examination of the concentrations of sulfate, nitrate, and hydrogen ions at the six monitoring stations suggested that there were significant geographic differences in these ion concentrations within the region. Sulfate concentrations also increased with elevation. Hydrogen ion concentrations increased from the north to the south.

---

[1] State University of New York College of Environmental Science and Forestry, One Forestry Drive, Syracuse, NY 13210-2788

[2] State University of New York College of Environmental Science and Forestry, Syracuse, NY 13210-2788

[3] Department of Civil and Environmental Engineering, Syracuse University, Syracuse, NY 13244

*Corresponding author: mito@mailbox.syr.edu, Phone: (315) 470-6916, Fax (315) 470-6996

# Mercury in Adirondack Wetlands, Lakes, and Terrestrial Systems

Melissa Kalicin[1]*, Margaret Lindeman[1], Charles T. Driscoll[1],
Robert Newton[2],Ron Munson[3], Walt Kretser[4], Joseph Yavitt[5]

A detailed study is being conducted on the biogeochemistry of mercury at Sunday Pond watershed in the Adirondack region of New York. Sunday Pond watershed is largely forested, with an abundance of wetlands. This study involves the measurement of mercury and methyl mercury in wet deposition (through the NADP MDN Program), soil, soil waters, surface waters and sediments. We estimate wet deposition of mercury to the site to be 10.8 μg/m$^2$-yr, with 0.6% of this occurring as methyl mercury. Concentrations and fluxes of total and methyl mercury are greatly elevated in forest floor leachate, with soil solution concentrations decreasing in the mineral soil. Soil concentrations of total mercury were highest in the forest floor (13-188 ng/g). Soil concentrations were low in the E horizon (3.7-25.2 ng/g), higher in the zone of organic deposition or Bh horizon (1.3-3.4 ng/g) and low in the lower mineral soil or Bs horizon (1.7-3.1 ng/g). Lake inlet concentrations of total mercury ranged from 1.3 to 11.5 ng/L, with a mean of 3.0 ng/L. Methyl mercury concentrations were somewhat lower ranging from less than 10% to over 50% of total mercury. Lake concentrations of mercury ranged from 2.0 to 15.9 ng/L, with methyl Hg ranging from 0.2 to 0.7 ng/L. Drainage water concentrations of mercury seem to be related to concentrations of dissolved organic carbon. A preliminary mass balance shows that wet deposition of total mercury is retained in the watershed. Sunday Pond is a sink for inputs of mercury. However, the watershed and lake are sources of methyl mercury to downstream surface waters.

---

[1] Department of Civil and Environmental Engineering, Syracuse University, Syracuse, NY 13244, ctdrisco@mailbox.syr.edu, phone (315) 443-3434, fax (315) 443-1243.

[2] Smith College, Clark Science Center, Department of Geology, Northampton, MA 01060, NEWTON@science.smith.edu, phone (413) 585-3946, fax (413) 585-3786.

[3] Tetra Tech, Inc., 661 Andersen Dr., Foster Plaza 7, Pittsburgh, PA 15220, Ron.Munson@tetra.com, phone (412) 921-8389, fax (412) 921-4040.

[4] Adriondack Lake Survey Corp., NYS DEC, Ray Brook, NY 12977, phone (518) 897-1352, fax (518) 891-1370.

[5] Department of Natural Resources, Fernow Hall, Cornell University, Ithaca, NY 14853, jby1@cornell.edu, phone (607) 255-6601, fax (607) 255-0349.

*Corresponding author

# Trends in Atmospheric Deposition Compared to Regional and Local Pollutant Emissions at a Rural Site in Southeastern New York, USA

Victoria R. Kelly, Gary M. Lovett, Kathleen C. Weathers
Institute of Ecosystem Studies
Millbrook, NY 12545

Regional and national trends in eastern North America show declines in sulfur, nitrogen and base cation emissions and deposition from 1990 levels. However, emissions have increased in the last few years. Using methods similar to procedures used by the EPA CASTNet program, we examined trends in concentrations and deposition of some gaseous and aerosol species as well as total wet and dry deposition of nitrogen and sulfur species at a site in southeastern New York. We compared these trends to local and regional emissions. Concentrations of gaseous $SO_2$ and $HNO_3$ and particulate $H^+$, $SO_4^{-2}$, $NH_4^+$, $Ca^{+2}$ and $Mg^{+2}$ decreased during the 12-year period from 1988 to 1999. No change was observed during this period in particulate $K^+$, $Na^+$, $Cl^-$ or total particulate matter < 2 µm diameter. Most constituent concentrations were higher during summer than winter. Total sulfur and nitrogen deposition declined from 1988-1999 and deposition correlated with regional emissions.

# Atmospheric Mercury Emissions from Municipal Solid Waste Landfills

S. Lindberg, H. Zhang[1], and G. Southworth[1], D. Reinhart[2],
P. McCreanor[3], D. Wallschlager[4], and J. Price[5]

The volatility of mercury is well known, and the possibility that Hg may be emitted to the atmosphere from municipal landfills has been suggested, but rarely quantified. From 1997 to 1999, we conducted three studies of Hg emissions from four Florida landfills. Our original data documented that Hg losses occurred via two primary pathways; fugitive losses from the working face, and losses with landfill gas (LFG) emissions. Hg concentrations in LFG appear to decrease strongly with increasing landfill age, suggesting that once buried, Hg may be sequestered. This presentation describes our recent studies to reduce the uncertainties in Hg losses from waste management by (1) measuring Hg fluxes from additional landfills, (2) monitoring Hg emissions during the storage and processing of Hg-bearing wastes, and (3) speciating Hg emissions in LFG.

Mercury emissions from the landfill surface were quantified using an automated flux chamber approach that relies on in-field near-real-time mercury analyses using a Tekran Mercury Analyzer 2537A. Fluxes were measured at various landfill locations, as well as at a waste transfer station. Waste was collected and sorted to identify sources of mercury. Ambient Hg measurements were made approximately 30-50 m downwind from the landfill working face during routine placement and compaction of wastes.

Briefly, our new data indicate that the most significant quantities of Hg are lost to the air during waste handling and dumping, and that volatile methylated Hg compounds are being formed in landfills. We identified several sources of Hg in waste, including broken thermometers, fluorescent bulbs, and old batteries. Fugitive emissions from the working face were correlated with waste dumping and spreading activities. Perhaps of most interest was the identification of highly elevated levels of gaseous dimethylmercury in LFG, and methylmercury in LFG condensates. If LFG is not combusted, landfills could be important sources of atmospheric methylated Hg compounds.

---

[1] Oak Ridge National Laboratory†
[2] University of Central Florida
[3] Mercer University
[4] Frontier Geosciences
[5] Florida Department of Environmental Protection
†Project supported by the Florida Department of Environmental Protection and the Electric Power Research Institute; ORNL is operated by Lockheed Martin Energy Research for the U.S. Department of Energy.

# Comparison of Non-Linear Regression and Autoregressive Moving Average (ARMA) Models for Precipitation Chemistry from East Central Florida

B. C. Madsen[1], D. M. Nickerson[1], T. W. Dreschel[2] and L. A. Maull[2]

The longest continuous rain chemistry monitoring in Florida is at a non-National Atmospheric Deposition Program site located on the University of Central Florida (UCF) campus. Two National Atmospheric Deposition Program (NADP) sites also exist in Central Florida. These are located in Bradford Forest (FL03) which has operated since 1978, and at Kennedy Space Center (FL99) which has operated since 1984. The chemical composition of major cations and anions have been evaluated as monthly volume weighted concentration and deposition. Stepwise regression, non-linear regression models and autoregressive moving average (ARMA) models were applied to log transformed variables. All series under consideration were stationary and exhibited auto-correlation. Consequently, ARMA models were fit separately to each concentration and deposition. In many of the series, auto-regression was present up to lags of 12 and 13 months. Subsequently, cross-correlation between pH and these variables were examined. Concentrations of non-marine $SO_4$, $NH_4$, $NO_3$ and Ca contribute significantly to the explanation of acidity. A second-order autocorrelation remained in the acidity series, even after these non-marine variables were taken into account. Preliminary results suggest that these approaches yield similar conclusions regarding seasonality and long-term trends associated with composition.

---

[1] University of Central Florida, Orlando 32816
[2] Dynamac Corporation, Kennedy Space Center 32899

# Effects of Reduced Acid Deposition to a First- and Third-Order Mid-Atlantic Coastal Plain Stream

Jacqueline L. Mann, Michael E. O'Connell and Karen L Prestegaard
Department of Geology
University of Maryland

Sulfur is both a common atmospheric pollutant and a component of sedimentary rocks. Since the 1990 Clean Air Act, atmospheric sulfur deposition rates have declined in Eastern U.S. watersheds. The effect of this decrease on stream sulfate concentrations depends on both geochemical and hydrologic processes within watersheds. Hydrogeochemical controls on sulfate sources were examined over a two-year period (1995-1996) in a Coastal Plain watershed underlain by pyrite-rich glauconitic sediments. Sulfur isotope compositions of waters collected at variable flow conditions were used in an end-member mixing analysis to determine the major sulfate sources to a first- and third-order stream. In the first-order stream, atmospheric sulfur was the dominant source of sulfate during high baseflow conditions when stream discharge was primarily derived from the shallow subsurface where pyrite abundance is lower. At low baseflow, a larger proportion of sulfate was derived from reaction with concentrated pyrite along relatively deep ground water flowpaths. Third-order stream flow, under most flow conditions, received a larger proportion from infiltrated overland flow waters discharged just upstream along shallow subsurface flowpaths; thus, atmospheric sulfate was the dominant source. Changes in the concentration of stream sulfate attributable to the reduction of sulfur emissions will likely be more pronounced in streams dominated by overland flow processes or where aquifer solids are sulfur-free.

