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PROCEEDINGS

ENVIRONMENTAL MONITORING, EVALUATION, AND PROTECTION IN NEW YORK: LINKING SCIENCE AND POLICY

New York Energy $mart℠

EMEP

Environmental Monitoring, Evaluation, & Protection

OCTOBER 7-8, 2003

Albany Marriott • 189 Wolf Road • Albany, NY

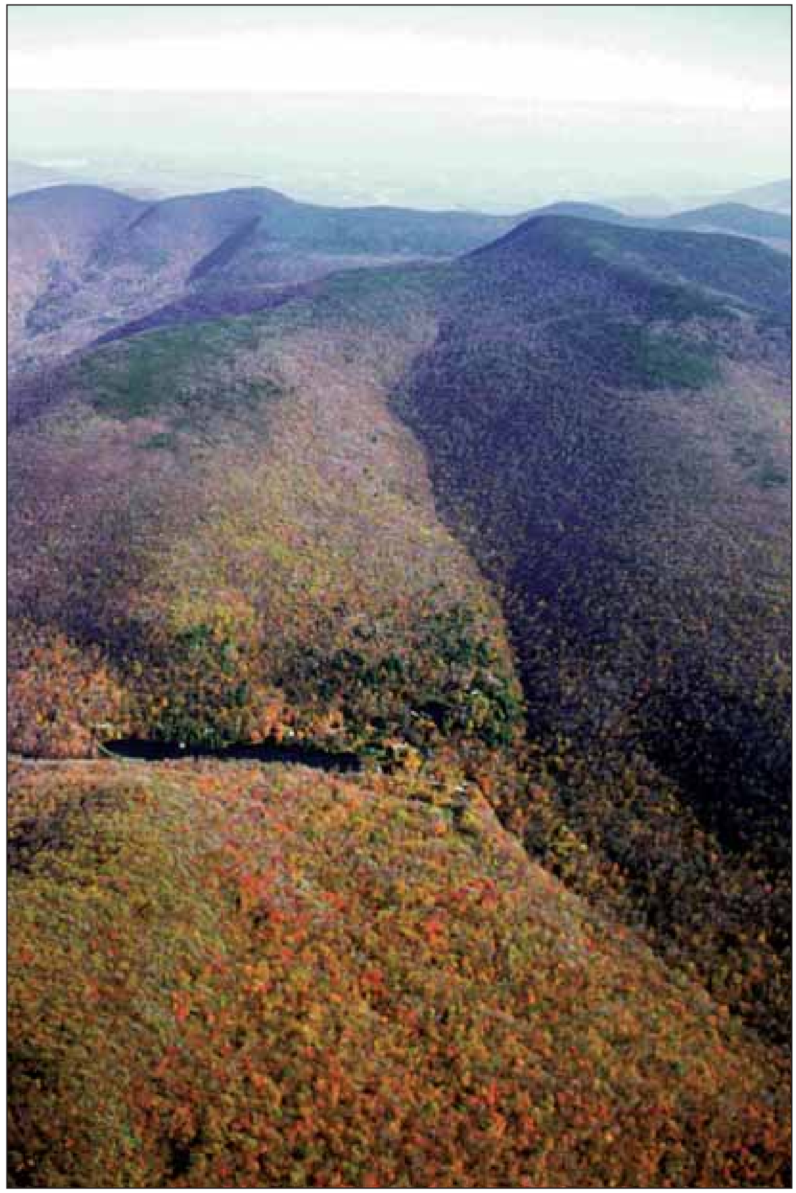

Photo by Michael McHale

Winnisook watershed, Catskill Mountians

This conference brings together scientists and policy makers to share information on environmental research in New York State and its implications for policy making. The New York Energy $mart℠ Environmental program supports policy-relevant research in order to enhance understanding of energy-related environmental issues. The program will highlight research on air quality and related health issues, ecosystem responses to atmospheric pollutants, and proposed pollution control policies affecting New York State. A series of panels, breakout and plenary sessions will focus on four key areas: particulate matter, acid deposition, ozone and mercury. Results of NYSERDA/EMEP-sponsored and related research projects will be presented in poster sessions throughout the two-day event. The plenary sessions will draw attention to major energy-related environmental issues of the 21st century and offer recommendations for improving the effectiveness of science-based policy.

Environmental Monitoring, Evaluation and Protection in New York:
Linking Science and Policy
October 7-8, 2003

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NOTICE

The summaries of presentations found in these proceedings were approved by speakers at the conference on **Environmental Monitoring, Evaluation and Protection in New York: Linking Science and Policy**, held on October 7-8, 2003 in Albany, New York. The papers reflect the opinions of the authors and do not necessarily reflect the opinions of the conference sponsors or the State of New York.

Acknowledgments

We appreciate the many individuals and organizations who contributed to the success of this conference.

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Northeast States for Coordinated Air Use Management (NESCAUM)

Session and Panel Chairs

Praveen Amar, NESCAUM
John Bachmann, U.S. EPA
Ellen Burkhard, NYSERDA
Joanne Fox-Przeworski, Bard Center for Environmental Policy
Richard Haeuber, U.S. EPA
Carl Johnson, NYSDEC
Sandra Meier, Environmental Energy Alliance of New York
Jim Vickery, U.S. EPA
Mark Watson, NYSERDA
Kathleen Weathers, Institute of Ecosystem Studies

Session Summary Writers

Praveen Amar, NESCAUM (EMEP Science Advisor)
George Hidy, Aerochem Associates (EMEP Science Advisor)
Kathy Fallon Lambert, Ecologic: Analysis and Communications (EMEP Outreach and Communications Team)

Special thanks to the Bard Center for Environmental Policy for assistance with the conference proceedings and organizing the conference, to Sally Atwater Editorial Arts for assistance with the session summaries, and to the many individuals who helped plan and conduct the conference and produce the proceedings.

Environmental Monitoring, Evaluation and Protection in New York:
Linking Science and Policy

FOREWORD

These proceedings represent a summary of the presentations at the conference on Environmental Monitoring, Evaluation, and Protection in New York: Linking Science and Policy, held October 7-8, 2003 in Albany, New York. The PowerPoint slide presentations from many of the session speakers are located on the EMEP website (www.nyserda.org/programs/environment/emep.asp).

The conference was made possible through a collaboration of the following organizations:

Adirondack Council
Center for Clean Air Policy
Clean Air Task Force
Environmental Energy Alliance of New York
New York Academy of Sciences
New York State Departments of Environmental Conservation, Health and Public Service
New York State Energy Research and Development Authority (NYSERDA)
Northeast States for Coordinated Air Use Management (NESCAUM)
U.S. Environmental Protection Agency
U.S. Geological Survey

There were over 220 conference attendees representing a wide cross section of organizations involved in policy making and scientific research. The conference highlighted the environmental research that is being supported in New York through NYSERDA's Environmental Monitoring, Evaluation and Protection (EMEP) Program, which is funded through the **New York Energy $mart**℠ Program (see Highlight Box). The conference brought together scientists and policy makers to share ideas on critical energy-related environmental issues in the region. This helps to ensure that limited resources for environmental research are used effectively, and most of all, that the scientific information developed is relevant to the formulation of environmental policy.

This is the third EMEP conference since its inception in 1998. The last conference focused on updates of EMEP projects, environmental issues associated with distributed generation, and information needs and future directions for a multipollutant and multimedia environmental protection strategy. This conference included sessions on increasing the effectiveness of science-policy communication, emissions control options, and energy-related environmental policy initiatives affecting New York State and the region. Synthesis papers have been prepared to summarize four sessions of the conference:

1. Fine particles: health effects, sources and implications for New York State;
2. Ecosystem response to changing levels of sulfur, nitrogen and mercury deposition;
3. Approaches to controlling particulate emissions and co-pollutants, and economic implications;
4. Impact of nitrogen compounds on human health, ecosystems and climate, and potential control options.

We would like to thank the conference sponsors and the many presenters and panelists who contributed to the event and these proceedings. NYSERDA and its partners in the EMEP program will continue to provide objective research and a forum for exchange of science-based information to help support sound environmental policy making in New York and the region. Also, a variety of new program products are now being produced to assist in the dissemination of research results and to convey information about current issues. In addition to project final reports, new two-page "Project Updates" describe each EMEP project and include recent findings and policy implications. Short topical papers summarize pollution associated with the generation of electricity which impact New York State: ozone and fine particles, acid deposition, and mercury. These products are available on the EMEP website:
(www.nyserda.org/programs/environment/emep.asp).

NEW YORK STATE ENVIRONMENTAL MONITORING, EVALUATION AND PROTECTION: PROGRAM OVERVIEW

Energy production and use pose one of the greatest anthropogenic burdens on our environment. In order to better understand these environmental impacts and how they could be mitigated, New York State established an energy-related environmental research program in 1998, and began providing a forum for exchange of research and policy information on issues ranging from acid rain, mercury transport, ozone, and fine particulates. Program Opportunity Notices (PONs) are issued periodically to seek proposals which address targeted research areas. Projects are reviewed and selected through a competitive process. The program is guided by a steering committee comprised of representatives from the New York State Departments of Environmental Conservation, Health, and Public Service; the U.S. Environmental Protection Agency; the National Oceanic and Atmospheric Administration; two utility associations; and an environmental/public interest group. A science advisory committee provides technical support and evaluation of projects.

Keynote Presentation

Major Energy- and Air-Related Environmental Issues for the 21st Century

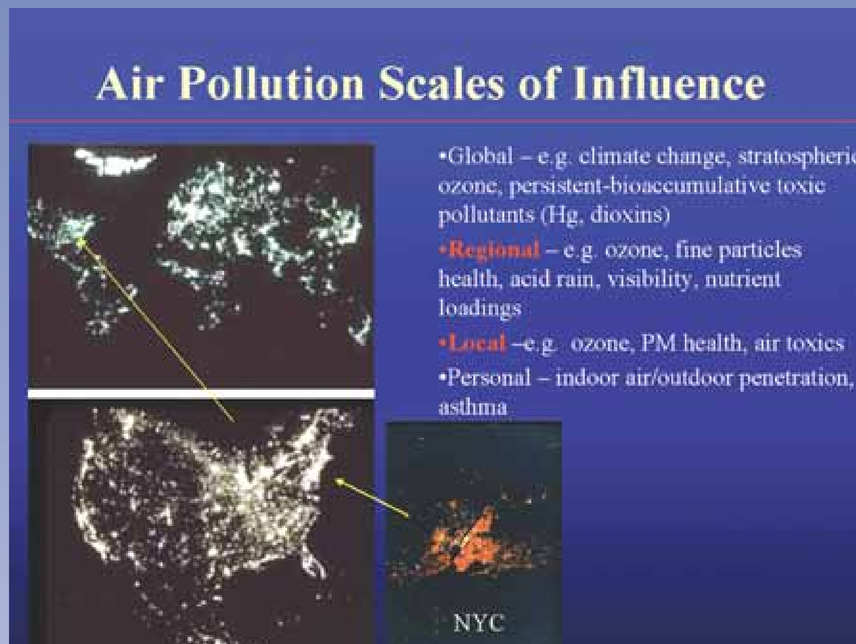
John Bachmann
Associate Director, Science/Policy and New Programs Management Issues, U.S. Environmental Protection Agency

The night sky is a good indicator of where people are, where energy is used, and where we have air pollution problems *(Figure 1)*. Although we have made progress in reducing pollution over the years, the ongoing expansion of the built environment continues to challenge our ability to manage air quality. Continued economic growth will need to go hand-in-hand with continued efforts to reduce pollution, in order for our quality of life to be sustained.

Air Pollution Scales of Influence
Environmental problems such as stratospheric ozone depletion, climate change, and bioaccumulative toxics like dioxins and mercury exert influence over a global scale. These problems are associated with pollutants that travel long distances across many physical and geopolitical boundaries.

On the regional scale—of great concern to New York State—are issues like tropospheric ozone, fine particles, and the health effects associated with those pollutants; acid deposition; and visibility impairment. Individual states cannot solve these problems by themselves. These are international as well as national regional issues.

Ambient particulate matter and air toxics also have a local component that must be addressed. And, on an even finer scale, we have the personal or indoor environment, which affects health problems such as asthma.



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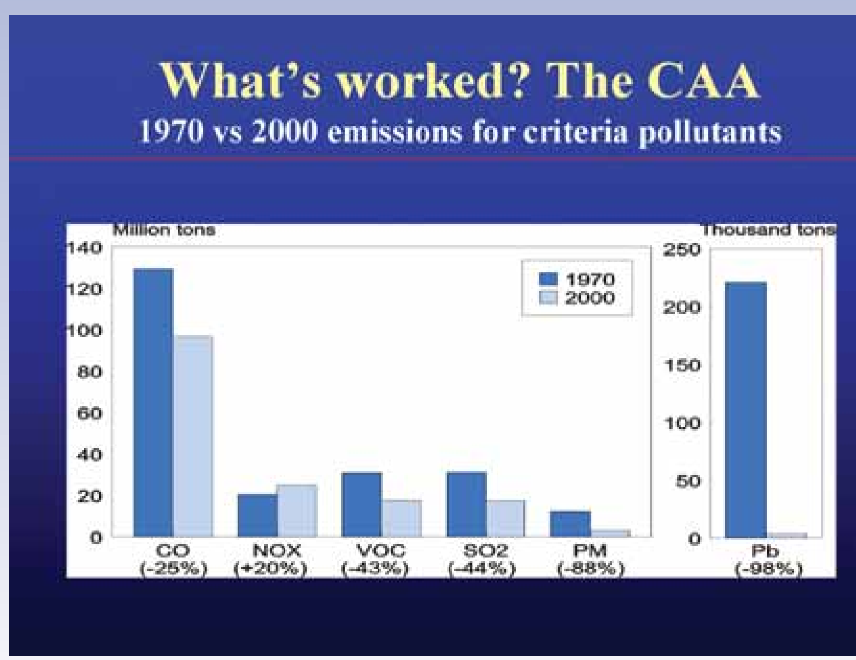

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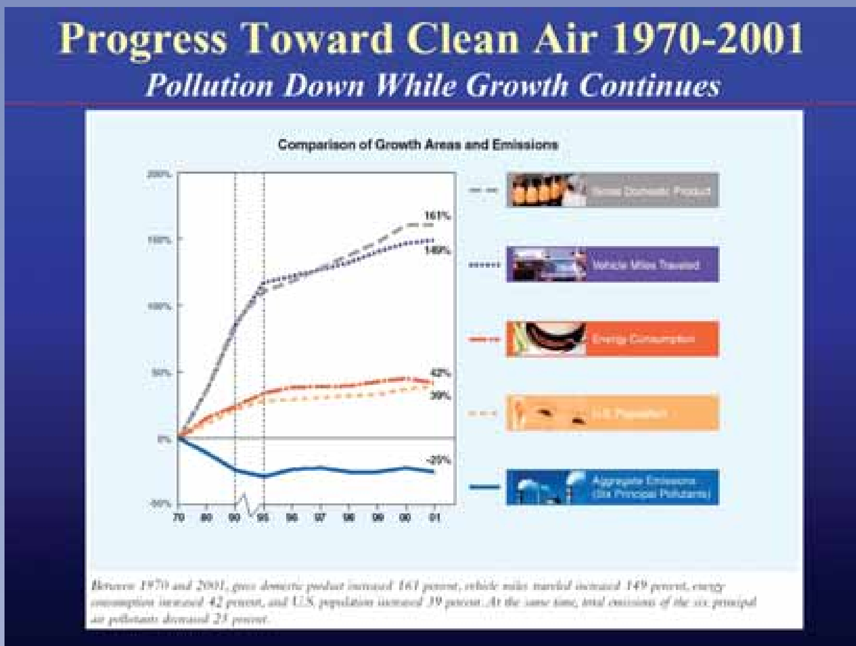


Figure 3

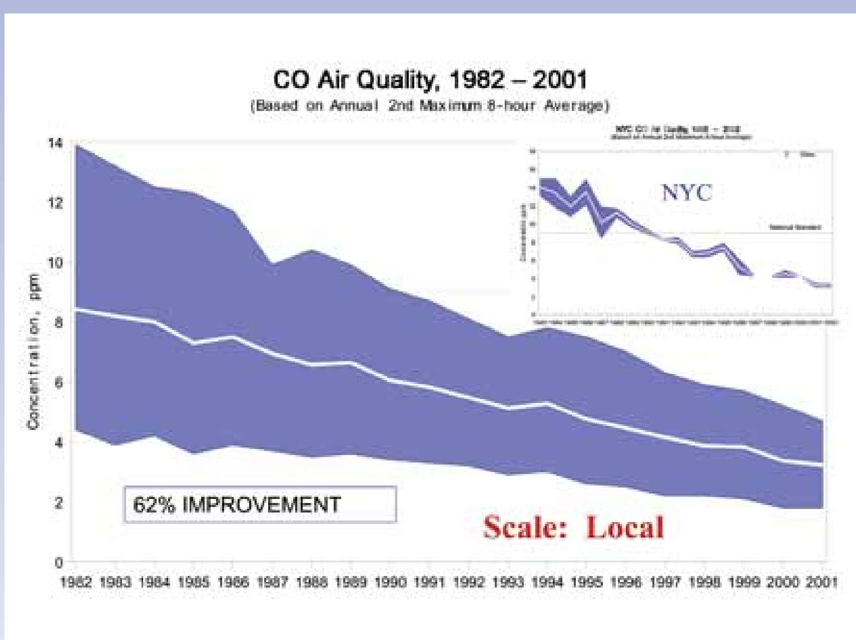


Figure 4

Three Decades of Progress

History has shown that if we put our national will to it, we can reduce emissions *(Figure 2)*. Carbon monoxide emissions have gone down substantially since 1970. Emissions of volatile organic compounds (VOCs) are down, sulfur dioxide (SO_2) is down significantly, and direct emissions of particulate matter (PM) have gone down as well. Lead was effectively removed from the air, once we took it out of gasoline. Nitrogen oxide (NO_x) emissions have not changed much. What's remarkable is that during this 30-year period, which included some notable improvements in air quality, the economy grew, the number of miles people drove increased, energy consumption went up, and the population grew *(Figure 3)*. We have been successful in reducing emissions—especially with automobiles, more recently with power plants— and we have decoupled the economy from traditional air pollution. But ultimately we have to strive for "zero emissions" if we are to continue this kind of growth in a sustainable manner.

Carbon Monoxide (CO). If we look at the national average of carbon monoxide emissions, we see tremendous improvement *(Figure 4)*. Progress in New York City is especially impressive, and part of that is transportation management. But the biggest reason is the cleaner automobile itself. So reducing CO was easy compared with some other emissions.

Ozone (O_3). Ozone is a more modest success story *(Figure 5)*. We clearly are better off today in the eastern United States, after a peak in 1988. But since then, we have not seen much progress—perhaps because we did not control the regional component of NO_x emissions. We are about to do that under a variety of programs, and we expect to start making progress on ozone again.

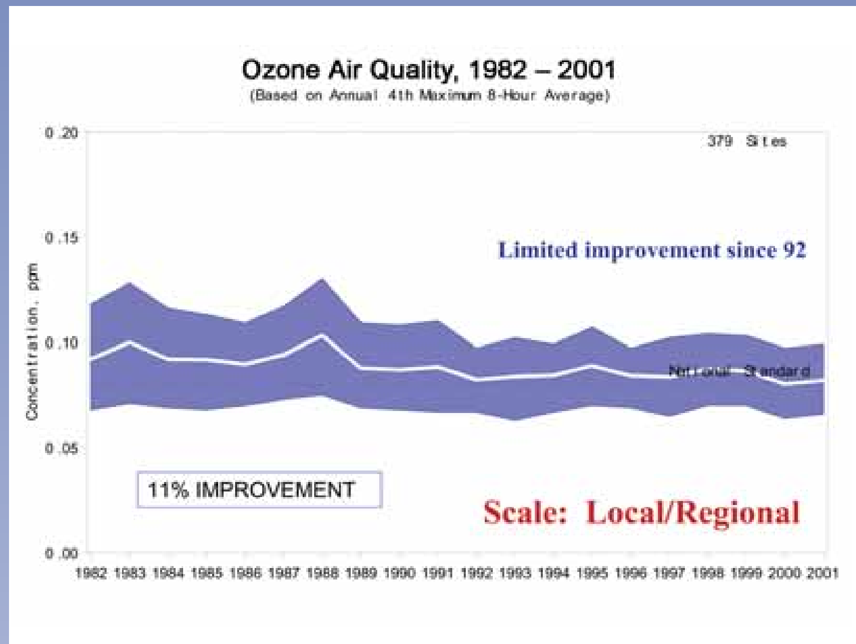
Acid Rain. The acid rain program has had significant success in all regions of the country. SO_2 emissions— actual, monitored data at the stack— show real results from this marketbased program. And sulfates are a major component of fine particles. We've also had progress on longterm acidification—an issue of great importance in New York State *(Figure 6)*. Because of the big reduction in sulfate, we are beginning to chip away at long-term acidification. There still remains episodic acidification, mostly associated with nitrogen, and the Adirondack region shows signs of being sensitive to nitrogen. Nitrogen is still an issue that will need to be addressed.

Challenges Ahead

Particulate matter forces us to look more holistically at air pollution sources. Ambient particulate matter has been associated with premature death from heart and lung disease; aggravation of heart and lung diseases, such as asthma; cardiac arrhythmias and heart attacks; coughing, wheezing, and chronic bronchitis; possibly even lung cancer and infant mortality.

There are multiple bad actors in this pollutant mix, and the whole may be greater than the sum of its parts. We do not understand some of the toxicological results: sulfates apparently do not have much innate toxicity yet continue to be associated with health effects. At this time, it is hard to identify any component of PM that is not related to a significant health effect.

What are the implications for future maximum achievable control technology (MACT) standards and control approaches? We have 24-hour and annual ambient air



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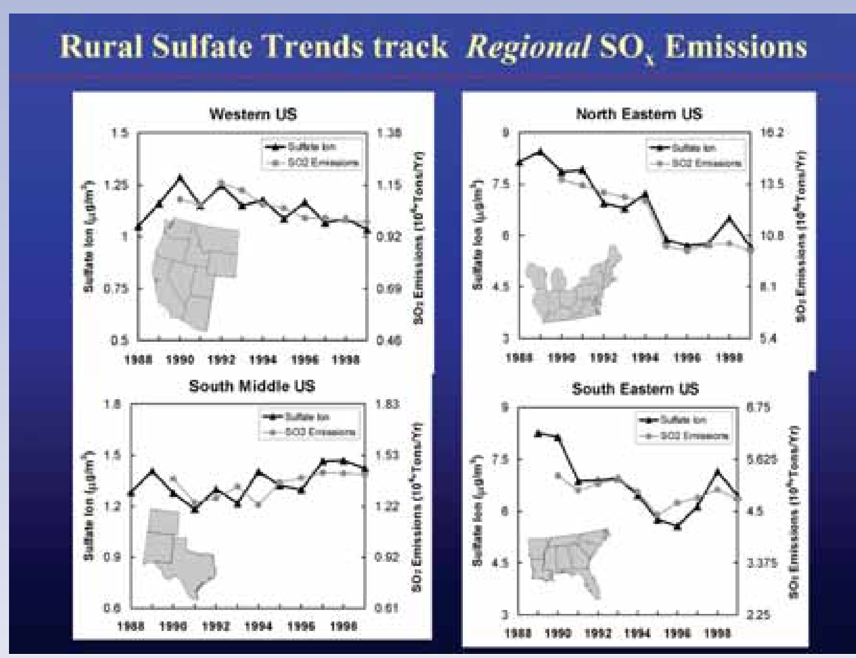

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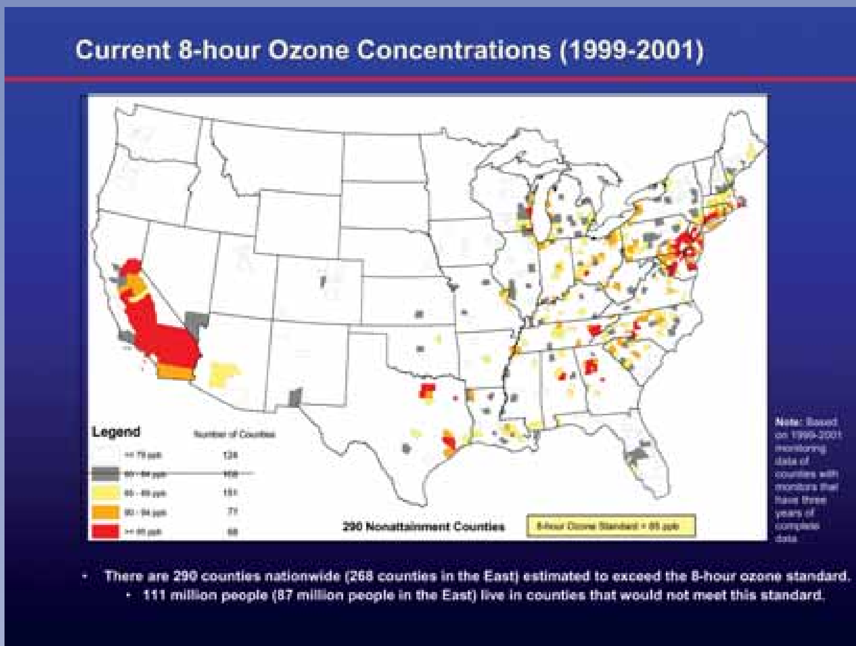


Figure 7

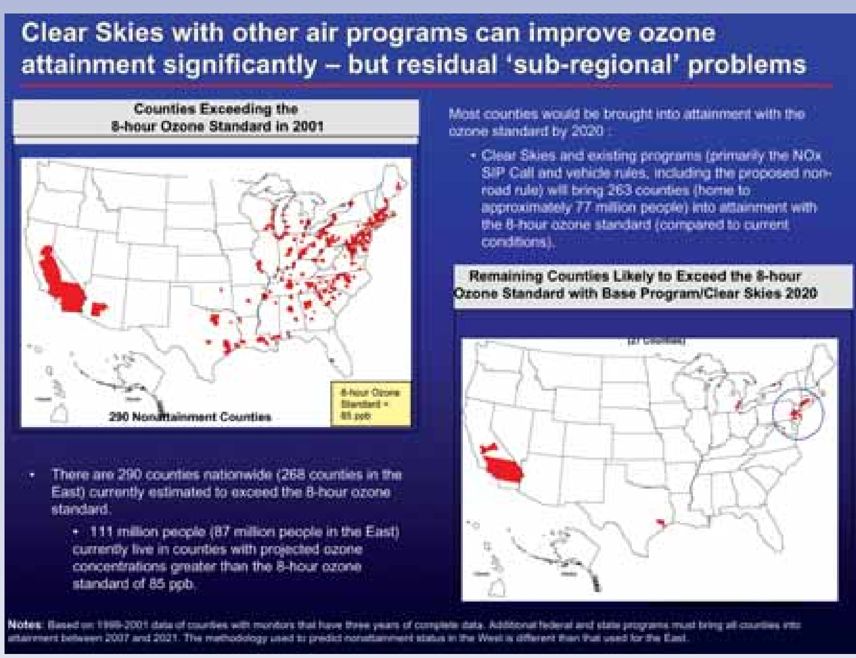


Figure 8

quality standards. We have the monitoring technology to move to shorter averaging times. These advances in monitoring— some of which have come from New York State—have been important.

One effect of particulate matter is visibility. Obviously it affects quality of life. It's not just an urban phenomenon— we have regional haze.

And then there are the health effects of ozone. New studies show effects at levels below the air quality standard. Ozone exposures appear related to school absenteeism and to premature mortality among the elderly. At least a part of the increase in asthma might be coming from ozone. We do not think it can explain the large increase in asthma rates, but in any case, ozone is a pollutant that we are spending billions of dollars to control *(Figure 7)*.

New York is relatively cleaner in the amount of sulfur and particulate matter emitted from energy facilities, but we have a regional particulate problem in the eastern United States, and the Bronx and Manhattan are areas that do not meet the PM standards. We see a similar picture for ozone. There is a persistent problem in California, but another problem is Canada, which I suspect explains part of what we see in western New York. We have an ozone annex to our air quality agreement with Canada, and we are going to be working on a fine particle annex as well. We have two mechanisms to address regional transport. EPA's preferred strategy is multipollutant legislation that addresses the power sector first—that is, the Clear Skies Initiative. This legislation also would address SO_2, NO_x, and mercury from the energy sector. The second strategy is the Clean Air Interstate Rule— a regulatory approach that uses current Clean

Air Act mechanisms, much like the state implementation plan (SIP) call, to achieve reductions. Figure 8 shows some estimates by EPA of the potential environmental improvements associated with these programs.

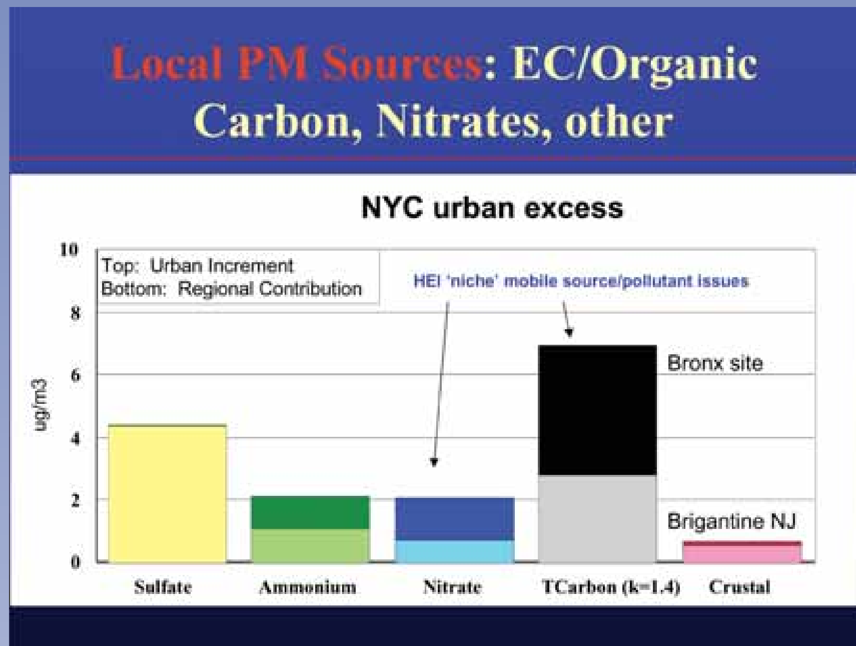
What is causing the high levels of PM2.5 in New York City? The ambient PM in New York City has a large organic and elemental carbon component, some nitrate, and ammonium. It also has a large sulfate component. While research to try to identify the specific sources contributing to this ambient PM is still underway, we know we have local sources of PM, especially of organic carbon *(Figure 9)*. A large contributor of black carbon is diesel engines. In the wintertime, the region uses a fair amount of oil for heating, which also contributes to the PM2.5 problem.