# Analysis of pH in Wet Deposition in North-Eastern Puerto Rico

R. Mendez-Tejeda, J. Penalbert-Ramos, and M. Rodriquez-Rosario
University of Puerto Rico at Carolina

The paper presents the results of a study conducted to investigate the variation in pH values of wet deposition samples taken in the northeast region of Puerto Rico. Also we analyzed the air mass trajectory. Rainfall samples were collected at the Carolina urban and sub-urban site and at El Yunque rainforest. The rainfall samples were collected during the period of June 1997 to June 1999, and the pH measurement levels were determined. The pH values obtained in the El Yunque rainforest region were compared to the values obtained at Carolina urban and suburban sites. The average pH value measured at El Yunque was 5.01 and for the Carolina sites was 4.64 for the period studied. The results show a greater tendency toward acidity at the Carolina site.

# Air Quality in the National Wildlife Refuge System

Kristi H. Morris

The Clean Air Act of 1977 designated 21 Fish and Wildlife Service (FWS) wilderness areas as Class I areas, giving them special protection against air pollution. The FWS is responsible for protecting natural resources, such as wildlife, vegetation, water, soils, and visibility in these areas from the effects of air pollution. The FWS Air Quality Branch focuses on key issues, including the ecosystem effects of atmospheric deposition, ozone, and mercury, and visibility impairment. The deposition of sulfur and nitrogen can have an acidifying or fertilizing effect on an ecosystem. Ozone in the lower atmosphere affects the human respiratory system and causes leaf injury and reduced growth of vegetation. The deposition of mercury is a concern because it accumulates in the food chain, and can reach toxic levels in humans and wildlife. Fine particles in the air make up "haze" and reduce visibility by scattering and absorbing light. Visibility conditions are poorest in the eastern U.S due to high emissions of sulfur dioxide. Sulfates, nitrates, organics, soot, soil and coarse material all contribute to visibility impairment. The poster showcases air quality monitoring efforts by the FWS and describes ecosystem effects in more detail.

---

U.S. Fish and Wildlife Service
Air Quality Branch
c/o NPS-AIR
P.O. Box 25287
Denver, CO 80225
Phone: (303) 987-6941
Fax: (303) 969-2822
e-mail: kristi_morris@nps.gov

# The Kempton Mine Complex Restoration Initiative

Paul Petzrick and John Sherwell
Maryland Department of Natural Resources
Tawes Building B3
Annapolis, MD  21401

Acid mine drainage (AMD) is significant source of stream acidification in many parts of the United States. AMD is typically associated with abandoned mines or mine tailings in which sulfide-bearing materials are oxidized after exposure to the atmosphere to produce sulfuric acid solutions that carry many dissolved metals. In the Appalachian Mountain region, abandoned coal mines are the principal source of AMD. The Kempton Mine Complex is an example of such a mine: with some twelve square miles of underground workings, the mine produces between three and three-and-half million gallon per day of pH 3 – 3.5 water and drains ultimately into the north branch of the Potomac River and the Chesapeake Bay.

The Kempton Mine Complex Restoration Initiative seeks to mitigate the AMD through a series of projects designed to manage water flow into and through the mine. Stable isotope and other geotechnical studies are currently underway to track the water balance in the mine. Innovative grouting materials made from coal combustion products from nearby electricity generating stations will be used to create barricades, dikes and pavement seals that will inhibit entry, redirect flow and seal reaction surfaces, in the mine.

This poster shows the status of the current assessment of the mine hydrology and chemistry and outlines the major components of this mitigation project.

# Influences on Wetlands and Lakes in the Adirondack Park of New York State
# A Catalog of Existing and New GIS Data Layers for the 400,000 Hectare Oswegatchie/Black River Watershed

Karen M. Roy
NYS Adirondack Park Agency
SUNY Plattsburgh
Adirondack Lakes Survery Corp.

The 2.4 million hectare Adirondack Park is experiencing the effects of acid deposition and watershed development on its lake and wetland resources. This EPA sponsored project developed and interpreted diverse mapped information for the 400,000 hectare Oswegatchie/Black River watershed using ArcInfo. Phase I depicted 1223 complex lake watersheds and over 60,000 wetland hectares with over 200 wetland covertypes. Phase II provided additional digital coverages: upland vegetation (using Thematic Mapper imagery); soil parent material; surficial and bedrock geology; Adirondack Park Agency land use map (including public lands); existing residential development; forest acquisition; fire history; major storm blowdowns; and atmospheric deposition. Digital maps are presented with a method for linking the data layers with key lake chemistry data form the Adirondack Lake Survey Corporation Long Term Monitoring waters.

For more information and complete references, see project report entitled "Influences on Wetlands and Lakes in the Adirondack Park of New York State: A Catalog of Existing and New GIS Layers for the 400.000-Hectare Oswegatchie/Black River Watershed" by K.M Roy, E.B. Allen, J.W. Barge, J.A. Ross, R.P. Curran, D.J. Bogucki, D.A. Franzi W.A. Krestser, M.M. Frank, D.M. Spada and J.S. Banta. August 1997. final Report to EPA State Wetlands Protection Grant No. CD992087-01.

---

**Poster Note**: Presentation of the geographic data layers on this poster is intended only for graphic reference due to reduced scale. The graphics are presented in two sizes. The Approximate relative scale of the small figures is 1:700,000 and of the large figures is 1:500,000. Please see the project report for scale of the source data. Be advised that the original source data are of widely varying scales. All geographic data are oriented for north at top of page.

# Modeling Atmospheric Nitrogen Deposition and Transport in the Chesapeake Bay Watershed: A GIS Approach

Scott A. Sheeder[1], Graduate Assistant; James A. Lynch[1], Ph.D.,
Professor of Forest Hydrology; and Jeffrey W. Grimm[2], Research Assistant

Atmospheric deposition of nitrogen (both nitrate and ammonium) has been identified as a contributing factor in the decline of water quality in the Chesapeake Bay. Studies have indicated that atmospheric deposition may account for 25% to 80% of the total nitrogen load entering the Bay. These estimates were based on annual estimates of atmospheric deposition to various land covers and the assumption that a fixed percentage of nitrogen deposition to each land cover was exported to tributaries that discharge into the Bay. Because of these and other assumptions and the limited spatial and temporal resolution of atmospheric deposition inputs used in these studies, considerable uncertainty exists regarding the accuracy of these estimates. This project was designed to reassess the potential contribution of atmospheric nitrogen deposition to the Chesapeake Bay using a GIS approach that incorporated higher resolution wet and dry deposition estimates and watershed retention coefficients with existing soil, hydrologic, and land use data. An interpolated surface illustrating nitrogen export potential was created for the CBW using the above grids and published nitrogen export coefficients. Wet and dry deposition loads to each of 64 sub-basins that comprise the CBW were estimated on a seasonal basis from 1984 through 1996. Wet deposition inputs were derived from a high resolution wet deposition model developed by the principal investigator. The model incorporates precipitation volume measurements from NOAA/NWS monitoring sites, digital elevation data, and other topographic variables (e.g., aspect, slope) that affect the amount and distribution of precipitation in the region. The model provides estimates of precipitation for any latitude and longitude within the region for any month or seasonal summary period. When combined with interpolated nitrate and ammonium concentration data from the National Atmospheric Deposition Program, estimates of wet deposition can be obtained. Dry deposition inputs were based on the ratio of dry to wet deposition as measured at CASTNet sites located within or near the CBW. Seasonal dry/wet deposition ratios were developed for each of the major land cover categories in the CBW. The nitrogen retention coefficients were applied to the deposition grids to obtain the amount of nitrogen deposition exported from each sub-basin. Estimates of nitrogen export based on model calculations were compared to existing stream export measurements as compiled by the USGS for each of the 64 watersheds. Watershed retention coefficients were adjusted so the modeled export did not exceed measured export. Preliminary results indicate that: (1) atmospheric deposition is a significant source of nitrogen contributing to the eutrophication of the Chesapeake Bay; however; (2) the contribution of nitrogen from atmospheric sources appears to be less (10% to 13%, 18% to 21% if direct deposition to the surface of the Bay is included in the calculations) than previously estimated (25% to 80%); (3) seasonal and intra-annual differences in atmospheric nitrogen loading also exist which may influence eutrophication processes; (4) these seasonal and intra-annual differences may also be important relative to tributary management strategies aimed at reducing nitrogen inputs to the Bay.

---

[1] School of Forest Resources, The Pennsylvania State University, Forest Resources Lab, University Park, PA, USA 16802

[2] Environmental Resource Research Institute, The Pennsylvania State University, 201 Forest Resources Lab, University Park, PA, USA 16802

# New York State Acid Deposition Monitoring Network Description, Data and Differences from NADP

Paul Sierzenga and Garry Boyton
Bureau of Air Quality Surveillance
New York State Department of Environmental Conservation

The New York State Department of Environmental Conservation began an acid deposition monitoring network in 1986 which currently consists of twenty sites throughout all of New York State. These are located in the major urban areas as well as the sensitive rural areas of the Adirondack and Catskill Mountains. This is a long term monitoring effort intended to identify trends and generate relevant information for policy makers. Laboratory analysis of the samples is performed by NYSDEC staff using DIONEX$^{tm}$ ion chromatography.

This oral presentation will describe the New York State network and analysis procedures highlighting differences with the NADP network. Some of the data trends will also be presented while a more complete data trend analysis of all the sampling locations will be provided in the poster session.