New research on health effects is underscoring the significance of roadway vehicles. Data from the Southern California PM Supersite show a high concentration of particle number right next to the freeway, with levels of particle number, black carbon, and carbon monoxide dropping significantly as you move away from the freeway *(Figure 10)*. There is extensive research going on now to attempt to better understand these exposure relationships.

Urban Planning

Health effects research raises another question: what about the design of the built environment? If you know that traffic affects quality of life, what does that suggest about urban planning? Increasingly, architects are coming to experts in air pollution and talking about how urban planning can deal with air pollution.

Trees in a city remove ozone and PM—one of the reasons air



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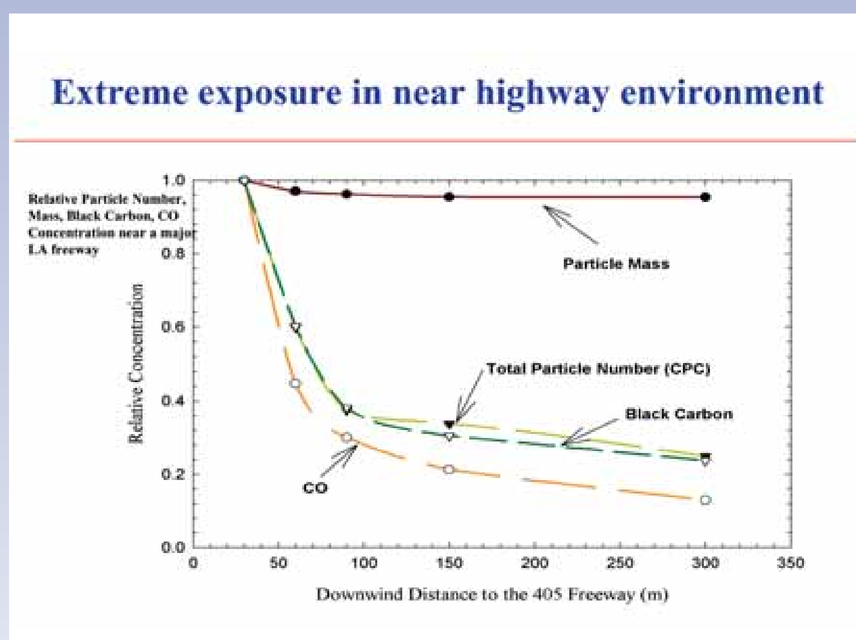

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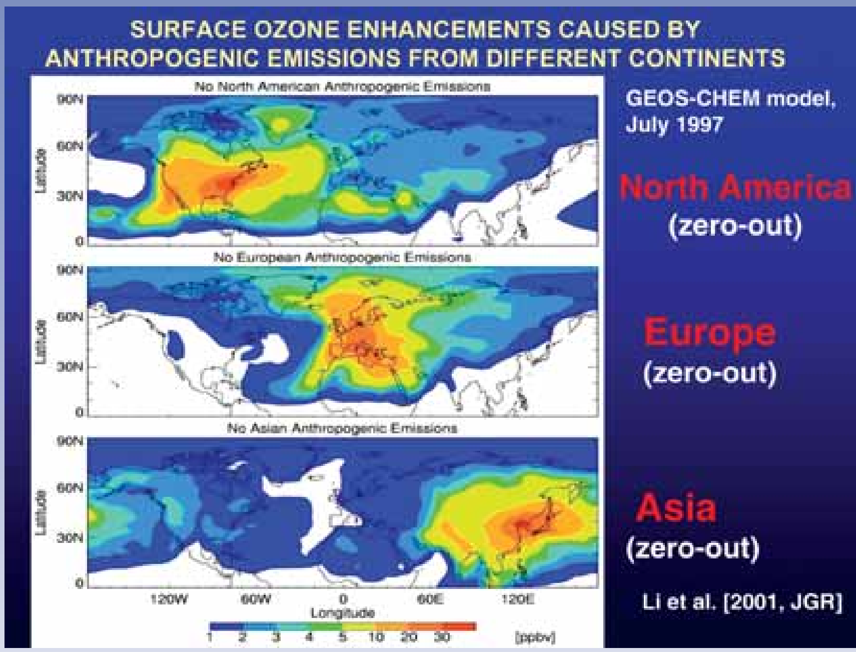


Figure 11

pollution today is lower in urban areas. Trees also cool the urban area, and cooling reduces emissions: the evaporative losses from VOCs, which also come from trees, actually go down. So the net effect of trees in the urban environment is undoubtedly positive. When you prepare your SIP for 10 years from now, will urban forestry be part of the plan? It may be, and New York and some other states are considering it.

Climate Interaction

Conventional air pollutants—like carbon monoxide, ozone, and black carbon, but also particles and sulfates— are a factor in climate. If we run a model in which we zero out North American emissions, air quality improves. Yet winds come across the ocean and hit the United States that are sometimes on the order of three and four parts per billion of ozone. Studies suggest that ozone background is two to four times higher today than it was in preindustrial times *(Figure 11)*.

What pollutant will be best to control to reduce this ozone? NO_x control would reduce ozone—absolutely. But somewhat equally effective would be to reduce methane, and reducing methane is more important for climate change mitigation. Methane reduction on a global scale actually seems to reduce ozone, at least in models. If that's so, there's a link between climate and air pollution. If we see the link, we adopt the methane strategy over the equally effective air pollution strategy of regional or global NO_x reductions.

Black carbon is also a potentially significant climate forcer—more important, possibly, in terms of fine particle standards, than some of the other particles we control, like sulfates. Sulfates may contribute to cooling, and reducing sulfur for health reasons and visibility reasons will also reduce the amount of net cooling from air pollution control.

Another challenge will be apportioning contributions and effects of air pollution to major sources. Researchers are trying to separate out the effects from vehicles, power plants, wood-burning stoves, and other factors. This type of source apportionment analysis is needed to help develop air quality management strategies.

Alternative Futures and Trends

We need to stop looking narrowly at air quality and look more broadly at total urban planning and the total environment—energy, agriculture, transportation, and multimedia issues. We know that integrated and marketoriented approaches are good, costeffective ways, and we want them to accelerate progress.

Looking to the future, international global air pollution and climate issues will likely receive increasing attention as new research findings emerge, and as we begin to shift focus from the more "manageable" local and regional issues that we have been addressing over the past few decades. We will need to see air quality management integrated into larger societal programs, like smart growth and urban planning. Local and voluntary programs, like many of the efforts here in New York State, will become more significant. Lastly, we need to track the results of these initiatives to prove that they really do benefit society in the way we hoped. Our challenges in the future are significant and we are faced with increasingly complex, interrelated systems spanning in many cases international borders, yet history has shown that if we put our will to it and combine forces of innovation with sound government policies, we can improve air quality while our economy continues to grow.

Air Quality and Related Health Research: Particulates (PM) and Co-Pollutants

The atmospheric and health science of airborne particles is a timely subject for informing public policy for air quality management. The Environmental Protection Agency is completing its review of the science relevant to revising the National Ambient Air Quality Standards (NAAQS) for particulate matter (PM); the agency is preparing the fifth revision of its Criteria Document (e.g. EPA, 2003), and released it's draft Staff Paper (EPA, 2003) recommending such revisions. At the same time, the implementation of the current standards implies that states, including New York, which anticipate regions that will be in PM non-attainment, are in the process of planning management approaches to reduce emissions of PM and its precursors beginning in 2005 to decrease the concentrations of resulting PM in order to achieve the national standard.

The 2003 NYSERDA Conference on Environmental Monitoring, Evaluation and Protection in New York has provided an important "snap-shot" of research progress on PM and its consequences on human health. The session was introduced by James Vickery, Acting Director of EPA's research program on PM. Ellen Burkhard of NYSERDA added a New York overview and perspective to the session, taking into account the NYSERDA sponsored research programs. The session's four major presentations summarized research progress in characterizing PM in New York, especially fine particles ($PM_{2.5}$), as well as the potential for human health effects from PM exposure.

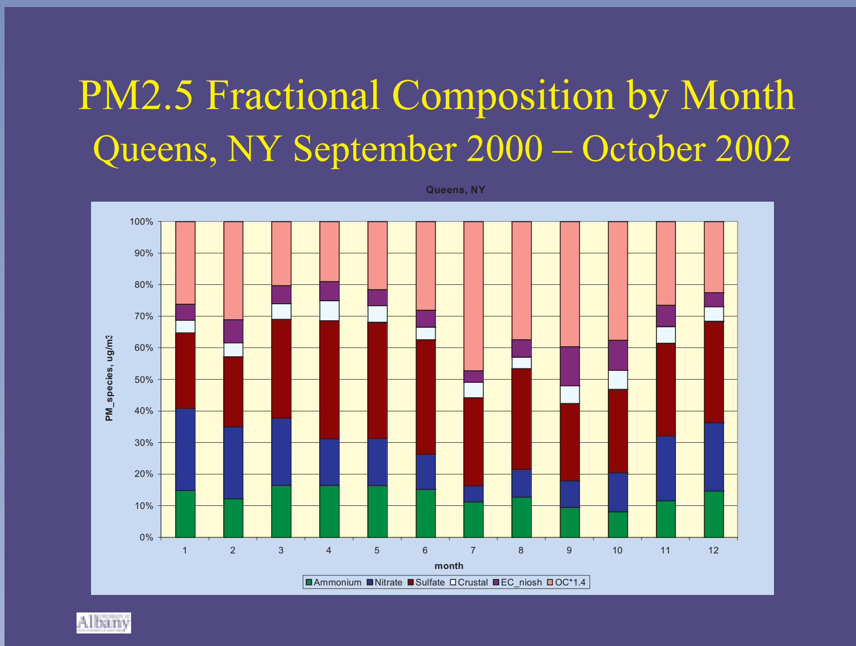
Mr. Vickery described a recent assessment of PM policy relevant atmospheric science prepared by NARSTO (2003). This assessment was prepared by more than 19 principal authors, under the chairmanship of Mr. Vickery, Ms. Marjorie Shepherd of Environment Canada, and Prof. Peter McMurry of the University of Minnesota. The report sets the stage for this conference by providing perspective on a number of subjects required for addressing the management of PM. These topics include ambient observations, atmospheric processes involving PM, emission inventories, air quality modeling, and a summary of the state of knowledge on PM health effects and visibility.

The NARSTO assessment discussed the importance of improving current knowledge about PM chemistry, and its spatial and temporal distributions as a basis for understanding the origins and variation of PM in New York and its neighbors. The limitations in knowledge about the carbon fraction of PM, and the value in developing regional or local conceptual models describing PM are key themes coming from this report.

The first presentation was given by Prof. Ken Demerjian of the State University of New York, Albany. Prof. Demerjian described the research results emerging from the New York "Supersite". This strategic ambient monitoring research program is co-sponsored by NYSERDA, the New York State Department of Environmental Conservation (NYS-DEC), and EPA to provide highly time-resolved chemical and physical characterization of $PM_{2.5}$, its precursors, and other photochemically active gases and priority pollutants in the New York region. The aerosol characterization program consists of three air measurement stations in New York State located at New York City, Whiteface Mountain and Pinnacle State Park. The use of the three sites allows for the study of regional background and transport phenomena relative to the urban location which has numerous additional local sources.

The presentation focused mainly on the work in progress in New York City for the fall 2000 to fall 2002 sampling period. Results indicate that the principal sources of PM in the State stem from the production and use of energy, including the combustion of fossil fuels. The study showed a large organic carbon component of fine particles sampled in the city, mixed with sulfate, nitrate and ammonium. The source of the organic and black carbon fractions of $PM_{2.5}$ are associated mainly with motor vehicle emissions, a substantial portion of which is from heavy duty trucks and buses.

During the sampling period, $PM_{2.5}$ mass was generally high in summer and is greatest in July but also high in January. The fraction of aerosol mass due to sulfate and organics were greatest in summer while the nitrate fraction was highest in winter and lowest



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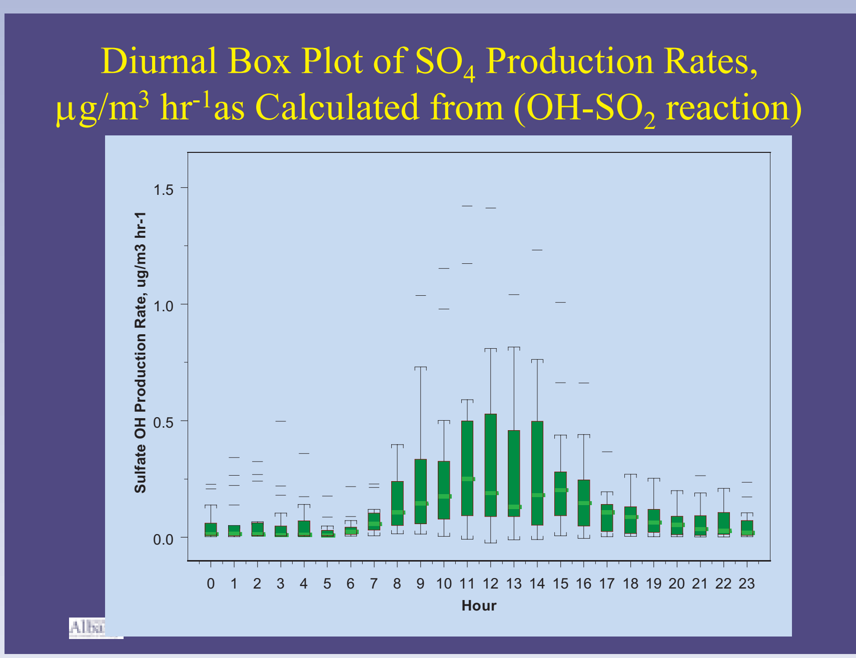


Figure A-2

in summer (Figure 1). These patterns are consistent with increased photochemical activity in summer and cooler temperatures in winter causing condensation of semivolatile nitrate species onto particles. Measurements of H_2SO_4 in aerosols, SO_2 and OH for the Queens site indicate significant H_2SO_4 production potential during summer (Figure 2), further illustrating the importance of local SO_2 sources to observed sulfate in $PM_{2.5}$ in NYC (note: this is from power-point presentation, but not covered at conference due to time constraints).

Dr. Demerjian described a successful program to test the use of natural gas fuel and ultra-low sulfur diesel with continuously regenerative traps (CRTs) on conventional diesel buses in New York City. The program showed a dramatic reduction in PM and SO_2 emissions compared to conventional diesel buses with no after treatment devices. Buses with each of these technologies, as well as conventional diesel buses, are significant emitters of organic PM. CNG buses had an increase in formaldehyde and methane emissions. The diesel buses with CRTs had the same total NO_x, but emissions shifted to higher NO_2/NO ratio. NO_x emissions from CNG buses increased along with methane and formaldehyde emissions. The carbonaceous gases may be managed readily by adding an oxidation catalyst converter to the bus exhaust but the increased NO_x emissions remain an issue.

The study also showed a significant reduction in SO_2 emissions from vehicles using ultra-low S diesel without after treatment devices. Planned decreases in sulfur content of transportation diesel fuels in 2006 are expected to reduce some of the local SO_2 and primary sulfate emissions to further decrease $PM_{2.5}$ levels in the city.

Moreover, the use of this fuel will allow the installation of emission control devices such as continuously regenerating traps (CRTs) and significantly reduce PM and VOCs from vehicle emissions.

Future Supersite activities are needed to support: PM model development and evaluation; upcoming SIP calls; health effects studies; accountability in air quality management; and studies of regional transport of $PM_{2.5}$, O_3, and precursors, and related source attribution studies.

A second important component of the supersite program was the testing and evaluation of new measurement techniques that complement or supplement filter based monitoring technologies. The program evaluated a number of semi-continuous methods for characterizing fine particles, including the TEOM, sulfate and nitrate instruments and the (Aerodyne) aerosol spectrometer. Even though some questions remain about instrumentation performance, this array of instrumentation is likely to replace filter based methods for monitoring in the next several years.

As a follow on to the discussion of the results from the supersite program, Prof. Phil Hopke gave the second presentation describing recent progress in air quality modeling using PM receptor techniques. These methods are being used to complement source-based models to identify sources of particles, and their precursor gases, particularly SO_2. The method favored by Prof. Hopke is "positive matrix factorization (PMF)". This method is distinct from the chemical mass balance approach in that it does not require a priori source profile information for its application. PMF has been applied to a number of sites in the Northeast, as illustrated for a rural location, Brigantine, NJ. PM at this site derives from both local influences in the greater New York metropolitan area, and distant sources, whose effect depends on the long-range atmospheric transport of pollution. For Brigantine, a seasonal analysis indicated that the carbon fraction was found to have about ten statistically "unique" source signatures. Sulfate, a component believed to be produced in the air from SO_2 oxidation, was found to have two signatures, which were associated with the S/Se ratio (Se is often used as a tracer for coal combustion). The analysis suggested that the sulfate components were identified with a photochemically dominated signal in summer, and a non-photochemical component in winter. Evidently an enriched organic component emerged with the sulfate component in summer, possibly suggesting a secondary origin for the organic species during the summer months. The origins of the sulfate components were investigated further using air mass flow patterns estimated from trajectory analysis (Figure 3).

The results from the Brigantine site illustrate the value of PMF as a complement to source based air quality modeling. The receptor modeling techniques have been limited in the past to identification of sources of primary particle emissions. The new results show progress in adding to this capability for identifying major sources of precursor gases such as SO_2. Professor Hopke will be applying PMF and other techniques to New York State air quality data in a project funded by EPA and NYSERDA.

The latter part of the session shifted to a discussion of research on the health effects associated with exposure to ambient particles. Dr. Mort Lippmann gave an overview of the current knowledge about the exposure and health effects of particles. He described the human respiratory track, deposition of particles in the lungs as a function of particle size and the known removal mechanisms for particles in the lungs. He summarized the large body of recent analysis of data reported in the literature, and surveyed in the recent draft EPA PM Criteria document (2003). These studies continue to show a significant association between ambient PM and adverse respiratory and cardiovascular health effects.

It is widely known that people in the U.S. spend more than 80% of their time indoors, but epidemiological evidence continues to associate outdoor PM concentrations with mortality and morbidity risks. The indoor-outdoor paradox has been resolved by separating the outdoor air component that penetrates indoors from the indoor source component. Using this hypothesis, the epidemiological association between mortality and morbidity and PM concentrations can be rationalized.

Investigation of the health effects of PM has continued through a large number of epidemiological analyses, and increasingly refined toxicological studies. Investigations suggest the association with concentrations of both fine and coarse particles, and potentially, the so-called ultrafine particles. However, interactions with "toxic" species have not been identified.

The support for maintaining an ambient air quality standard based on PM mass concentration continues to rely primarily on the expanding epidemiological results and corroborating toxicological studies. A number of new studies have been reported, and re-analyses of older results has taken place, including major efforts sponsored by the Health Effects Institute. The analyses of data have revealed issues in the basic statistical packages involving a procedure called the generalized analytical method, "GAMS". This procedure was applied to large historical data sets in several cases; the initial application was found to contain errors. With subsequent reanalysis, the initial epidemiological results were largely verified. These indicate that short-term mortality and long term mortality, and morbidity effects of PM exposure yield a risk to humans.

Recent multi-pollutant analyses point to a PM component as found in the single PM pollutant cases; effects of exposure to gases are additive but do not decrease the influence of PM. There is a suggestion that SO_2 is a surrogate for ultrafine particle exposure, but this is yet to be verified.

There is also concern about defining the role of background PM concentrations on defining an ambient air quality standard. However, Dr. Lippmann did not elaborate on the difficulties of defining or establishing a PM background for different parts of the U.S. In any case, the current knowledge about PM indicates that the fine particle ambient air quality standard based on mass concentration is supported. Evidence suggests that the PM_{10} standard should be refined to focus on mass concentration of coarse particles, defined operationally as the range between 2.5 µm and 10 µm. diameter.

Dr Lippmann ended with a summary of unresolved problems in characterizing health effects of ambient air pollution. These include: the lack of conclusive biological mechanisms for PM-related effects; potential confounding by co-pollutants; evaluation of the effects of components, surface coatings, or other characteristics of PM; the shape of the concentration-response relationships; methodological uncertainties in epidemiological analyses; the extent of life-span shortening; characterization of annual and daily background concentrations; understanding of the effects of coarse fraction PM, and effects of air toxics.

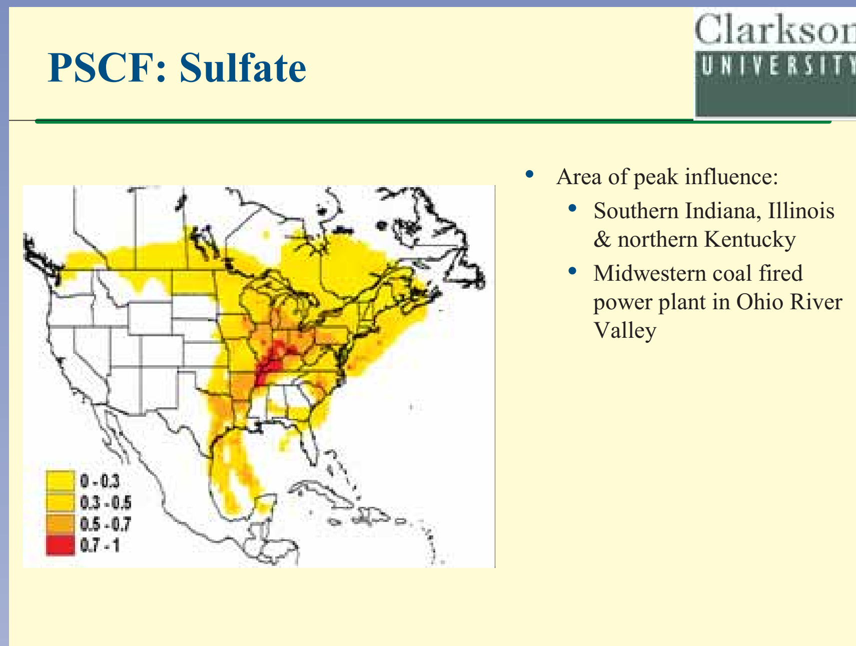


Figure A-3

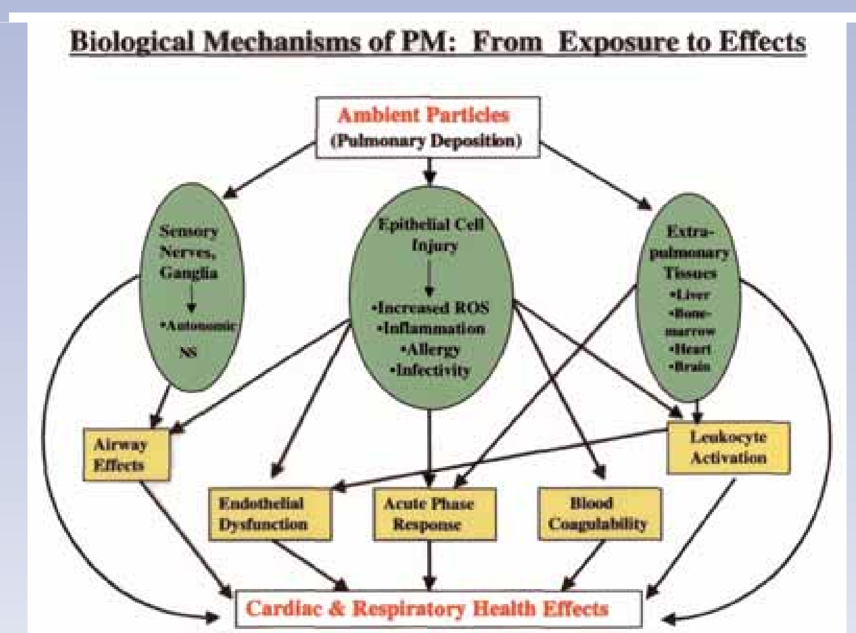


Figure A-4

The last paper of the session presented by Dr. Mark Utell followed Dr. Lippmann's discussion. Dr. Utell described recent progress on the plausible biological mechanisms through which potentially toxic components of PM could influence human health. The targets for adverse human response to PM exposure focus on the respiratory system, and the cardiovascular system (Figure 4).

There has been significant progress in characterizing the PM physical and chemical properties with (a) the cardiovascular interaction mechanism, (b) aspects of inflammation and altered immunity response, and (c) the influence of oxidative stress as a systemic effect from reactive oxygen species. Biological mechanisms appear to follow from endothelial injury, pulmonary and extra-pulmonary inflammation and increased oxidation from pollutant interactions, some of which have been examined in animal studies. Effects also appear in the vascular tone of the heart, and alter the autonomic nervous system. Asthmatics appear to be particularly sensitive to inflammation in the bronchi, where extra-pulmonary tissue is affected influencing in turn the heart and brain tissue. Ultrafine particles appear to be of particular concern in these cases. Of the many hypotheses for human health outcomes, evidence suggests that workers should continue to focus research priorities to study the influence of ultrafine particles and certain soluble metals but as of yet, none of the major hypotheses identified in Atmospheric Observations: Helping Build A Scientific Basis For Decisions Related to Airborne Particulate Matter (Greenbaum and Albriton, 1998) can be ruled out.

Given the recent progress on possible mechanisms for PM influence on biological processes, the path forward looks to investigation to refined identification of the hazardous components of PM, including the molecular toxicity of components, the sub-population susceptibility (e.g., abnormal blood vessels, and people with respiratory system disease), and especially the cardiovascular response to PM exposure.

Conclusions

Taken in total, Session A provided a valuable picture of recent progress in the atmospheric science addressing the origins and processing of particulate matter in the atmosphere that is relevant to managing air pollution in New York. The presentations in the session also provided important insight into the influence on human health from exposure to particulate matter in outdoor air. The insights given by key investigators sponsored in part by NYSERDA have contributed substantially to the expansion of knowledge on these subjects.

There were two areas of large uncertainty associated with ambient particle concentrations, and sources. The first of these concerns carbon, and the second relates to particulate nitrate.

The results of measurements in New York City clearly indicate the importance of carbon, which is comparable in concentration to sulfate. There appear to be insufficient observations in other urban areas of New York to establish the importance of carbon away from New York City. Measurement methods are needed to differentiate between black carbon and organic carbon, and between the semi-volatile and the stable condensable components. Because carbon is so important to PM chemistry, these measurement issues need to be addressed, and detailed speciation of the carbon fraction needs to be undertaken, using mass spectroscopic techniques combined with separation by gas or liquid chromatography. Since 20% or less of the organic fraction has been identified, particular attention to speciation is needed for both the condensable fraction and the semi-volatile components. Adjunct with this need, there is concern that differentiation of biogenic and anthropogenic sources of carbon be clarified and apportioned to various source types.

Nitrate chemistry is complicated by the equilibrium between sulfate, ammonium, nitrate, nitric acid and ammonia. The relatively large nitrate component found in New York City suggests the need for detailed investigation of this equilibrium, including careful measurement of NH3, in combination with the other components. With complete concentration data, one can use sulfate-nitrate equilibrium calculations to establish the response of the New York particles to changes in NH_3 and HNO_3.

The two papers discussing the status of knowledge of PM health effects indicate that further acute and chronic epidemiological studies would be made more valuable with knowledge of toxicity mechanisms. Advancing the understanding of possible health effects of PM now requires that significant progress be made in establishing key mechanisms that can be tested in studies of populations exposed to different kinds of ambient PM. The Utell work exemplifies important progress in knowledge about PM and cardiovascular disease. Expanded toxicity studies for other mechanisms, noted for example in NARSTO (2003) are warranted at high priority.

Session A Summary was prepared by Dr. George Hidy. Dr. Hidy is the principal of Aerochem Associates and serves as a Science Advisor to the EMEP Program.

Ecosystem Response to Deposition of Sulfur, Nitrogen, and Mercury

Trends in atmospheric emissions associated with fossil fuel combustion have changed dramatically over the past century. Recent emissions reductions have produced changes in deposition that provide the opportunity to evaluate how ecosystems respond to pollution levels and the extent to which recovery has occurred. Co-chaired by Kathleen Weathers, Forest Ecologist, Institute of Ecosystem Studies, and Mark Watson, Senior Project Manager, NYSERDA, this session of the 2003 NYSERDA Conference on Environmental Monitoring, Evaluation and Protection in Albany focused on ecosystem response to changing levels of sulfur, nitrogen, and mercury in New York State.

A Road Map for NYSERDA's EMEP Program
Watson outlined information gaps that research projects sponsored by the Environmental Monitoring, Evaluation, and Protection program are addressing through monitoring, field and process studies, syntheses and assessments, and modeling.