# Fish Population Assessment and Spring Water Chemistry In Adirondack Headwater Streams

Howard A. Simonin, James R. Colquhoun, Eric A. Paul,
John Symula, and Howard J. Dean

Fish populations in 36 Adirondack headwater streams were surveyed by electrofishing in the fall of both 1979 and 1999. The streams were all judged to provide suitable year-around trout habitat containing pools, riffles, shaded areas, and shelter from high stream flow. Water samples were taken from these streams for chemical analysis during the spring of both 1980 and 2000. The occurrence of salmonids and of all fish appeared to be directly related to the water chemistry during the spring. In most cases streams which had pH levels less than 5.0 in the spring were fishless. No young of the year brook trout were found in streams which had a spring air equilibrated pH less than 4.98. A higher number of fish and a greater number of species were collected in 1999 than during 1979, but this may have been due to better electrofishing efficiency during 1999. No consistent change was observed in spring pH levels of the study streams from 1980 to 2000. However, considerable annual and seasonal variability is evident in spring stream samples depending on stream flow. There was a significant decrease in calcium concentrations in the spring 2000 stream samples when compared with similar samples collected in 1982. Sensitive and acid impacted streams continue to exist in the Adirondacks even though sulfate deposition has decreased.

---

New York State Department of Environmental Conservation
Aquatic Toxicant Research Unit
8314 Fish Hatchery Road
Rome, NY 13440 (phone 315/337-0910)

# Calcium and Sodium Dryfall at NADP/NTN Sites

Gary J. Stensland, Illinois State Water Survey
Steven Lindberg, Oak Ridge National Laboratory

Atmospheric calcium deposition data are needed by those studying base cation depletion in soils and the resulting impact on the health of forests and surface waters in the eastern USA. Regional air quality monitoring networks in the east have not measured the ambient air concentrations of calcium and other constituents that have most of their mass in airborne particles greater than about 5 micrometers in diameter. NADP/NTN has collected and analyzed about 10,000 dry-side bucket samples that had been exposed at the sites for eight weeks. This study evaluates and analyzes this database that will be referred to as a dryfall database.

Visual examination of dry-side buckets exposed for eight weeks shows that substantial organic debris is often present, and is recorded in the comment field for each sample. Bird droppings constitute a particularly serious organic contaminant that has an especially large affect on measured concentrations of ammonium, potassium and phosphate. Earlier reports by Gatz et al. and analyses in this study demonstrate that the dryfall data can be analyzed to produce useful dryfall values for specific constituents like calcium and sodium.

Factors can considered that would cause the NADP/NTN dryfall data to be biased either high or low. 1) Wind scouring would bias the data low. 2) The dry-side buckets during exposure at the site are about one meter above the ground and thus the data are likely to be biased high compared to data collected at a greater distance from the ground. 3) The dry-side samples are extracted in deionized water and thus the NADP/NTN dryfall data will be biased low compared to "total" elemental measurements. This extraction effect will vary with the element being considered while the exposure issues will vary from site to site.

The Integrated Forest Study, led by Johnson and Lindberg, included throughfall and stemflow measurements that allowed dryfall to be estimated to trees at many sites for two years. A comparison between these measurements and nearby NADP/NTN dryfall measurements is presented; the agreement is good.

Dryfall summary maps of median calcium and sodium values are presented, in units of Kg/Ha/Yr. The lowest calcium value is 0.1 for an Idaho site and the highest two values are 9.9 for the Indiana Dunes site and 7.8 for the site near Vincennes, IN. The area with highest values extends from eastern Nebraska to Ohio. Our previous work suggests that travel on unpaved roads may be the dominant source of calcium in this region. Values in New York range from 2.6 to the lowest value of 0.5 at the Huntington Forest site. The sodium dryfall values range from the lowest value of .07 at the Idaho site and two Colorado sites to values of 2.8 - 4.2 at four coastal sites in MA, FL and TX.

# What a Difference Ten Years Has Made in Ammonium in Rain and Snow in the United States - The Changing Landscape of Ammonia Sources and Deposition

Gary J. Stensland, Bob Larson, Van C. Bowersox, and Roger D. Claybrooke
Illinois State Water Survey

The Acid Deposition Control Title (IV) of the 1990 Clean Air Act Amendments calls for reductions in annual sulfur dioxide and nitrogen oxide emissions in order to “reduce the adverse effects of acid deposition”, without addressing emissions of acid-neutralizing compounds. Chief among the acid-neutralizing compounds in U.S. air is ammonia, which is present in precipitation as the ammonium cation, $NH_4^+$. Ammonium is rich in nitrogen and together with nitrate comprises virtually all of the inorganic nitrogen deposited by precipitation. Recent studies have shown that atmospheric deposition of nitrate and ammonium is a significant source of nutrients in some nitrogen-limited ecosystems, such as coastal estuaries.

In this study, we use NADP National Trends Network (NTN) data to examine 5-year average ammonium concentrations in precipitation for two time periods: 1985-89 and 1995-99. We display color contour maps to show the spatial distributions of ammonium concentrations in precipitation in the contiguous United States. These maps were based on objectively-analyzed data from 150 NTN stations that met preselected data completeness criteria in both time periods. To examine changes in these two time periods, we subtracted the objectively-analyzed 1985-89 concentrations from the objectively-analyzed 1995-99 concentrations. Ammonium concentrations generally increased over this 10-year interval (mean difference: +3.0 [s.d. 2.9] μeq/L or +25.6% [s.d. 23.5%], median difference: +2.5 μeq/L or +22.5%, range: -2.8 μeq/L to +17.6 μeq/L or -24.9% to +121%). Color contour maps of these differences are displayed.

We also examined sources of airborne ammonia in the two 5-year periods in an effort to identify potential explanations for the spatial distributions and temporal changes of ammonium concentrations. At this time, the results of this source identification effort are very preliminary. Among the sources of airborne ammonia we examined are livestock manure (beef cattle, dairy cows, hogs, laying hens, broiler chickens, and turkeys), fertilizer applications, and automobile exhaust. Using published emission factors, we estimate the ammonia emitted from each of these sources, comparing their relative strengths and potential importance in explaining spatial and temporal patterns. Finally, we will discuss but not quantify crop-emitted ammonia, because of the extreme variability of published estimates of this source.

# A Meteorological Explanation for Differences Between Precipitation and Sulfate Data Collected from Two Neighboring NTN Sites in Central Pennsylvania

Mark A. Taylor and Dennis Lamb
Department of Meteorology
Pennsylvania State University

In central Pennsylvania, the Penn State (PA15) and Leading Ridge (PA42) NADP/NTN sites are located about 16 km apart, affording a unique opportunity for comparison. By contrast, collocated sites within NADP/NTN are on the order of 5 m apart, and standard network sites are located approximately 112 km apart on average. Given the close proximity of the Penn State and Leading Ridge sites, the precipitation amounts and sulfate concentrations might be expected to exhibit many similarities. However, this is not necessarily the case. The goal of this study is to compare data collected from these two NADP/NTN sites and determine some possible meteorological causes for the observed differences. In this comparison study, the data are treated in the same manner as Nilles et al. (1993) in their study of collocated site precision. For the purpose of gauging the degree of difference outside of experimental error, the calculated differences in the Penn State and Leading Ridge data are compared to the precision thresholds established from the collocated site study. Depending on whether precipitation events are of synoptic scale (500 - 2000 km) or of convective scale (10 - 100 km), paired sample analyses can yield results within the precision thresholds established for collocated sites or be different by several times that magnitude.

# Atmospheric Deposition Changes Across New York State and Adjacent New England Following Implementation of the 1990 Clean Air Act

Jack T. Tessier[1]*, Raymond D. Masters[2], and Dudley J. Raynal[1]

In 1990, Congress passed amendments to the Clean Air Act requiring electric utility power plants to decrease emissions of sulfur dioxide and nitrogen oxides. Phase I of this plan began in 1995. We analyzed precipitation volume, wet deposition, and concentration of nitrate, sulfate, and sum of base cations measured at NADP sites in New York (NY), Vermont (VT), and New Hampshire (NH). We compared five-year means prior to and following passage of the 1990 Clean Air Act and for five years after implementation of Phase I. Most NY sites exhibited a decline in sulfate deposition over the assessed time periods, whereas only one site in Vermont displayed this trend. Only one of the monitoring stations recorded a decline in base cation deposition. The trend of decreasing sulfate deposition was driven by a decline in sulfate concentration rather than by precipitation volume. Three sites showed a decline in base cation concentration and several NY sites, but none in VT and NH, had decreasing nitrate concentrations. None of the sites exhibited a significant change in precipitation volume and this factor appears to be overshadowing the declines in ion concentration and thus minimizing declines in ion deposition. Since current declines in ion concentration are not sufficient to result in decreased deposition at all locations further emission decreases may be in order.

---

[1] State University of New York College of Environmental Science and Forestry, 350 Illick Hall, 1 Forestry Dr., Syracuse, NY, 13210.

[2] Adirondack Ecological Center, Huntington Wildlife Forest, Newcomb, NY, 12927.

*Corresponding author: phone (315) 470-6793, email jttessie@syr.edu.

## A Comparison Between Coastal and Inland Deposition Using Three AIRMoN Monitoring Sites: PA15, DE02, MD15

Julie Thomas
Air Quality Liaison to the Chesapeake Bay Program

The Smith Island AIRMoN site was established to see how much deposition and precipitation falls on the Bay relative to land-locked sites. Extrapolating land-based measurements to represent deposition to the Bay surface may not be the best way to estimate wet deposition to the Bay. This poster will compare the chemistry and precipitation AIRMoN data from three sites in the Chesapeake Bay Watershed: Lewes (DE 02), Smith Island (MD 15), and Penn State (PA 15). The Lewes site is located on the Atlantic Coast, Smith Island is located in the Chesapeake Bay, and the Penn State is inland and north of the first two. The poster presentation will show differences in deposition and chemistry between the three sites.

---

410 Severn Ave, Suite 109
Annapolis, MD 21403
phone: 410-267-9848
fax: 410-267-5777
email: thomas.julie@epa.gov

# Atmospheric Deposition of Trace Metals In the San Francisco Bay Area

Pam Tsai[1], Eric Hansen[2], and Rainer Hoenicke[1]

Atmospheric deposition is considered one of the primary sources/pathways for the loading of pollutants to the San Francisco Bay. No historical empirical measurements were available to estimate the magnitude of the pollutant loading attributable to atmospheric deposition. Gross retroactive calculations based on ambient air monitoring results and results from a preliminary study indicated that contribution of atmospheric deposition to the total loading ranged from less than 1% up to 20% for certain toxic pollutants.

Under the umbrella of the Regional Monitoring Program for Trace Substances ("RMP"), a pilot study was initiated in the San Francisco Bay Area in August 1999. The primary objective of the pilot study was to obtain seasonal and annual estimate of the deposition of some selected pollutants from the air directly to the surface of the Bay (i.e. direct atmospheric deposition). Samples have been collected at three sites located in South Bay, Central Bay, and North Bay.

This paper presents the methodology and preliminary results regarding direct atmospheric deposition of copper, nickel, cadmium, chromium, and mercury to the Bay. In addition, pollutant loading from direct atmospheric deposition is compared to the loading from other sources or pathways.

---

[1] San Francisco Estuary Institute, Richmond, California
[2] City of San Jose Environmental Services Department, San Jose, California

# Effects of the Acid Rain Program Emission Reductions on Ambient Particulate Matter Measurements in Maryland

Kenneth Walsh, Science Applications International Corporation
John Sherwell, Maryland Power Plant Research Program

Title IV of the Clean Air Act Amendments of 1990 (the Acid Rain Program) addresses the control of acidic deposition through innovative programs to control emissions from utilities and major combustion sources. A major focus of the Acid Rain Program has been investigation into the acidification of waterways through wet and dry deposition processes. The National Acid Deposition Program (NADP) collects data from over 200 sites to investigate the effects of national air pollution control programs and monitor the annual reductions in acidic deposition.

This paper examines one of the additional benefits of the Acid Rain Program, the improvement in ambient air quality in the State of Maryland. The same chemical species contributing to acidic deposition (sulfates and nitrates) also form aerosols that are measured as particulate matter (PM) less than 2.5 microns in diameter (PM2.5) and reduce visibility. In July 1997, the U.S. Environmental Protection Agency (EPA) promulgated a Final Rule on the National Ambient Air Quality Standards (NAAQS) for Particulate Matter that included annual and daily standards for PM2.5.

This paper investigates the annual changes in sulfur dioxide and nitrogen oxide emissions and the accompanying changes in air quality during the 1990's at MidAtlantic PM monitors. The ambient PM sulfate concentrations decreased as much as twenty percent at both rural and urban monitors during the time from 1992 to 1997. However, PM nitrate measurements only decreased at the urban monitors. The decreases in PM component species matched the reductions seen in total PM10 and total PM2.5 at monitors in Maryland and national park areas, leading to the conclusion that reductions in other particulate matter species (such as organic aerosols or crustal materials) were not significant during the 1990's.

# Atmospheric Deposition to Mountainous Terrain: Scaling-Up to the Landscape

K.C. Weathers[1, 3], G.M. Lovett[1], S.E. Lindberg[2], S.M. Simkin[1], and D.N. Lewis[1]

Despite over two-decades of deposition research, measuring total deposition to complex terrain has been elusive. Here we present an empirical modeling approach for scaling point measurements of atmospheric deposition to landscapes.

Deposition of a variety of airborne constituents shows a predictable response to major landscape features that can be quantified in the field. We are quantifying these response functions across the landscapes of two National Parks, chosen for their potential air pollutant impacts and complicated terrain features.

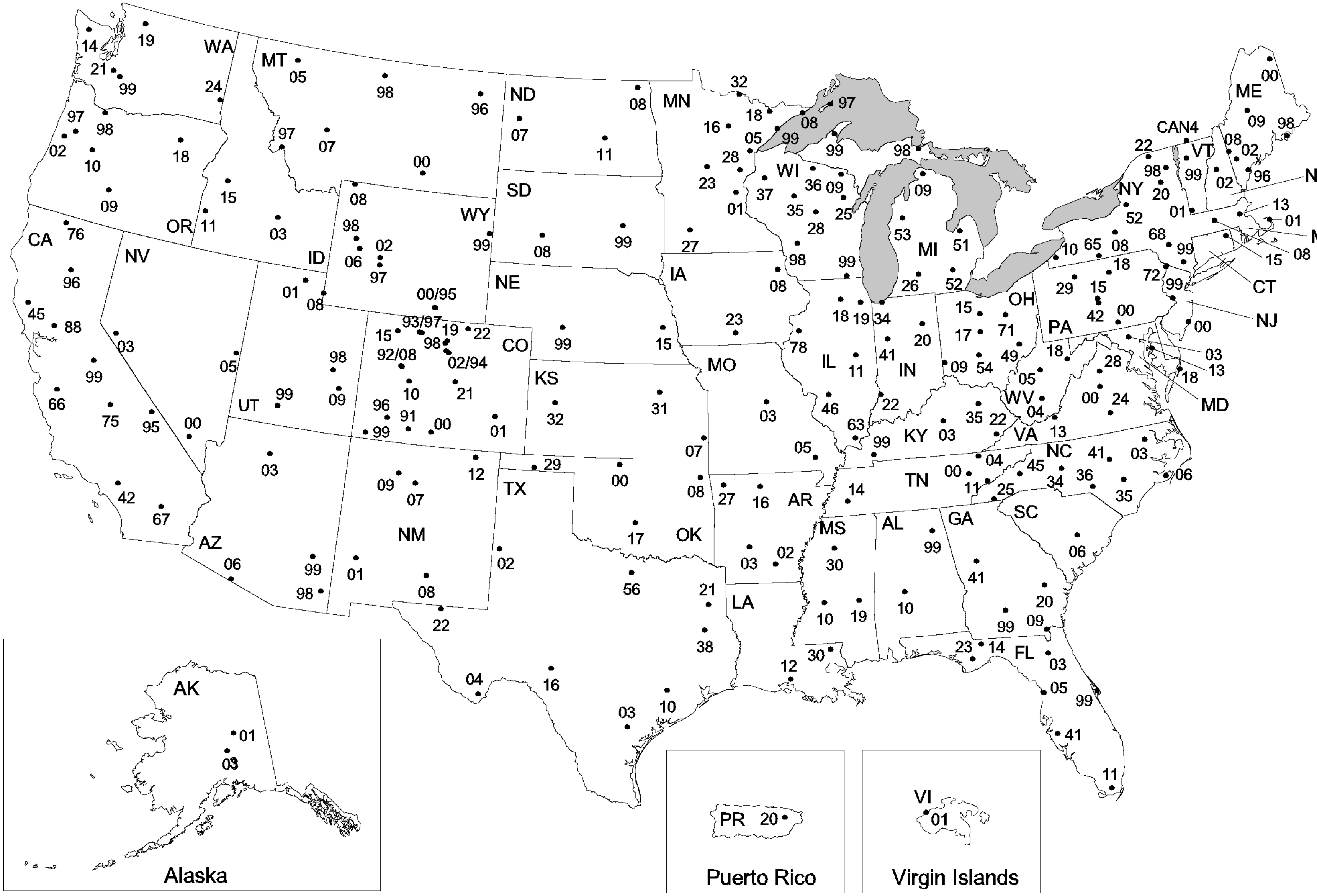
The depositional patterns are characterized as a function of terrain features using sulfate fluxes in throughfall and lead in surface soils as indices of deposition. These measures are excellent indices of total deposition of sulfur and nitrogen, and each addresses a time scale critical to the modeling approach. Response functions are derived statistically to quantify the enhancement of deposition in areas of interest relative to routine monitoring locations. These response functions are used in a GIS to scale up from the monitoring locations to the entire landscape, based on the spatial distribution of the primary controlling terrain features. The modeling approach is generic, and can be applied to other regions, and to a variety of airborne materials. Preliminary results suggest that vegetation type and elevation are the terrain features that have the greatest influence on pollutant and nutrient fluxes.

---

[1] Institute of Ecosystem Studies, Box AB, Millbrook, NY 12545 USA
[2] Oak Ridge National Laboratory, PO Box 2008, Oak Ridge, TN 37831 USA
[3] Weathersk@ecostudies.org
(845) 677-5343 (phone)
(845) 677-5976 (fax)