Monitoring

- Through its 52-lake long-term monitoring program, the Adirondack Lakes Survey Corporation is tracking the response of Adirondack lakes and streams to changes in atmospheric deposition.
- The Institute of Ecosystem Studies is studying the response of forests to experimentally enhanced nitrogen deposition and assessing the long-term effects of chronic nitrogen deposition in the Hudson Valley.
- The Adirondack Cooperative Loon Program is measuring mercury exposure in more than 40 Adirondack lakes. This project will provide data to evaluate the relationship between methyl mercury availability and the health of loon populations.
- The New York Department of Environmental Conservation is monitoring mercury concentrations in fish in over 125 New York lakes. The program will provide data to the State's Department of Health to inform fish consumption advisories.
- NYSERDA is providing short-term funding for New York State's two Mercury Deposition Network sites, Huntington Forest in the Adirondacks and Biscuit Brook in the Catskills.

Field and process studies

- Tetra Tech has used a mass balance model to quantify mercury inputs, outputs, and cycling in Sunday Lake, a drainage lake in the Adirondacks. The model accounts for influences on mercury cycling and accumulation in fish.
- The SUNY College of Environmental Science and Forestry is examining sediment cores to assess the controls on the fate of sulfate, the contribution to watershed nitrogen by speckled alder, and the history of mercury deposition.
- The SUNY College of Environmental Science and Forestry is also using a small watershed approach and an integrated model to predict patterns of acidification in the Adirondacks. This long-term study serves as a baseline for similar research in the region.
- The U.S. Geological Survey is studying the Black River and Oswegatchie River watersheds of the western Adirondack region to improve characterizations of the acid-base status of New York watersheds.
- The U.S. Geological Survey is also evaluating the use of isotopes to differentiate sources of atmospheric nitrogen and inputs of anthropogenic nitrogen to land and surface waters.

Synthesis and assessments

- The Hubbard Brook Research Foundation has completed a project evaluating the multiple sources of nitrogen and its effects across New York and New England. The synthesis includes an assessment of potential mitigation strategies.
- E&S Environmental Chemistry is using research, monitoring, and modeling results to estimate the response of lakes in the Adirondacks to varying levels of deposition. The study will also identify regions and

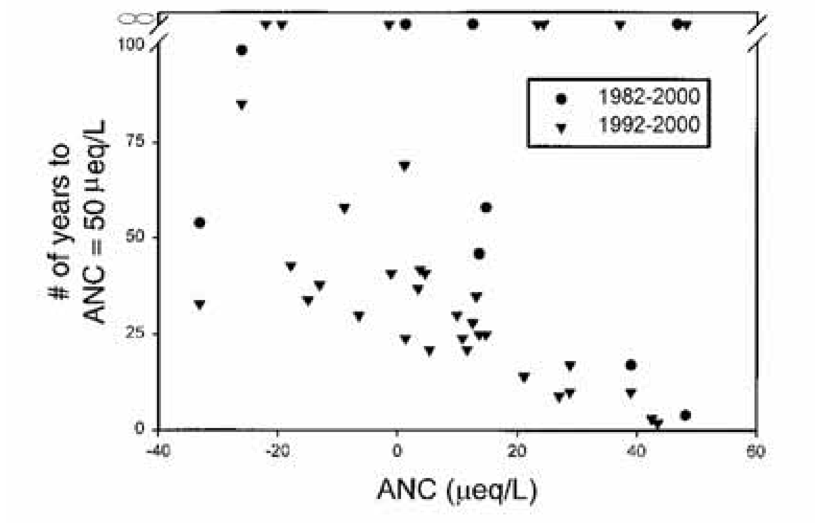


Figure B-1

Years required to achieve target ANC value (50 g/L)

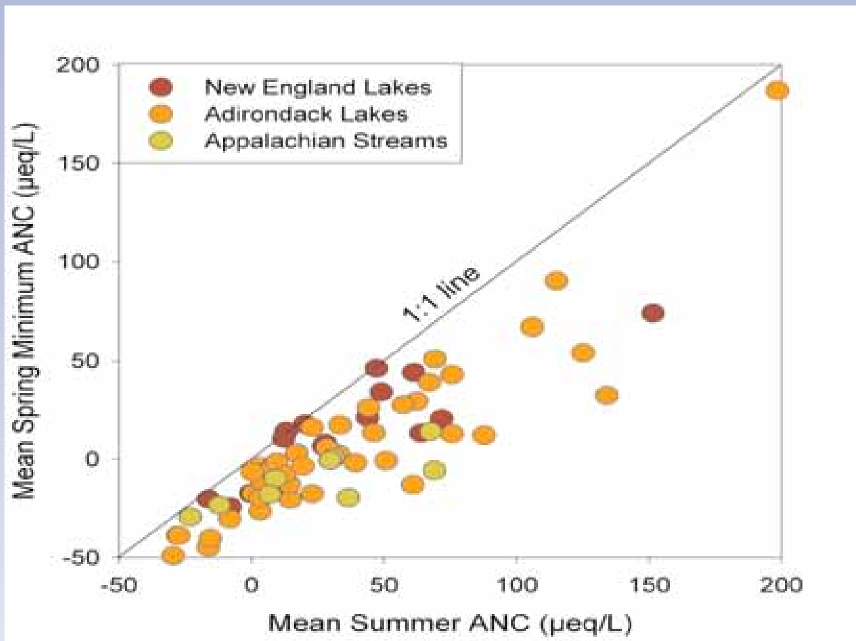


Figure B-2

watershed types that are unlikely to recover.

- The U.S. Geological Survey has modeled projected recovery of surface water chemistry in Adirondack lakes and streams, and has created an integrated database for the Web.
- The U.S. Geological Survey also studied whether spatial patterns of aquatic biota in the Neversink River in the Catskills have changed with changes in surface water chemistry.

Modeling

- Atmospheric and Environmental Research, Inc., used a model to determine the relative contributions of local emissions versus long-range transport to mercury deposition in New York State.
- The University at Albany is using atmospheric models to evaluate the transport, transformation, and deposition of mercury in New York State.
- Resources for the Future is analyzing the benefits and costs associated with potential emissions reduction policies for sulfur dioxide, nitrogen oxides, and carbon dioxide from the electricity sector.

Atmospheric Emissions and Deposition in the East

Kathleen Weathers, Forest Ecologist, Institute of Ecosystem Studies, described emissions and deposition of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) in the 31 states of the eastern United States from 1991 to 2000. NO_x emissions showed very little decline, whereas SO_2 emissions decreased by 30%. The largest declines in emissions occurred in the electric utility sector, compared with vehicles and other sources; the relative contribution of vehicular NO_x emissions has increased.

Weathers and her colleagues find statistically significant relationships between SO_2 emissions and volume-weighted sulfate concentrations in precipitation; and between SO_2 emissions and dry deposition of sulfur. However, data from Whiteface Mountain, New York, do not indicate a relationship between emissions reductions and the concentrations and deposition of sulfur in cloud water.

Until recently, according to Weathers, no strong relationship had been identified between NO_x emissions and nitrogen concentrations in precipitation or air. However, Butler et al. (2003) recently showed that a 50% decline in total NO_x emissions from all sources should result in an approximately 38% decline in nitrate levels in precipitation and deposition. A 50% reduction in nonvehicle emissions would lead to a 19% to 22% decrease. Thus, reducing NO_x emissions is predicted to have 75% to 95% efficiency in reducing precipitation nitrate concentrations, depending on the source of the reduction. These findings have important consequences for policies aimed at reducing nitrogen pollution and its associated effects.

Surface Water Chemistry in the Adirondacks

Karen Roy, Program Manager, Adirondack Lakes Survey Corporation, presented results on water chemistry trends for lakes and streams in the Adirondacks, quantifying the extent to which surface waters are improving in response to changes in acidic deposition. Based on data from 48 Adirondack lakes for 1992-2000 and from 16 lakes for 1982-2000, the trend analysis indicates the following:

- widespread improvement in surface water sulfate;
- varied improvement in surface water nitrate;
- improved acid-neutralizing capacity (ANC) in 29 lakes;
- decreased toxic aluminum in 28 lakes; and
- increased pH in 18 lakes, with 2 lakes decreasing.

Recovery is starting, according to Roy, but the rate of improvement is slow, and chemical conditions are still critical in many lakes. For example, in 2000, compared with what is considered hospitable to aquatic biota, 34 of 48 lakes had mean ANC below 50 µeq/L; average pH was less than 5.5 in 23 lakes; and toxic Al was over 2 µmol/L in 16 lakes. Roy and her colleagues estimate that it may be decades before many lakes reach a target ANC value of 50 µeq/L (Figure B-1); the findings were published in *Environmental Science and Technology* in May 2003.

At about the same time, the Environmental Protection Agency published a report on acidification trends in the northeastern United States, including the Adirondacks, the headlines for which made broad claims of recovery. Crucial differences between the two surveys were lake size and summer versus year-round sampling; moreover, EPA's definition of acidified waters would give a more favorable picture of chemical recovery. The details of the report show a large number of Adirondack waters whose ANC is 30-40 in summer drop to critical levels-at or below zero ANC-during spring snowmelt, meaning that for the Adirondacks, a summer ANC level of 30-40, as opposed to 0, may be needed to protect waters year-round (Figure B-2). Year-round data generated by the Adirondack Long-Term Monitoring program permit such important, more detailed analyses.

Roy also reported findings on three streams monitored weekly since 1992, which concluded that flow variation plays a significant role in chemistry changes. The limited chemistry data were individual to each stream, however, and researchers could not conclusively relate stream chemistry responses to atmospheric deposition changes in the region.

Surface Water Chemistry Trends in the Catskills and Adirondacks

Douglas A. Burns, Research Hydrologist, U.S. Geological Survey, compared water chemistry in the Catskills (5 streams) and the Adirondacks (12 lakes). Burns offered several cautions about the use of trend analysis:

- Trend analysis should use appropriate statistical techniques. For example, linear regression analysis would not be appropriate unless the data are normally distributed.
- If trend analysis is conducted with fewer than 10 years of data, the outcomes are very sensitive to anomalous years. Ideally, 15 or more years of data would be used in trend analysis.
- Flow correction may be necessary for some chemistry data. For example, nitrate and acid-neutralizing capacity (ANC) are very flow-sensitive.

For both the Catskills and the Adirondacks sites, precipitation sulfate and nitrate decreased and pH increased slightly from 1984 to 2001. Since 1992, sulfate and nitrate have decreased, and pH and ANC have increased (Figure B-3a), consistent with results presented by Karen Roy.

Comparing the chemistry trends, Burns found that temporal trends in streamwater sulfate are well

Precipitation – Annual Trends

Site	SO_4^{2-}	SO_4^{2-}	NO_3^-	NO_3	pH	pH
	92-01	84-01	92-01	84-01	92-01	84-01
Catskills						
Biscuit Brook	NT	-1.04	NT	-0.35	NT	+0.01
Delaware	NT	-1.15	NT	-0.34	+0.01	+0.01
West Point	-1.08	-1.16	NT	-0.30	+0.01	+0.01
Adirondacks						
Bennett Bridge	NT	-1.36	NT	-0.43	NT	+0.01
Huntington	NT	-1.00	NT	-0.30	+0.01	+0.01
Whiteface	-0.94	-1.16	NT	-0.19	+0.01	+0.01

Figure B-3

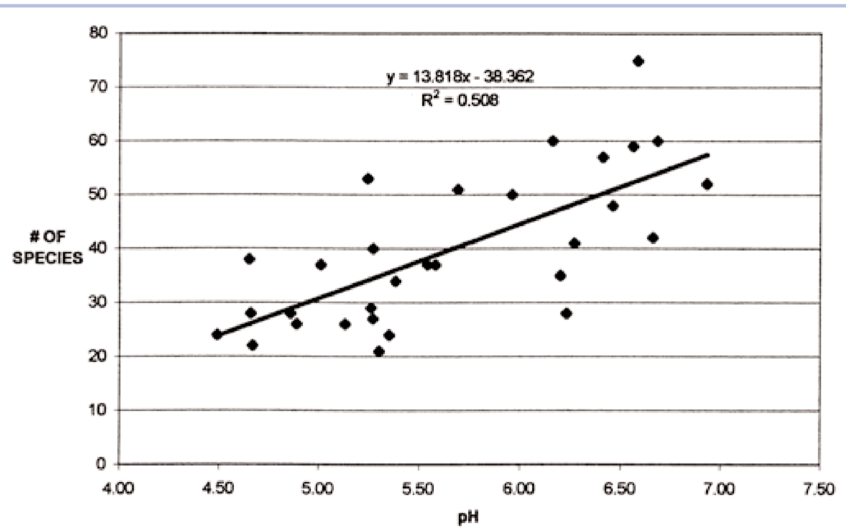


Figure B-4

Relationship Between Number of Phytoplankton Species and pH

correlated between the Adirondacks and Catskills (Figure B-3b). This suggests that regional trends in precipitation chemistry are a major driver of streamwater chemistry. Conversely, streamwater nitrate, pH, and ANC are not well correlated between the two regions, suggesting that these chemical attributes may be more sensitive to local conditions.

Burns and his colleagues are comparing soil and vegetation data to see why streamwater nitrate may not respond consistently to atmospheric inputs. Tree species composition may influence the net retention of nitrogen and surface water nitrate concentrations. Soils under sugar maple stands, for example, have lower carbon-to-nitrogen ratios and higher nitrification rates. If sugar maple declines in the future because of nutrient, insect, and climate stress, the resultant changes in tree stand composition may affect nitrate-driven acidification.

An integrated biogeochemical model, PnET-BGC, is helping elucidate watershed processes and the response of water bodies to acid deposition. Charles Driscoll, Syracuse University, and colleagues have compared Biscuit Brook in the Catskills with four Adirondack Lakes and found low sulfur retention in all watersheds. This is consistent with the strong correlation in sulfate trends. The model results also suggest that land-use history and in-lake processes affect nitrogen retention rates, consistent with the lack of a correlation in nitrate trends.

Model simulations suggest that although atmospheric deposition has been the greatest source of acidity, the largest contributors to ANC are mineral weathering, cation exchange, and in-lake processes, which can differ significantly between watersheds.

This explains, in part, why ANC trends do not simply track trends in sulfate deposition.

Biological Response in the Adirondacks
Sandra Nierzwicki-Bauer, Director, Darrin Fresh Water Institute, RPI, discussed how aquatic biota are responding to surface water trends. In 1994, the Adirondack Effects Assessment Program was established to evaluate the effectiveness of the Clean Air Act Amendments of 1990 by determining the relationships between changes in water chemistry and aquatic biota. Nierzwicki-Bauer and colleagues sampled 30 lakes from the Adirondack Lakes Survey Corporation sites. Data collected between 1994 and 2001 show the following:

- a positive relationship between lake pH and species richness of phytoplankton and zooplankton (Figure B-4);
- a positive relationship between lake pH and aquatic macrophyte species richness in drainage lakes (but not seepage lakes); and
- both positive and negative correlations between water chemistry and specific bacteria in microbial communities.

Results from Brooktrout Lake, a case study, show the same surface water trends as the larger population of lakes but strongly seasonal patterns in nitrate, with pronounced decreases during the summer growing season (Figures B-5a, B-5b).

Brooktrout Lake also shows increasing trophic states and declining dissolved oxygen and light extinction during summer, suggesting that nitrate trends are influenced by lake productivity. The findings from the case study imply that aquatic biota may have

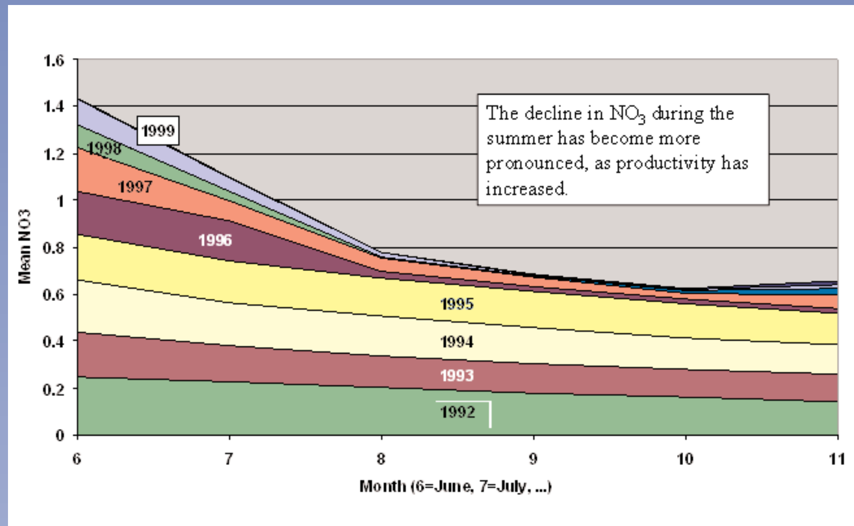


Figure B-5a

Brook Trout Lake - Seasonal Patterns in Nitrates

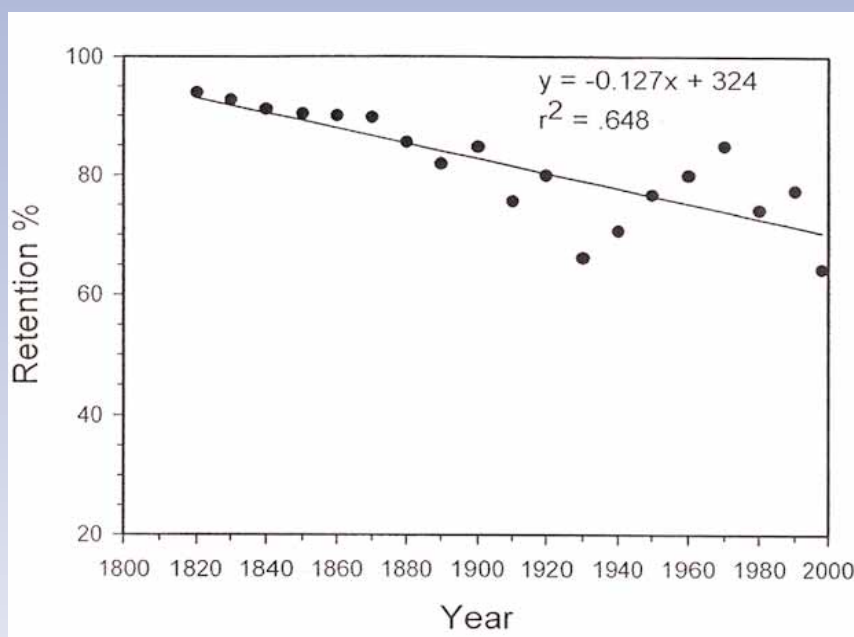


Figure B-5b

Mercury Retention Based Upon Sediment Patterns of Eight Adirondack Lakes

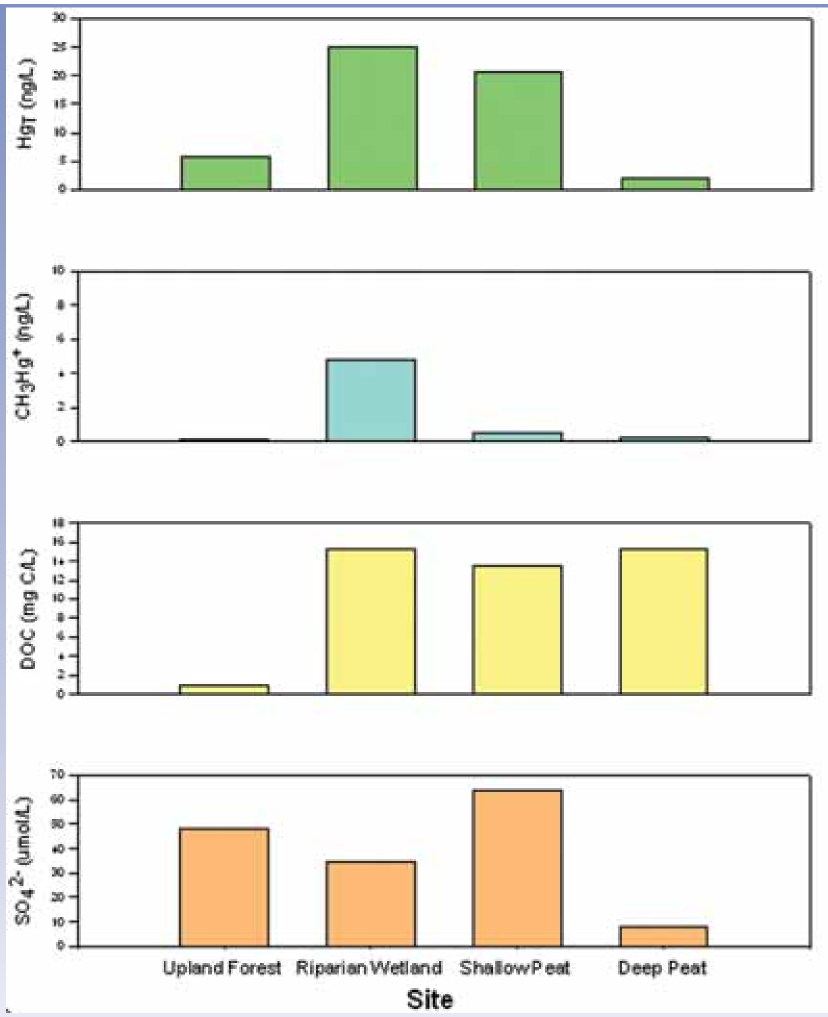


Figure B-6

Comparison of Deposition Levels in Sunday Lake Watershed

an important effect on water chemistry. Nierzwicki-Bauer concludes that biotic compartments should be better integrated into models in order to more accurately predict ecosystem response to changes in acidic deposition.

Mercury Transport and Transportation in Ecosystems
Charles T. Driscoll, Professor of Civil and Environmental Engineering, Syracuse University, summarized the findings on mercury in the Sunday Lake watershed in the Adirondacks. In the 1990s, a study of water column and fish mercury concentrations in 32 lakes found that methyl mercury in water was strongly correlated with dissolved organic carbon, and that lakes whose lower layers were deficient in oxygen had higher levels of methyl mercury than well-oxygenated waters. Yellow perch in these lakes had elevated levels of mercury that increased with age and decreased with water pH. A relationship also existed between mercury bioconcentration and dissolved organic carbon (DOC) in lakes: the bioconcentration factor decreased as lake DOC increased. Thus it appears that DOC is important in the transport of mercury to surface waters but may bind up mercury and reduce its bioavailability.

Lake sediment patterns show that mercury increased from 1800 to the late 1900s but has been decreasing over the past decade in response to lower mercury emissions. An analysis of sediment patterns for eight lakes shows a strong positive relationship between mercury flux and the ratio of watershed area to lake surface area. Plotted over time, these data suggest that mercury retention has decreased in the past 150 years, though the reasons for this are not yet well understood (Figure B-6).

The Sunday Lake watershed has been intensively studied. Over three years, Driscoll and his colleagues sampled mercury in groundwater and in the aquatic food chain. They found significant differences in the mercury cycling in peatlands and riparian wetlands within the watershed. Although peatlands have low levels of total mercury, most of it appeared as methyl mercury. The peatlands are not well hydrologically connected to adjacent surface waters. Conversely, the riparian wetlands show high levels of total and methyl mercury and are well connected. Thus, even though only 10% of water flows through them, riparian wetlands produce a large amount of methyl mercury and account for a large contribution to the total supply of methyl mercury to Sunday Lake.

Mass balance work for Sunday Lake shows a substantial contribution of mercury in litterfall. In fact, dry deposition accounts for fully two-thirds of mercury input, indicating a need for better estimates of dry deposition.

Session B Summary was prepared by Kathy Fallon Lambert. Ms. Lambert is the President of Ecologic: Analysis and Communications, and is a member of the EMEP outreach and communications team.

Control of Particulates and Co-Pollutants: Technology Options and Costs

This session of the 2003 NYSERDA Conference on Environmental Monitoring, Evaluation and Protection in Albany considered technical and policy approaches for controlling particulate emissions (PM) and the economic implications. Sandra Meier, Associate Director, Environmental Energy Alliance of New York, chaired the session. Presenters addressed four areas of interest to policymakers who are preparing state implementation plans (SIPs) to meet National Ambient Air Quality Standards for both ozone and particulate matter (PM): accurate baseline emissions inventories for PM and its precursors, the available technologies and associated costs for controlling emissions from the electric utility sector, emissions from the mobile source sector, and emissions reduction credits process for new, small-scale combined heat and power projects.

Status of Particulate Matter Emissions Inventories

Phil Lorang, Group Leader for Emission Factors and Inventories, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency (EPA), described the roles played by states, regional planning organizations, and industry in preparing inventories from information about point, area, and mobile sources. Emissions data, generally annual, are combined with other information to develop inputs for modeling purposes. Spatial and temporal allocation factors are then used to provide an inventory that has finer resolution in both space and time so that grid models can develop hourly, daily, episodic, seasonal, and yearly predictions.

A new consolidated emissions reporting rule of the Environmental Protection Agency (EPA) requires states to include the “condensable” fraction of PM, thereby improving the accuracy of reported PM data. Recent investments by regional planning organizations in inventory development and quality assurance will also result in more accurate estimates of emissions. The better data are expected to be incorporated in the draft 2002 National Emission Inventory, to be released in fall 2004.

Because of its complexity, the New York City metropolitan area may be poorly represented by the standard national methods used to estimate emissions from area sources. For example, the inventory shows significant residential coal use in New York State even though the residential sector has switched to other fuels. Also at issue are the correct estimates of condensable PM. Based on dilution tunnel tests sponsored by NYSERDA and others, it appears that EPA’s PM-2.5 emissions factor for natural gas–fired sources is about 25 times the measured value. It also appears that New York State needs to collect more accurate information on the stack heights of point sources.

Lorang noted that the emissions inventories have dramatically improved over the years and that the 2002 inventory, when ready, should be a substantial improvement over the previous efforts.

Utility PM and Precursor Emissions and Multipollutant Control Options

Praveen K. Amar, Director of Science and Policy, Northeast States for Coordinated Air Use Management, covered the regulatory landscape for emissions of SO_2, NO_x, PM, and mercury from the electric utility sector. Based on case studies of control technologies for NO_x and SO_2 from power plants from the 1940s to 2000, a recent report showed that regulation with well-defined targets and deadlines drives the development and implementation of control technologies: technological innovation follows, rather than precedes, regulatory requirements. Additionally, early estimates of the costs imposed by new regulation have dramatically overstated actual compliance costs. If used to establish emissions reduction requirements, faulty initial cost estimates could lead to weak regulatory policies and a lower level of environmental protection.

Analysis of the seasonal ozone control policy for electric utilities shows that NO_x emissions could have been halved at an additional cost of 5% to 10% if the control technology had been used year-round. Thus, additional NO_x reductions to

PM Control Technologies for Power Plants

- Electrostatic precipitators (ESPs)
  - 72% of U.S. coal-fired boilers, total PM up to 99.9%, fine PM 80-95%
- Baghouses
  - 14% of U.S. coal-fired boilers, total PM up to 99.9%, fine PM 99-99.8%
- PM scrubbers
  - 2% of U.S. coal-fired boilers, total PM 95-99%, fine PM 30-85%
- Cyclones

Energy and Environmental Strategies

Figure C-1

Hg Control

Effect of existing control technologies

Control Technology	Effect on Oxidized Hg	Effect on Elemental Hg	Effect on Particulate Hg
ESP	Little if any	Little, if any	Efficient removal
Fabric Filter	Adsorption on fly ash (western fuel) Decrease due to oxidation in some cases	Adsorption on fly ash (high LOI ash) Decrease due to oxidation in some cases	Efficient removal
Flue Gas Desulfurization	Efficient removal	Little if any removal Increase due to reduction of adsorbed oxidized mercury in some cases	No effect
SCR	Increase due to oxidation	Decrease due to oxidation	Increase in some cases
SNCR	No effect	No effect	No effect

Energy and Environmental Strategies

Figure C-2

improve public health, reduce regional haze, and mitigate acid rain and estuary nitrification can be cost-effective.

Electric power plants currently emit about 40% of the nation's anthropogenic mercury emissions. Amar noted that of the northeastern states, Massachusetts, Connecticut, New Hampshire, and New Jersey are instituting accelerated and stricter controls on mercury than is EPA with its maximum achievable control technology rulemaking. Since mercury is found in the finer fraction of PM, baghouses designed to catch fine particulate matter also control mercury emissions. However, 84% of power plants in the United States today use the less effective electrostatic precipitators, and thus new regulations on mercury may mean that existing power plants must retrofit their boilers with baghouses.

Rui F. Afonso, Principal, Energy and Environmental Strategies, focused on current and emerging technologies for controlling SO_2, NO_x, and mercury from electric utility sources. From the perspective of power plant owners, selecting the "correct" technologies involves complex variables that include a changing regulatory landscape, interactions between technologies to control different pollutants, plant life and economic performance, and the risk of investing in new technology. Until recently, new technologies came to the market with dramatically higher performance attributes than the equipment they replaced. Today, however, many commercial technologies can deliver 90% or greater reduction in NO_x, SO_2, PM, and mercury emissions (Figures C-1, C-2). In what Afonso called the new technology paradigm, innovators must offer other advantages to potential buyers. As compliance dates draw near, even as environmental regulations are in sometimes in conflict and deregulation of the electricity sector is evolving, the choice of new-generation technologies becomes more complex.

Afonso described recent work on selective catalytic reduction (SCR) for mercury removal. For bituminous coal (about half of the coal used in the United States), SCR causes significant oxidation of elemental mercury into oxidized and ionic mercury. This helps in later capture of more soluble mercury in a wet scrubber. However, this oxidation process seems to decrease over time and is also reduced by the presence of ammonia, the reagent used in SCRs to control NO_x. For subbituminous coals, field studies indicate minimum oxidation, making SCRs less effective.

Results from U.S. Department of Energy demonstration projects are encouraging: four power plants using activated carbon injection achieved 60% to 90% control of mercury. Moreover, emerging multipollutant technologies have the potential to reduce costs, increase performance, and increase flexibility for power plant owners.

State-of-the-Art Diesel Emissions Control Systems
Timothy V. Johnson, Director, Emerging Regulations and Technologies, Corning Environmental Technologies, reported that recent tailpipe regulations are spurring rapid development of engine and emissions control technologies for diesel fuel–powered mobile sources. U.S. standards for NO_x and PM emissions for 2010 are an order of magnitude more stringent than those for the year 2004, requiring increasing use of diesel particulate filters and diesel oxidation catalysts for PM and hydrocarbon control, and selective catalytic reduction and lean-NO_x traps for NO_x control.