# NTN MAP AND SITE LISTINGS

# National Atmospheric Deposition Program
## National Trends Network



# National Atmospheric Deposition Program/National Trends Network Sites
## September 30, 2000

| State Site Code | Site Name | County | Sponsoring Agency | Start Date |
|---|---|---|---|---|
| **Alabama** | | | | |
| AL10 | Black Belt Ag Substation | Dallas | US Geological Survey | 08/83 |
| AL99 | Sand Mountain Ag Experiment Station | DeKalb | Tennessee Valley Authority | 10/84 |
| **Alaska** | | | | |
| AK01 | Caribou - Poker Creek | Fairbanks | USDA Forest Service | 12/92 |
| AK03 | Denali NP - Mount McKinley | Denali | National Park Service - Air Resources Div | 06/80 |
| **Arizona** | | | | |
| AZ03 | Grand Canyon NP - Hopi Point | Coconino | National Park Service - Air Resources Div | 08/81 |
| AZ06 | Organ Pipe Cactus NM | Pima | National Park Service - Air Resources Div | 04/80 |
| AZ98 | Chiricahua | Cochise | US Environmental Protection Agency-CAMD | 02/99 |
| AZ99 | Oliver Knoll | Graham | US Geological Survey | 08/81 |
| **Arkansas** | | | | |
| AR02 | Warren 2WSW | Bradley | US Geological Survey | 05/82 |
| AR03 | Caddo Valley | Clark | US Geological Survey | 12/83 |
| AR16 | Buffalo NR - Buffalo Point | Marion | National Park Service - Air Resources Div | 07/82 |
| AR27 | Fayetteville | Washington | US Geological Survey | 04/80 |
| **California** | | | | |
| CA42 | Tanbark Flat | Los Angeles | USDA Forest Service | 01/82 |
| CA45 | Hopland | Mendocino | US Geological Survey | 10/79 |
| CA66 | Pinnacles NM - Bear Valley | San Benito | National Park Service - Air Resources Div | 11/99 |
| CA67 | Joshua Tree NP - Black Rock | San Bernardino | National Park Service - Air Resources Div | 09/00 |
| CA75 | Sequoia NP - Giant Forest | Tular | National Park Service - Air Resources Div | 07/80 |
| CA76 | Montague | Siskiyou | US Geological Survey | 06/85 |
| CA88 | Davis | Yolo | US Geological Survey | 09/78 |
| CA95 | Death Valley NP - Cow Creek | Inyo | National Park Service - Air Resources Div | 02/00 |
| CA96 | Lassen Volcanic NP - Manzanita Lake | Shasta | National Park Service - Air Resources Div | 06/00 |
| CA99 | Yosemite NP - Hodgdon Meadow | Tuolumne | National Park Service - Air Resources Div | 12/81 |
| **Colorado** | | | | |
| CO00 | Alamosa - Weather Service Office | Alamosa | US Geological Survey | 04/80 |
| CO01 | Las Animas Fish Hatchery | Bent | US Geological Survey | 10/83 |
| CO02 | Niwot Saddle | Boulder | NSF/INSTAAR-University of Colorado | 06/84 |
| *CO08 | Four Mile Park | Garfield | US Environmental Protection Agency-CAMD | 12/87 |
| CO10 | Gothic | Gunnison | US Environmental Protection Agency-CAMD | 02/99 |
| CO15 | Sand Spring | Moffat | Bureau of Land Management | 03/79 |
| CO19 | Rocky Mountain NP - Beaver Meadows | Larimer | National Park Service - Air Resources Div | 05/80 |
| CO21 | Manitou | Teller | USDA Forest Service | 10/78 |
| CO22 | Pawnee | Weld | SAES-Colorado State University | 05/79 |
| CO91 | Wolf Creek Pass | Mineral | USDA Forest Service | 05/92 |
| CO92 | Sunlight Peak | Garfield | US Environmental Protection Agency-CAMD | 01/88 |
| CO93 | Buffalo Pass - Dry Lake | Routt | USDA Forest Service | 10/86 |
| CO94 | Sugarloaf | Boulder | US Environmental Protection Agency-CAMD | 11/86 |
| CO96 | Molas Pass | San Juan | USDA Forest Service | 07/86 |
| CO97 | Buffalo Pass - Summit Lake | Routt | USDA Forest Service | 02/84 |
| CO98 | Rocky Mountain NP - Loch Vale | Larimer | USGS/Colorado State University | 08/83 |
| CO99 | Mesa Verde NP - Chapin Mesa | Montezuma | US Geological Survey | 04/81 |
| **Connecticut** | | | | |
| CT15 | Abington | Windham | US Environmental Protection Agency-CAMD | 01/99 |
| **Florida** | | | | |
| FL03 | Bradford Forest | Bradford | St. John's River Water Management District | 10/78 |
| FL05 | Chassahowitzka NWR | Citrus | US Fish & Wildlife Serv - Air Quality Branch | 08/96 |
| FL11 | Everglades NP - Research Center | Dade | National Park Service - Air Resources Div | 06/80 |
| FL14 | Quincy | Gadsden | US Geological Survey | 03/84 |
| FL23 | Sumatra | Liberty | US Environmental Protection Agency-CAMD | 01/99 |
| FL41 | Verna Well Field | Sarasota | US Geological Survey | 08/83 |
| FL99 | Kennedy Space Center | Brevard | NASA/Dynamac Corp. | 08/83 |
| **Georgia** | | | | |
| GA09 | Okefenokee NWR | Charlton | US Fish & Wildlife Serv - Air Quality Branch | 06/97 |
| GA20 | Bellville | Bellville | US Environmental Protection Agency-CAMD | 04/83 |
| GA41 | Georgia Station | Pike | SAES-University of Georgia | 10/78 |
| GA99 | Chula | Tift | US Geological Survey | 02/94 |

| State<br>Site Code | Site Name | County | Sponsoring Agency | Start Date |
|---|---|---|---|---|
| **Idaho** | | | | |
| ID03 | Craters of the Moon NM | Butte | National Park Service - Air Resources Div | 08/80 |
| ID11 | Reynolds Creek | Owyhee | US Geological Survey | 11/83 |
| ID15 | Smiths Ferry | Valley | US Geological Survey | 10/84 |
| **Illinois** | | | | |
| IL11 | Bondville | Champaign | SAES-University of Illinois | 02/79 |
| IL18 | Shabbona | DeKalb | SAES-University of Illinois | 05/81 |
| IL19 | Argonne | DuPage | DOE-Argonne National Laboratory | 03/80 |
| IL46 | Alhambra | Madison | US Environmental Protection Agency-CAMD | 01/99 |
| IL63 | Dixon Springs Ag Center | Pope | SAES-University of Illinois | 01/79 |
| IL78 | Monmouth | Warren | US Geological Survey | 01/85 |
| **Indiana** | | | | |
| IN20 | Huntington Reservoir | Huntington | US Geological Survey | 08/83 |
| IN22 | Southwest Purdue Ag Center | Knox | US Geological Survey | 09/84 |
| IN34 | Indiana Dunes NL | Porter | National Park Service - Air Resources Div | 07/80 |
| IN41 | Purdue University Ag Farm | Tippecanoe | SAES-Purdue University | 07/82 |
| **Iowa** | | | | |
| IA08 | Big Springs Fish Hatchery | Clayton | US Geological Survey | 08/84 |
| IA23 | McNay Memorial Research Center | Lucas | US Geological Survey | 09/84 |
| **Kansas** | | | | |
| KS07 | Farlington Fish Hatchery | Crawford | US Geological Survey | 03/84 |
| KS31 | Konza Prairie | Riley | SAES-Kansas State University | 08/82 |
| KS32 | Lake Scott State Park | Scott | US Geological Survey | 03/84 |
| **Kentucky** | | | | |
| KY03 | Mackville | Washington | US Geological Survey | 11/83 |
| KY22 | Lilley Cornett Woods | Letcher | NOAA-Air Resources Lab | 09/83 |
| KY35 | Clark State Fish Hatchery | Rowan | US Geological Survey | 08/83 |
| KY99 | Mulberry Flats | Trigg | TVA/Murray State University | 12/94 |
| **Louisiana** | | | | |
| LA12 | Iberia Research Station | Iberia | US Geological Survey | 11/82 |
| LA30 | Southeast Research Station | Washington | US Geological Survey | 01/83 |
| **Maine** | | | | |
| ME00 | Caribou | Aroostook | NOAA-Air Resources Lab | 04/80 |
| ME02 | Bridgton | Cumberland | Maine Dept of Environmental Protection | 09/80 |
| ME08 | Gilead | Oxford | US Geological Survey | 09/99 |
| ME09 | Greenville Station | Piscataquis | SAES-University of Maine | 11/79 |
| ME96 | Casco Bay - Wolfe’s Neck Farm | Cumberland | EPA/University of Southern Maine | 01/98 |
| ME98 | Acadia NP - McFarland Hill | Hancock | National Park Service - Air Resources Div | 11/81 |
| **Maryland** | | | | |
| MD03 | White Rock Substation | Carroll | Constellation Energy Group | 10/84 |
| MD13 | Wye | Queen Anne | SAES-University of Maryland | 03/83 |
| MD18 | Assateague Island NS - Woodcock | Worchester | Maryland Department of Natural Resources | 09/00 |
| **Massachusetts** | | | | |
| MA01 | North Atlantic Coastal Lab | Barnstable | National Park Service - Air Resources Div | 12/81 |
| MA08 | Quabbin Reservoir | Franklin | NESCAUM | 03/82 |
| MA13 | East | Middlesex | NESCAUM | 02/82 |
| **Michigan** | | | | |
| MI09 | Douglas Lake- Univ Michigan Biological Station | Cheboygan | SAES-Michigan State University | 07/79 |
| MI26 | Kellogg Biological Station | Kalamazoo | SAES-Michigan State University | 06/79 |
| MI51 | Unionville | Tuscola | US Environmental Protection Agency-CAMD | 01/99 |
| MI52 | Ann Arbor | Washtenaw | US Environmental Protection Agency-CAMD | 01/99 |
| MI53 | Wellston | Wexford | USDA Forest Service | 10/78 |
| MI97 | Isle Royale NP - Wallace Lake | Keneenaw | National Park Service - Air Resources Div | 05/85 |
| MI98 | Raco | Chippewa | US Environmental Protection Agency-CAMD | 05/84 |
| MI99 | Chassell | Houghton | National Park Service - Air Resources Div | 02/83 |

| State<br>Site Code | Site Name | County | Sponsoring Agency | Start<br>Date |
|---|---|---|---|---|
| **Minnesota** | | | | |
| MN01 | Cedar Creek | Anoka | Minnesota Pollution Control Agncy | 12/96 |
| MN05 | Fond du Lac | Carlton | EPA/Fond du Lac Reservation | 11/96 |
| MN08 | Hovland | Cook | Minnesota Pollution Control Agency | 12/96 |
| MN16 | Marcell Experimental Forest | Itasca | USDA Forest Service | 07/78 |
| MN18 | Fernberg | Lake | US Environmental Protection Agency-CAMD | 11/80 |
| MN23 | Camp Ripley | Morrison | US Geological Survey | 10/83 |
| MN27 | Lamberton | Redwood | Minnesota Pollution Control Agency | 01/79 |
| MN28 | Grindstone Lake | Pine | Minnesota Pollution Control Agency | 12/96 |
| MN32 | Voyageurs NP - Sullivan Bay | St. Louis | National Park Service - Air Resources Div | 05/00 |
| MN99 | Wolf Ridge | Lake | Minnesota Pollution Control Agency | 12/96 |
| **Mississippi** | | | | |
| MS10 | Clinton | Hinds | US Geological Survey | 07/84 |
| MS19 | Newton | Newton | NOAA-Air Resources Lab | 11/86 |
| MS30 | Coffeeville | Yalobusha | Tennessee Valley Authority | 07/84 |
| **Missouri** | | | | |
| MO03 | Ashland Wildlife Area | Boone | US Geological Survey | 10/81 |
| MO05 | University Forest | Butler | US Geological Survey | 10/81 |
| **Montana** | | | | |
| MT00 | Little Big Horn Battlefield | Big Horn | US Geological Survey | 07/84 |
| MT05 | Glacier NP - Fire Weather Station | Flathead | National Park Service - Air Resources Div | 06/80 |
| MT07 | Clancy | Jefferson | US Geological Survey | 01/84 |
| MT96 | Poplar River | Roosevelt | EPA-Ft. Peck Tribes | 12/99 |
| MT97 | Lost Trail Pass | Ravalli | USDA Forest Service | 09/90 |
| MT98 | Havre | Hill | US Geological Survey | 07/85 |
| **Nebraska** | | | | |
| NE15 | Mead | Saunders | SAES-University of Nebraska | 07/78 |
| NE99 | North Platte Ag Station | Lincoln | US Geological Survey | 09/85 |
| **Nevada** | | | | |
| NV00 | Red Rock Canyon | Clark | Bureau of Land Management | 01/85 |
| NV03 | Smith Valley | Smith | US Geological Survey | 08/85 |
| NV05 | Great Basin NP - Lehman Caves | White Pine | National Park Service - Air Resources Div | 01/85 |
| **New Hampshire** | | | | |
| *NH02 | Hubbard Brook | Grafton | USDA Forest Service | 07/78 |
| **New Jersey** | | | | |
| NJ00 | Edwin B. Forsythe NWR | Atlantic | US Fish & Wildlife Serv - Air Quality Branch | 10/98 |
| NJ99 | Washington Crossing | Mercer | US Environmental Protection Agency-CAMD | 08/81 |
| **New Mexico** | | | | |
| NM01 | Gila Cliff Dwellings NM | Catron | EPA/New Mexico Environment Dept. | 07/85 |
| NM07 | Bandelier NM | Los Alamos | DOE-Los Alamos National Lab | 06/82 |
| NM08 | Mayhill | Otero | US Geological Survey | 01/84 |
| NM09 | Cuba | Sandoval | Bureau of Land Management | 02/82 |
| NM12 | Capulin Volcano NM | Union | EPA/New Mexico Environment Dept. | 11/84 |
| **New York** | | | | |
| NY08 | Aurora Research Farm | Cayuga | SAES-Cornell University | 04/79 |
| NY10 | Chautauqua | Chautauqua | US Geological Survey | 06/80 |
| NY20 | Huntington Wildlife | Essex | EPA/State Univ of New York-Syracuse | 10/78 |
| NY22 | St. Regis Mohawk - Fort Covington | Franklin | US Environmental Protection Agency-CAMD | 08/99 |
| NY52 | Bennett Bridge | Oswego | EPA/State Univ of New York-Oswego | 06/80 |
| NY65 | Jasper | Steuben | US Geological Survey | 02/80 |
| NY68 | Biscuit Brook | Ulster | US Geological Survey | 10/83 |
| NY98 | Whiteface Mountain | Essex | US Geological Survey | 07/84 |
| NY99 | West Point | Orange | US Geological Survey | 09/83 |
| **North Carolina** | | | | |
| NC03 | Lewiston | Bertie | North Carolina State University | 10/78 |
| NC06 | Beaufort | Carteret | US Environmental Protection Agency-CAMD | 01/99 |
| NC25 | Coweeta | Macon | USDA Forest Service | 07/78 |
| NC34 | Piedmont Research Station | Rowan | North Carolina State University | 10/78 |
| NC35 | Clinton Crops Research Station | Sampson | North Carolina State University | 10/78 |
| NC36 | Jordan Creek | Scotland | US Geological Survey | 10/83 |
| NC41 | Finley Farms | Wake | North Carolina State University | 10/78 |
| NC45 | Mount Mitchell | Yancey | North Carolina State University | 11/85 |

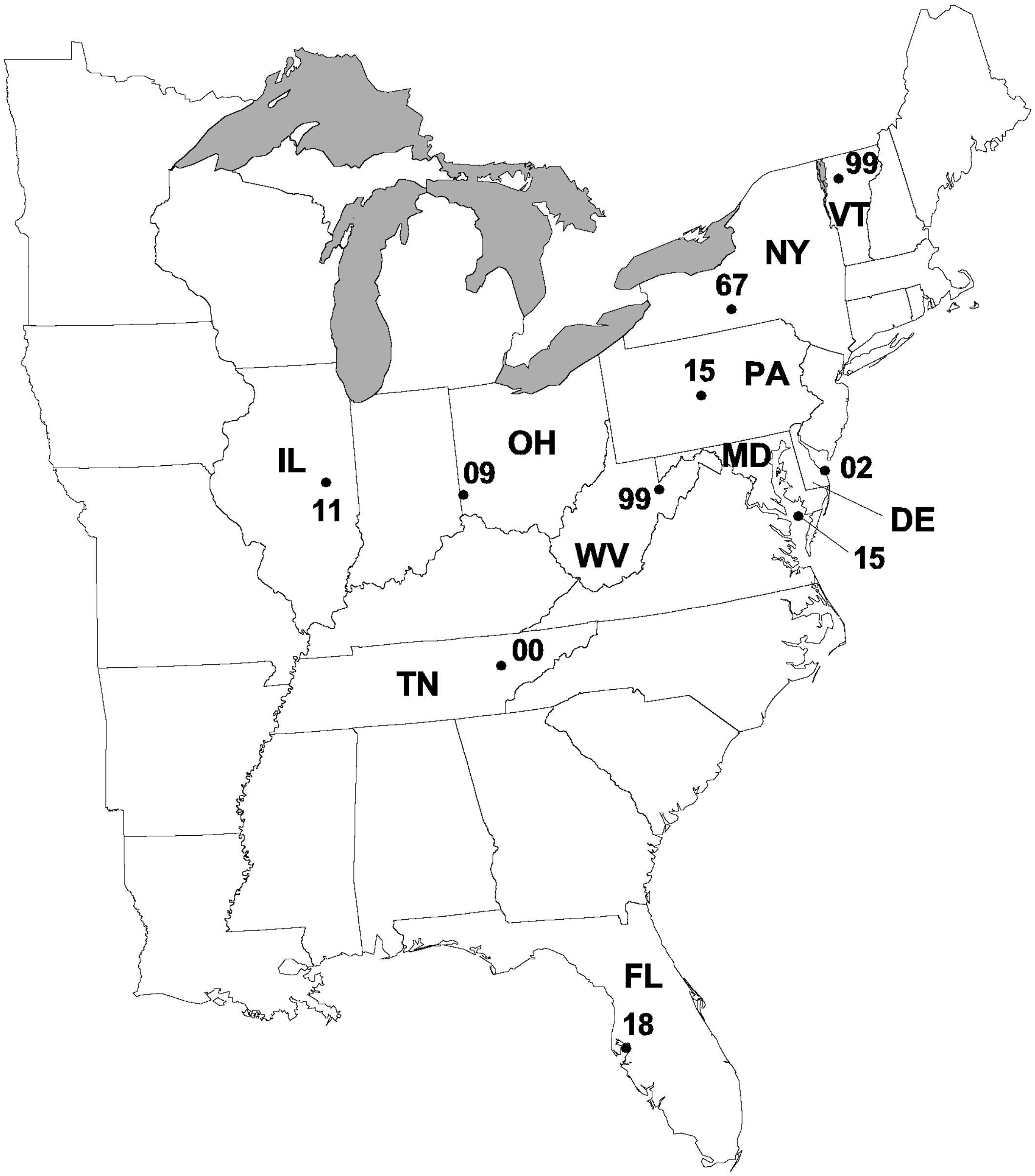
| State Site Code | Site Name | County | Sponsoring Agency | Start Date |
|---|---|---|---|---|
| **North Dakota** | | | | |
| ND07 | Theo Roosevelt NP - North Unit Headquarters | McKenzie | National Park Service - Air Resources Div | 05/81 |
| ND08 | Icelandic State Park | Pembina | US Geological Survey | 10/83 |
| ND11 | Woodworth | Stutsman | US Geological Survey | 11/83 |
| **Ohio** | | | | |
| OH09 | Oxford | Butler | US Geological Survey | 08/84 |
| OH15 | Lykens | Crawford | US Environmental Protection Agency-CAMD | 01/99 |
| OH17 | Delaware | Delaware | USDA Forest Service | 10/78 |
| OH49 | Caldwell | Noble | US Geological Survey | 09/78 |
| OH54 | Deer Creek State Park | Pickaway | US Environmental Protection Agency-CAMD | 01/99 |
| OH71 | Wooster | Wayne | US Geological Survey | 09/78 |
| **Oklahoma** | | | | |
| OK00 | Salt Plains NWR | Alfalfa | US Geological Survey | 12/83 |
| OK08 | Lake Eucha | Delaware | Oklahoma Conservation Commission | 02/00 |
| OK17 | Great Plains Apiaries | McClain | NOAA-Air Resources Lab | 03/83 |
| OK29 | Goodwell Research Station | Texas | US Geological Survey | 01/85 |
| **Oregon** | | | | |
| OR02 | Alsea Guard Ranger Station | Benton | US Environmental Protection Agency-CAMD | 12/79 |
| OR09 | Silver Lake Ranger Station | Lake | US Geological Survey | 08/83 |
| OR10 | H J Andrews Experimental Forest | Lane | USDA Forest Service | 05/80 |
| OR18 | Starkey Experimental Forest | Union | US Geological Survey | 03/84 |
| OR97 | Hyslop Farm | Benton | US Environmental Protection Agency-CAMD | 04/83 |
| OR98 | Bull Run | Clackamas | USGS-City of Portland | 07/82 |
| **Pennsylvania** | | | | |
| PA00 | Arendtsville | Adams | US Environmental Protection Agency-CAMD | 01/99 |
| PA15 | Penn State | Centre | NOAA-Air Resources Lab | 06/83 |
| PA18 | Young Woman's Creek | Clinton | US Geological Survey | 04/99 |
| PA29 | Kane Experimental Forest | Elk | USDA Forest Service | 07/78 |
| PA42 | Leading Ridge | Huntingdon | SAES-Pennsylvania State University | 04/79 |
| PA72 | Milford | Pike | USDA Forest Service | 12/83 |
| **Puerto Rico** | | | | |
| PR20 | El Verde | Rio Grande | USDA Forest Service | 02/85 |
| **South Carolina** | | | | |
| SC06 | Santee NWR | Clarendon | US Geological Survey | 07/84 |
| **South Dakota** | | | | |
| SD08 | Cottonwood | Jackson | NOAA-Air Resources Lab | 10/83 |
| SD99 | Huron Well Field | Huron | US Geological Survey | 11/83 |
| **Tennessee** | | | | |
| TN00 | Walker Branch Watershed | Anderson | DOE/Oak Ridge Natl Lab/Lockheed-Martin | 03/80 |
| TN04 | Speedwell | Claiborne | US Environmental Protection Agency-CAMD | 01/99 |
| TN11 | Great Smoky Mountain NP - Elkmont | Sevier | National Park Service - Air Resources Div | 08/80 |
| TN14 | Hatchie NWR | Haywood | Tennessee Valley Authority | 10/84 |
| **Texas** | | | | |
| TX02 | Muleshoe NWR | Bailey | US Geological Survey | 06/85 |
| TX03 | Beeville | Bee | NOAA-Air Resources Lab | 02/84 |
| TX04 | Big Bend NP - K-Bar | Brewster | National Park Service - Air Resources Div | 04/80 |
| TX10 | Attwater Prairie Chicken NWR | Colorado | US Geological Survey | 07/84 |
| TX16 | Sonora | Edwards | US Geological Survey | 06/84 |
| TX21 | Longview | Gregg | Texas Natural Resource Conservation Comm | 06/82 |
| TX22 | Guadalupe Mountains NP-Frijole Ranger Station | Culberson | US Geological Survey | 06/84 |
| TX38 | Forest Seed Center | Nacogdoches | Texas Natural Resource Conservation Comm | 08/81 |
| TX56 | LBJ National Grasslands | Wise | US Geological Survey | 09/83 |
| **Utah** | | | | |
| UT01 | Logan | Cache | US Geological Survey | 12/83 |
| UT08 | Murphy Ridge | Rich | BP Amoco | 03/86 |
| UT09 | Canyonlands NP - Island in the Sky | San Juan | National Park Service - Air Resources Div | 11/97 |
| UT98 | Green River | Emery | US Geological Survey | 04/85 |
| UT99 | Bryce Canyon NP - Repeater Hill | Garfield | National Park Service - Air Resources Div | 01/85 |
| **Vermont** | | | | |
| VT01 | Bennington | Bennington | US Geological Survey | 04/81 |
| VT99 | Underhill | Chittenden | US Geological Survey | 06/84 |
| **Virgin Islands** | | | | |
| VI01 | Virgin Islands NP - Lind Point | St. John | National Park Service - Air Resources Div | 04/98 |