In the near term, filters and catalysts will be used. The filters become plugged with collected PM, however, and thus strategies to accomplish on-board filter regeneration are being improved. By 2007, Johnson expects advanced combustion technologies, such as low-temperature combustion and high exhaust gas recirculation, will begin to appear in heavy-duty diesel vehicles. Additionally, improved filter designs will increase ash storage capacity. One policy-relevant issue concerns the use of filters: even though they are effective in removing ultrafine particles (less than 0.1 micron in diameter), they might, under some limited conditions, permit the formation of aerosol nanoparticles (less than 0.030 micron in diameter), which are thought to cause adverse human health effects. However, ultralow-sulfur fuel and the use of catalysts show promise for mitigating this phenomenon.

Compared with PM, NO_x is more difficult to control in the lean conditions present in diesel engines. An alternative to the selective catalytic reduction systems technology is the NO_x adsorber. During the lean phase of engine operation, it stores NO_x as a nitrate. Then, in the rich mode, the stored nitrate dissociates to NO_2, which is then converted to molecular nitrogen through chemical reactions.

For the more advanced systems needed to meet the more stringent 2010 standards, integrated systems are currently being field-tested, with NOx reductions of 82% and PM reductions of 89% under some driving conditions.

Emissions Reduction Credits and Small-Scale Combined Heat and Power Projects
Thomas Bourgeois, Senior Economist and Director of Research, Pace University Energy Project, outlined the use of market-based emissions trading approaches that provide economic incentives for combined heat and power (CHP) projects. CHP is the simultaneous production of electrical or mechanical power and thermal energy from a single process. It is becoming a popular application of distributed generation with excellent energy efficiency, due to its ability to utilize waste heat and the potential for significant reductions in emissions.

The siting of a large number of CHP projects in New York State is proceeding, with NYSERDA funding. Currently, $46.5 million has been earmarked for 95 projects, which are expected to produce 105 MW of electric power. Although CHPs have low operating costs, the up-front expense of installing the system remains an economic barrier. Capturing the value of on-site pollution reductions via quantification, certification, and sale of pollution credits can provide additional cash flow to make CHP projects economical (Figures C-3, C4).

In New York, one economic incentive for new CHP projects comes from a marketable currency of emissions reduction credits (ERCs). These credits are created when existing high-emitting heating systems at industrial, commercial, and large residential facilities are converted from traditional boilers to efficient CHP systems with emissions controls. The net reductions in emissions of NO_x and PM can be substantial and are calculated according to New York State Department of Environmental Conservation rules and the federal Clean Air Act. ERCs, expressed in tons per year, are based on emissions reductions that are permanent, real, surplus, quantifiable, and enforceable.

Bourgeois noted that promoting CHP projects in the State requires streamlining the process of creating ERCs, lowering transaction costs, and shortening the time it takes the State regulatory agency to certify ERCs. The California Air Resources Board, for example, has a process by which emissions of NO_x, CO, VOCs, and PM can be certified for certain distributed generation technologies. Another possibility is to use the verified emissions results from EPA's Environmental Technology Verification Program.

CHP has enormous potential for the industrial and commercial sectors. Altogether, more than 26,000 sites in New York State could produce some 8,000 MW of electric power. Target markets with the most potential include the chemical industry, food processing plants, paper and pulp mills, office buildings, schools, and hotels and motels. The niche CHP market most relevant to ERC creation is the replacement of old boilers that burn fuel oil with high-efficiency, low-emissions CHP packaged systems. The environmental and economic benefits of an expanded CHP program for New York could be considerable.

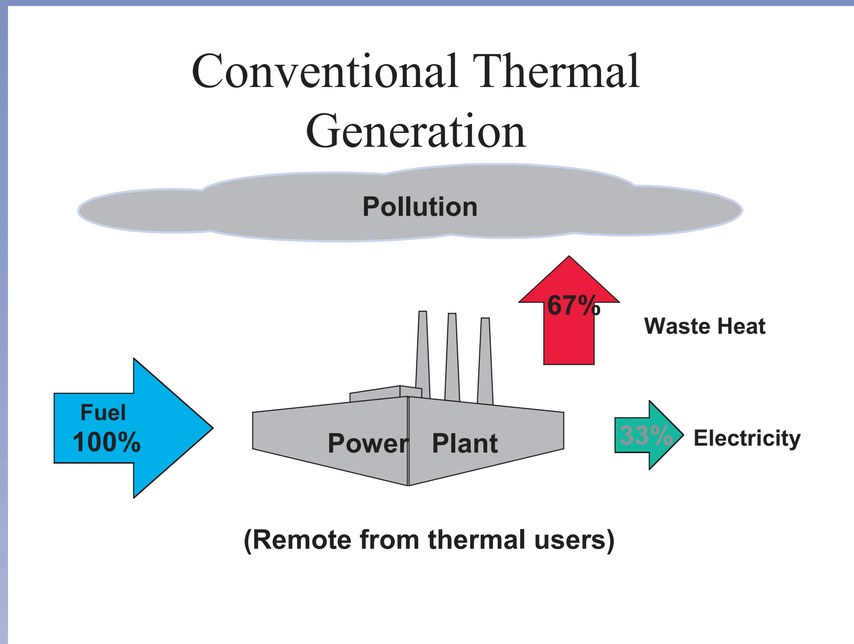


Figure C-3

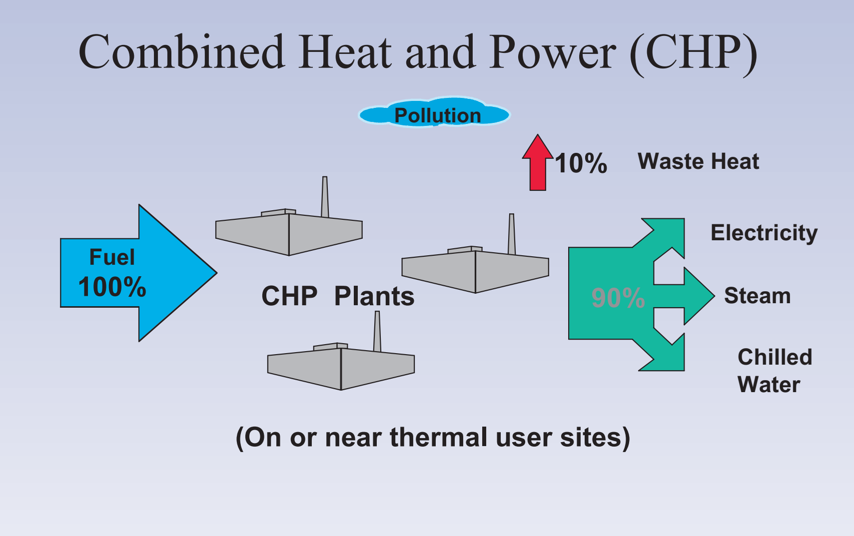


Figure C-4

Session C Summary was prepared by Dr. Praveen Amar. Dr Amar is the Science and Policy Director at NESCAUM and serves as a Science Advisor to the EMEP program.

Crosscutting Science and Policy Issues Related to Nitrogen in the Environment

Nitrogen pollution contributes to ground-level ozone, acidic deposition and the resulting acidification of soil and surface waters, disruption of forest processes, coastal overenrichment, and other environmental problems. Sources of reactive nitrogen include nitrogen in food and fertilizer and airborne emissions of nitrogen oxides and ammonia.

Session D of the 2003 NYSERDA Conference on Environmental Monitoring, Evaluation and Protection in Albany assessed what is known about the sources of nitrogen pollution, its impacts, potential management strategies, and the benefits of nitrogen reductions. The session was chaired by Richard Haeuber, Environmental Protection Specialist, Clean Air Markets Division, U.S. Environmental Protection Agency. Four presentations focused on reactive nitrogen at the global, regional, and state levels and on the costs and benefits of atmospheric emissions reductions.

Nitrogen and the Energy and Industry Connection

William Moomaw, Professor of International Environmental Policy, Fletcher School of Law and Diplomacy, Tufts University, observed that historically, most ecological systems have been limited in productivity by a lack of reactive nitrogen. Although the atmosphere is 78% nitrogen, most of it is in an inert form, unavailable to organisms. Over the past century, however, nitrogen limitation has changed to nitrogen saturation. More reactive nitrogen now cycles through our ecosystems than can be assimilated without detrimental impacts. The environmental effects of reactive nitrogen are particularly potent, since a single molecule can "cascade" through the atmosphere, the land, and aquatic systems, thereby contributing to a variety of environmental problems (Figure D-1). This cascading makes nitrogen an especially powerful pollutant; but for the same reason, the reduction of nitrogen pollution promises multiple benefits.

In the past two centuries, flows of reactive nitrogen have more than doubled on a globally averaged basis but increased by factors of 10 to 100 in regional hot spots. The increase is largely driven by nitrogen fertilizer and fossil fuel combustion for energy. As the human population grows, reactive nitrogen flows will likely increase in the future, and the nitrogen cascade will intensify (Figure D-2). Reductions in nitrogen pollution can be achieved through increased efficiency in nitrogen use in food production, decreased nitrogen oxide emissions from fossil fuel combustion, and the conversion of reactive nitrogen to inert nitrogen prior to its release into the environment.

U.S. policies, Moomaw believes, have had some success in reducing the growth and emissions levels of some forms of reactive nitrogen, but additional effort is needed. He advocates three basic approaches to controlling nitrogen flows:

1. focusing state and local efforts on the most cost-effective means of reducing reactive nitrogen, such as using regulatory powers to promote low-emissions vehicles, especially diesel trucks and off-road construction equipment;
2. closing policy gaps, such as New Source Review, which allows the continued operation of inefficient coal-fired power plants; and
3. providing economic incentives and encouraging technological advances in farming to improve food production efficiency and reductions in fertilizer use.

Nitrogen Pollution in the Northeast

Kathy Fallon Lambert, Executive Director, Hubbard Brook Research Foundation, brought the nitrogen issue to the regional scale, addressing the major sources and effects of reactive nitrogen in the Northeast, and the potential management strategies-the subject of her coauthored BioScience article (Driscoll et al. 2003).

Sources of reactive nitrogen in watersheds in the Northeast vary with land use and population (Figure D-3). In most small (50-100 hectare) forested watersheds, atmospheric deposition

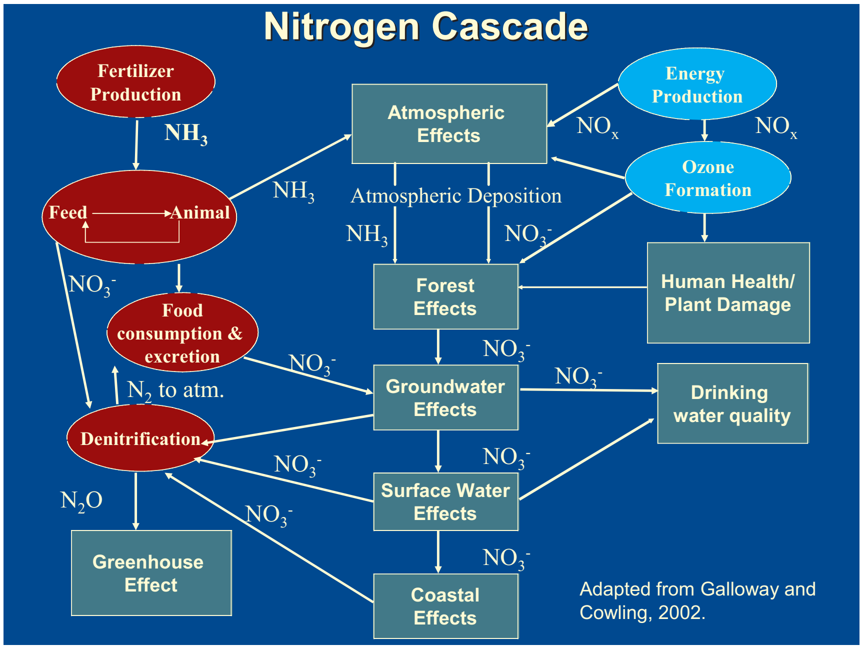
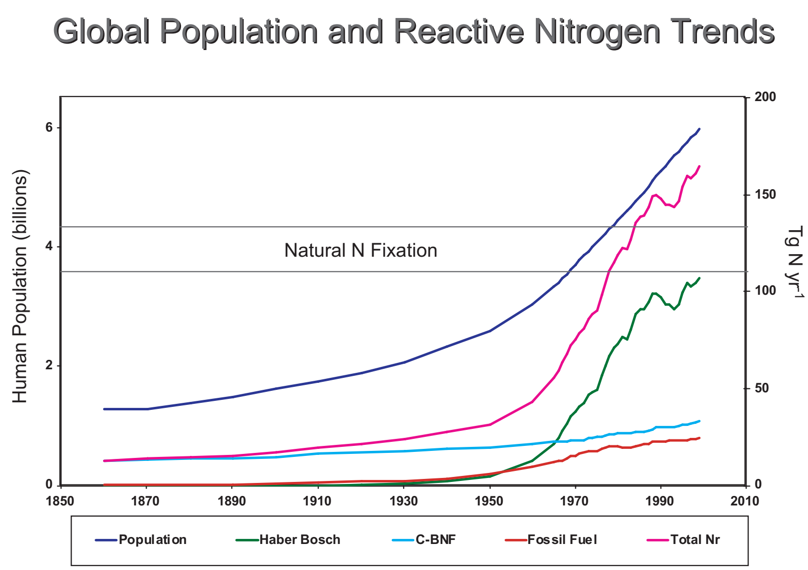


Figure D-1



From Galloway et al. 2002. In review.

Figure D-2

constitutes nearly 100% of reactive nitrogen inputs. Downstream, nitrogen in food becomes the major source of anthropogenic nitrogen in suburban and urban regions.

Analyzing atmospheric emissions, Lambert and her colleagues report that nitrogen oxides and ammonia originate from several sources, including vehicles (37%), electric utilities (24%), and agricultural sources (20%). The associated deposition of reactive nitrogen at the Hubbard Brook Experimental Forest in New Hampshire has been relatively constant over the past several decades. This finding is consistent with the lack of change in nitrogen emissions, despite pollution reduction efforts.

Nitrogen emissions and deposition contribute to ground-level ozone (and its related adverse impacts on forest productivity and human health), acid rain, visibility reduction, and the overenrichment of coastal waters. Ambient levels of ozone are estimated to decrease forest productivity 4% to 13% in the Northeast as a result of diminished net photosynthesis (Figure D-4). The researchers found nitrogen inputs to several major estuaries dominated by wastewater and atmospheric deposition. Large inputs of reactive nitrogen to coastal estuaries degrade water quality and fishery habitats through eutrophication and reductions in dissolved oxygen.