| State<br>Site Code | Site Name | County | Sponsoring Agency | Start<br>Date |
|---|---|---|---|---|
| **Virginia** | | | | |
| VA00 | Charlottesville | Albemarle | US Geological Survey | 10/84 |
| VA13 | Horton's Station | Giles | Tennessee Valley Authority | 07/78 |
| VA24 | Prince Edward | Prince Edward | US Environmental Protection Agency-CAMD | 01/99 |
| VA28 | Shenandoah NP - Big Meadows | Madison | National Park Service - Air Resources Div | 05/81 |
| **Washington** | | | | |
| WA14 | Olympic NP - Hoh Ranger Station | Jefferson | National Park Service - Air Resources Div | 05/80 |
| WA19 | North Cascades NP-Marblemount Ranger Station | Skagit | US Geological Survey | 02/84 |
| WA21 | La Grande | Pierce | US Environmental Protection Agency-CAMD | 04/84 |
| WA24 | Palouse Conservation Farm | Whitman | US Geological Survey | 08/85 |
| WA99 | Mount Rainier NP - Tahoma Woods | Pierce | National Park Service - Air Resources Div | 10/99 |
| **West Virginia** | | | | |
| WV04 | Babcock State Park | Fayette | US Geological Survey | 09/83 |
| WV05 | Cedar Creek State Park | Gilmer | US Environmental Protection Agency-CAMD | 01/99 |
| WV18 | Parsons | Tucker | USDA Forest Service | 07/78 |
| **Wisconsin** | | | | |
| WI09 | Popple River | Florence | Wisconsin Department of Natural Resources | 12/86 |
| WI25 | Suring | Oconto | Wisconsin Department of Natural Resources | 01/85 |
| WI28 | Lake Dubay | Portage | Wisconsin Department of Natural Resources | 06/82 |
| WI35 | Perkinstown | Taylor | US Environmental Protection Agency-CAMD | 01/99 |
| WI36 | Trout Lake | Vilas | Wisconsin Department of Natural Resources | 01/80 |
| WI37 | Spooner | Washburn | Wisconsin Department of Natural Resources | 06/80 |
| WI98 | Wildcat Mountain | Vernon | Wisconsin Department of Natural Resources | 08/89 |
| WI99 | Lake Geneva | Walworth | Wisconsin Department of Natural Resources | 06/84 |
| **Wyoming** | | | | |
| WY00 | Snowy Range - West Glacier Lake | Albany | USDA Forest Service | 04/86 |
| WY02 | Sinks Canyon | Fremont | Bureau of Land Management | 08/84 |
| WY06 | Pinedale | Sublette | Bureau of Land Management | 01/82 |
| WY08 | Yellowstone NP - Tower | Park | National Park Service - Air Resources Div | 06/80 |
| WY95 | Brooklyn Lake | Albany | USDA Forest Service | 09/92 |
| WY97 | South Pass City | Fremont | SF Phosphates Ltd. - Bridger Teton NF | 04/85 |
| WY98 | Gypsum Creek | Sublette | Exxon Co. | 12/84 |
| WY99 | Newcastle | Weston | Bureau of Land Management | 08/81 |
| **Canada** | | | | |
| CAN4 | Sutton | Brome | US Geological Survey | 09/86 |

*Intercomparison sites

# AIRMoN MAP AND SITE LISTINGS

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

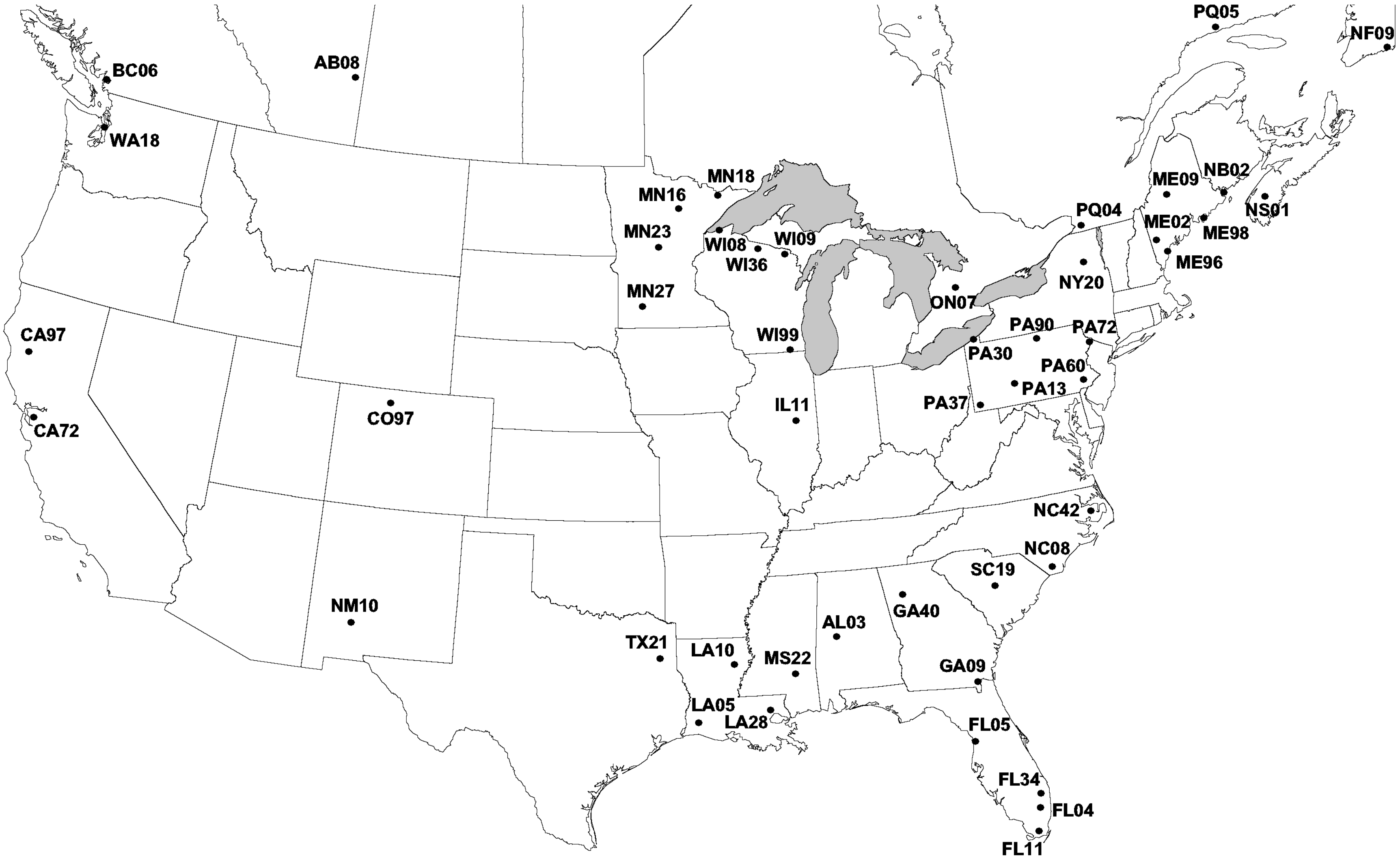


# NADP/Atmospheric Integrated Research Monitoring Network Sites
## September 30, 2000

| State<br>Site Code | Site Name | County | Sponsoring Agency | Start Date |
|---|---|---|---|---|
| **Delaware** | | | | |
| DE02 | Lewes | Sussex | NOAA-Air Resources Laboratory | 09/92 |
| **Florida** | | | | |
| FL18 | Tampa Bay | Hillsborough | EPA/Tampa Bay Regional Planning Council | 08/96 |
| **Illinois** | | | | |
| IL11 | Bondville | Champaign | NOAA-Air Resources Laboratory | 10/92 |
| **Maryland** | | | | |
| MD15 | Smith Island | Somerset | NOAA-Air Resources Laboratory | 11/95 |
| **New York** | | | | |
| NY67 | Cornell University | Thompkins | NOAA-Air Resources Laboratory | 09/92 |
| **Ohio** | | | | |
| OH09 | Oxford | Butler | NOAA-Air Resources Laboratory | 10/92 |
| **Pennsylvania** | | | | |
| PA15 | Penn State | Centre | NOAA-Air Resources Laboratory | 10/92 |
| **Tennessee** | | | | |
| TN00 | Oak Ridge National Lab | Anderson | NOAA-Air Resources Laboratory | 09/92 |
| **Vermont** | | | | |
| VT99 | Underhill | Chittenden | NOAA-Air Resources Laboratory | 01/93 |
| **West Virginia** | | | | |
| WV99 | Canaan Valley Institute | Tucker | NOAA-Air Resources Laboratory | 06/00 |

## MDN MAP AND SITE LISTINGS

# National Atmospheric Deposition Program
## Mercury Deposition Network



# National Atmospheric Deposition Program/Mercury Deposition Network Sites
## September 30, 2000

| State/Province Site Code | Site Name | County | Sponsoring Agency | Start Date |
|---|---|---|---|---|
| **Alabama** | | | | |
| AL03 | Centreville | Bibb | Southern Company/Atmospheric Research and Analysis, Inc. | 06/00 |
| **California** | | | | |
| CA72 | San Jose | Santa Clara | US EPA/San Francisco Estuary Institute | 01/00 |
| CA97 | Covelo | Mendocino | Electric Power Research Institute | 12/97 |
| **Colorado** | | | | |
| CO97 | Buffalo Pass - Summit Lake | Routt | USDA Forest Service-Rocky Mtn Forest & Range Exp Station | 10/98 |
| **Florida** | | | | |
| FL04 | Andytown | Broward | South Florida Water Management Institute | 01/98 |
| FL05 | Chassahowitzka NWR | Citrus | US Fish and Wildlife Service - Air Quality Branch | 07/97 |
| FL11 | Everglades NP - Research Center | Dade | South Florida Water Management Institute | 10/95 |
| FL34 | ENRP | Palm Beach | South Florida Water Management Institute | 07/97 |
| **Georgia** | | | | |
| GA09 | Okefenokee NWR | Charlton | US Fish and Wildlife Service - Air Quality Branch | 07/97 |
| GA40 | Yorkville | Paulding | Southern Company/Atmospheric Research and Analysis, Inc. | 06/00 |
| **Illinois** | | | | |
| IL11 | Bondville | Champaign | Illinois State Water Survey | 01/99 |
| **Louisiana** | | | | |
| LA05 | Lake Charles | Calcasieu | Louisiana Department of Environmental Quality | 10/98 |
| LA10 | Chase | Franklin | Louisiana Department of Environmental Quality | 10/98 |
| LA28 | Hammond | Tangipahoa | Louisiana Department of Environmental Quality | 10/98 |
| **Maine** | | | | |
| ME02 | Bridgton | Cumberland | Maine Dept. of Environmental Protection | 06/97 |
| ME09 | Greenville Station | Piscataquis | Maine Dept. of Environmental Protection | 09/96 |
| ME96 | Casco Bay - Wolfe's Neck Farm | Cumberland | US EPA/University of Southern Maine | 01/98 |
| ME98 | Acadia NP - McFarland Hill | Hancock | NPS-Acadia NP & ME Dept of Environmental Protection | 09/95 |
| **Minnesota** | | | | |
| MN16 | Marcell Experimental Forest | Itasca | USDA Forest Service-North Central Forest Experiment Station | 02/95 |
| MN18 | Fernberg | Lake | USDA Forest Service & MN Pollution Control Agency | 03/95 |
| MN23 | Camp Ripley | Morrison | Minnesota Pollution Control Agency | 07/96 |
| MN27 | Lamberton | Redwood | Minnesota Pollution Control Agency | 07/96 |
| **Mississippi** | | | | |
| MS22 | Oak Grove | Perry | Southern Company/Atmospheric Research and Analysis, Inc. | 06/00 |
| **New Mexico** | | | | |
| NM10 | Caballo | Sierra | Bureau of Reclamation/New Mexico State University | 05/97 |
| **North Carolina** | | | | |
| NC08 | Waccamaw State Park | Columbus | North Carolina Dept of Environment & Natural Resources | 05/95 |
| NC42 | Pettigrew State Park | Washington | North Carolina Dept of Environment & Natural Resources | 05/95 |
| **New York** | | | | |
| NY20 | Huntington Wildlife | Essex | US EPA/State University of New York - Syracuse | 12/99 |
| **Pennsylvania** | | | | |
| PA13 | Allegheny Portage Railroad NHS | Cambria | PA Dept of Environmental Protection/Penn State University | 01/97 |
| PA30 | Erie | Erie | PA Dept of Environmental Protection/Penn State University | 06/00 |
| PA37 | Holbrooke | Greene | US Dept of Energy/National Energy Technology Laboratory | 05/99 |
| PA60 | Valley Forge | Montgomery | PA Dept of Environmental Protection/Penn State University | 12/99 |
| PA72 | Milford | Pike | PA Dept of Environmental Protection/Penn State University | 09/00 |
| PA90 | Hills Creek State Park | Tioga | PA Dept of Environmental Protection/Penn State University | 01/97 |

| State/Province<br>Site Code | Site Name | County | Sponsoring Agency | Start Date |
|---|---|---|---|---|
| **South Carolina** | | | | |
| SC19 | Congaree Swamp State Park | Richland | South Carolina Dept of Health & Environmental Quality | 03/95 |
| **Texas** | | | | |
| TX21 | Longview | Gregg | Texas Natural Resource Conservation Commission | 11/95 |
| **Washington** | | | | |
| WA18 | Seattle - NOAA | King | Frontier Geosciences, Inc | 03/96 |
| **Wisconsin** | | | | |
| WI08 | Brule River | Douglas | Wisconsin Department of Natural Resources | 03/95 |
| WI09 | Popple River | Florence | Wisconsin Department of Natural Resources | 06/95 |
| WI36 | Trout Lake | Vilas | Wisconsin Department of Natural Resources | 05/95 |
| WI99 | Lake Geneva | Walworth | Wisconsin Department of Natural Resources | 01/97 |
| **CANADA** | | | | |
| **Alberta** | | | | |
| AB08 | Esther | | Environment Canada - Prairie and Northern Region | 04/00 |
| **British Columbia** | | | | |
| BC06 | Reifel Island | | Environment Canada - Environmental Conservation Branch | 04/00 |
| **New Brunswick** | | | | |
| NB02 | St. Andrews | Charlotte | Environment Canada - Atmospheric Environment Branch | 07/96 |
| **Newfoundland** | | | | |
| NF09 | Newfoundland | | Environment Canada - Atmospheric Environment Branch | 06/00 |
| **Nova Scotia** | | | | |
| NS01 | Kejimkujik NP | Queens | Environment Canada - Atmospheric Environment Branch | 07/96 |
| **Quebec** | | | | |
| PQ04 | Saint Anicet | | Environment Canada - Atmospheric Environment Branch | 04/98 |
| PQ05 | Mingan | | Environment Canada - Atmospheric Environment Branch | 04/98 |

# PROCEEDINGS NOTES

# PROCEEDINGS NOTES

# PROCEEDINGS NOTES

## PROCEEDINGS NOTES

## PROCEEDINGS NOTES

## PROCEEDINGS NOTES