To evaluate emissions reduction policies and their effects on acidification in small forested watersheds and nitrogen loading to coastal estuaries, Lambert and her collaborators used a model known as PnET-BGC. Simulations showed that emissions reductions would bring about improvements in most surface waters, but not even the most aggressive options achieved the target levels for acid neutralizing capacity within 50 years in Biscuit Brook in New York State and the

Hubbard Brook watershed in New Hampshire.

Model results for coastal estuaries show that nutrient loading is most effectively reduced by an integrated management strategy addressing wastewater, emissions from vehicles and electric utilities, and agricultural sources. The single action that would most substantially decrease nitrogen delivery to estuaries is biological nitrogen removal from wastewater treatment plants.

Nitrogen in Rivers and Estuaries of New York State

Elizabeth Boyer, Assistant Professor, SUNY College of Environmental Science and Forestry, described efforts to estimate the origins of nitrogen in Northeast watersheds, its fate in watersheds, and its movement into streams and estuaries. Several challenges to establishing such budgets and quantifying nitrogen inputs have emerged:

- the presence of multiple species of nitrogen in the atmosphere, including ammonia species, nitrogen oxides, and organic nitrogen;
- the existence of multiple input pathways (e.g., wet and dry deposition), making it difficult to quantify total nitrogen inputs across variable landscapes; and
- the difficulty of "scaling up" measurements of nitrogen deposition from specific sites to large watersheds.

Atmospheric nitrogen deposition may be underestimated for several reasons: most monitoring sites are in rural areas, ammonium deposition measurements can be affected by biological activity in collection buckets, and the input of organic nitrogen is not adequately considered. Recent research suggests that organic nitrogen could contribute up to 30% of total nitrogen deposition in the Northeast. Boyer summarized the uncertainties in nitrogen deposition

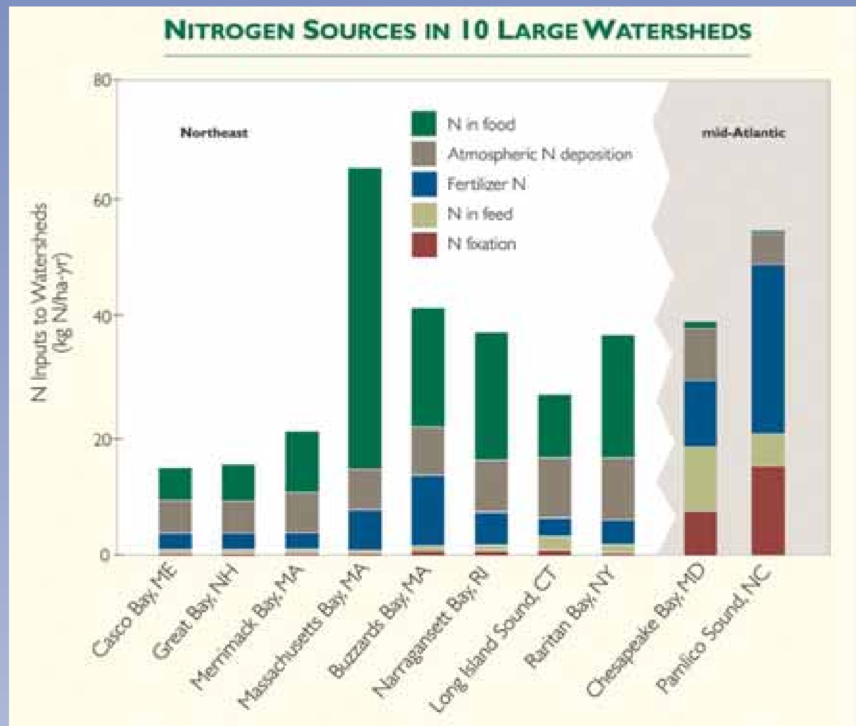


Figure D-3

Reprinted with permission from "Nitrogen Pollution: From the Sources to the Sea," Hubbard Brook Research Foundation, 2003.

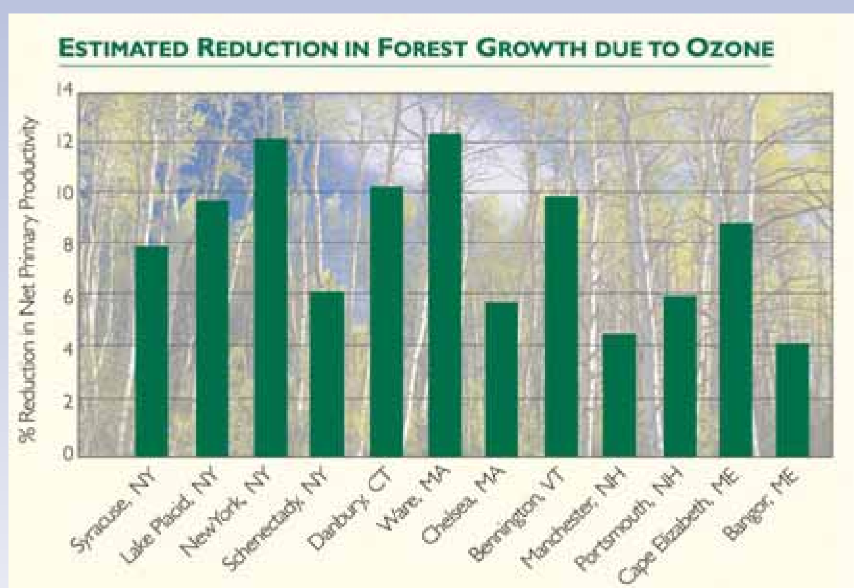


Figure D-4

Reprinted with permission from "Nitrogen Pollution: From the Sources to the Sea," Hubbard Brook Research Foundation, 2003.

Mass balance model

N inputs from uplands to the coastal zone

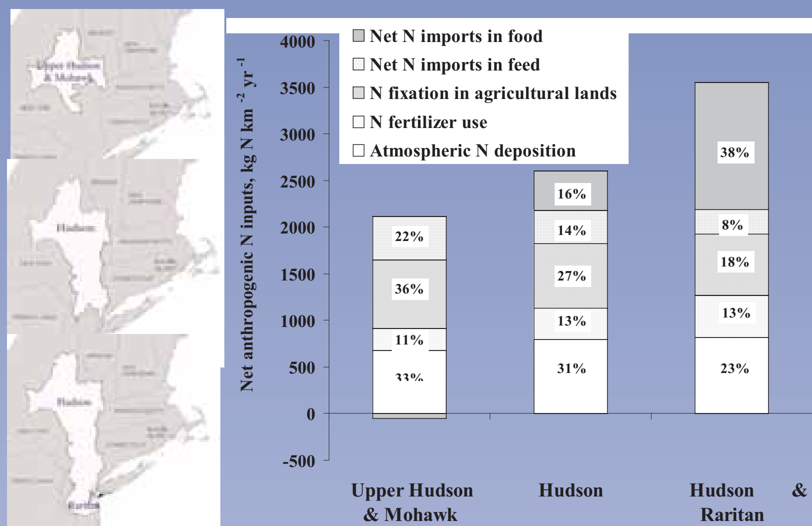
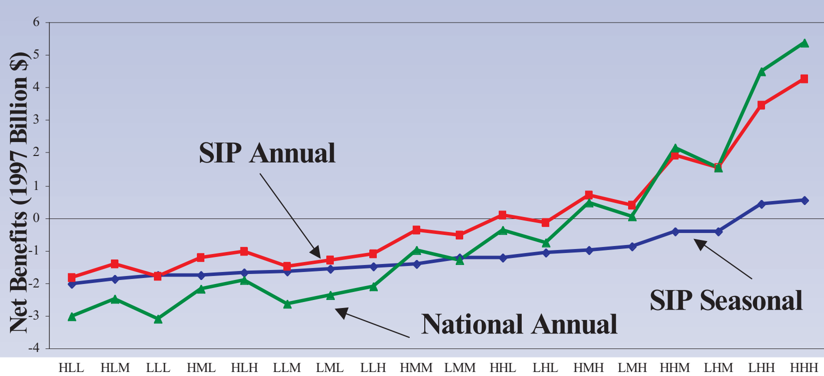


Figure D-5

Net Benefits for the Nation, 2008



Combinations of assumptions in scenario analysis characterizing market structure, epidemiology and valuation.

Figure D-6

estimates and underscored the importance for policymaking of better estimates and a better understanding of atmospheric deposition.

Boyer and her collaborators have used two modeling approaches to improve anthropogenic nitrogen budgets: a mass balance model called Total Net Nitrogen Inputs and a regression model known as Sparrow (Spatially Referenced Regression on Watershed Attributes). The mass balance model results for the Hudson River watershed show that nitrogen inputs vary from upstream to downstream with changes in human population, as the relative contribution of nitrogen in food increases from the sparsely populated uplands to the densely populated coastal zone (Figure D-5).

The Sparrow model was used to evaluate differences in nitrogen inputs for two watersheds in New York with a similar size but different land-use patterns. When comparing the Mohawk and the Seneca watersheds, Boyer and her colleagues found that land-use differences can result in changes in nitrogen inputs. Although atmospheric deposition was the largest single input for both watersheds, the next largest input was associated with urban runoff in the Mohawk basin and with agricultural activities in the Seneca watershed. The researchers concluded that relatively small land-use changes can have large effects on the nitrogen cycle.

Both modeling approaches indicate that atmospheric emissions and associated deposition are a significant source of nitrogen input to New York State watersheds.

Benefits of Reduced Air Pollution in the United States

Dallas Burtraw, Senior Fellow, Resources for the Future, focused on cost-benefit analysis of reductions in atmospheric emissions from electric utilities.

Value of SO_2 Emission Reductions by State

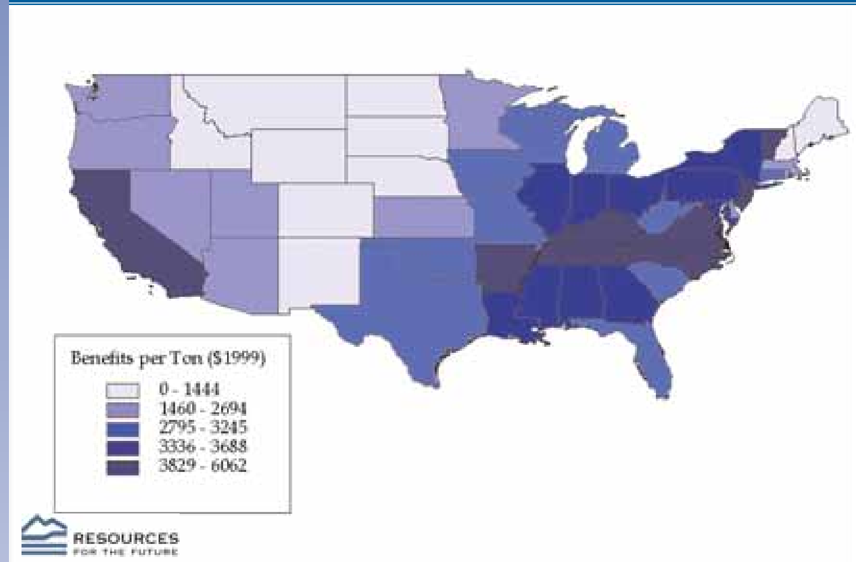


Figure D-7

Title IV of the Clean Air Act Amendments of 1990 established the SO_2 emissions trading program for electric utilities. Despite concerns that a trading program would create hot spots in areas sensitive to acidic deposition, a regional analysis of SO_2 allowance trading in the eastern United States shows that emissions have decreased consistently across the region. Burtraw concluded that it does not appear that SO_2 trading is causing a problem.

To achieve further reductions in NO_x emissions from electric utilities and reduce ground-level ozone in the eastern United States, the Environmental Protection Agency has issued its state implementation plan (SIP) call. Although ground-level ozone is largely a summertime problem in the eastern United States, Burtraw and his colleagues have analyzed the cost-effectiveness of the NO_x SIP call in dealing with year-round effects, such as acidic deposition. Assuming year-round NO_x reductions, the project team found that net benefits (i.e., benefits minus costs) are consistently favored by a year-round approach to emissions reductions (Figure D-6) and that regional reductions are generally more cost effective than mandated nationwide cuts in emissions.

Burtraw and his colleagues have also analyzed the costs and benefits of multipollutant bills introduced in Congress. Using existing literature on human health benefits, they have determined that reductions in SO_2 and NO_x emissions achieved by the proposed policies appear to be cost-effective (Figure D-7). In fact, based on the economic studies, even greater cuts in SO_2 emissions would be justified. Mercury is also addressed under some proposed policies. Based on available information, Burtraw expects that, broadly speaking, mercury trading under certain constraints could lower costs, but the benefits are not well quantified.

Most cost-benefit analyses of emissions reductions policies have focused on improvements in human health rather than on general environmental improvements, largely because economic information on “nonuse” values is lacking. To address this shortcoming, Burtraw is seeking to quantify values that are characteristically ignored in cost-benefit analyses by surveying “willingness to pay” to improve natural resources in the Adirondacks and including economic benefits associated with nonuse values.

Session D Summary was prepared by Kathy Fallon Lambert. Ms. Lambert is the President of Ecologic: Analysis and Communications, and is a member of the EMEP outreach and communications team.

CONFERENCE CLOSING ADDRESS

Elizabeth Thorndike, Founder and Director, Center for Environmental Information and Member of the NYSERDA Board

The discussions in this conference have underscored the significant environmental impact of energy use and the need for regional, national, and even international solutions and cooperation, both in research and in policy making, to solve the problems.

This doesn't mean that one state cannot make a difference. In fact, many initiatives seem to be taking place at the state level. Governor Pataki's Regional-State Climate Initiative is an important example. As was pointed out by the speaker from the Department of Public Service, the economies of the New England states, New York, New Jersey, and California together constitute the world's third largest economy.

With modest financial resources, New York has launched an excellent scientific research program in the Environmental Monitoring, Evaluation, and Protection Program here at NYSERDA. With an outstanding research community, with the leveraging of funding that takes place, and with the focus on enhanced communication, the research that has been presented here does indeed provide a good scientific foundation for health-related and environmental management decisions that are ahead of us.

The conference addressed a variety of science and policy topics, through breakout sessions, panel discussions, plenary presentations, and an extensive poster presentation. From discussions in the ***Fine Particulate Matter and Health Effects*** sessions, it is clear that we are making progress in understanding this environmental threat - but we have really just scratched the surface. While a body of research has emerged that has given us the statistical confidence to conclude that fine particles cause adverse health effects, we do not yet know what exactly it is in the fine particle soup that is causing the impacts. Is it the sulfates, the metals, the organic mixture, or is it the very small, ultra fine particles? And, while we're focusing on reducing the PM2.5 mass in our air quality management strategies, what if we achieve that mass reduction by reducing a constituent that is comparatively inert and not the major component contributing to adverse health effects? We may get some benefits, but will we attain our public health goals? We are still at the beginning of understanding this very important field and if our track record in addressing ozone holds true, it will be some time before we fully understand the nature of airborne particulate pollution.

So how do we proceed in the meantime? We've heard good arguments that we should do what we can to reduce ambient levels of PM2.5 and hold the course, while we continue to understand better the specific constituents causing the adverse health effects. Should we have a standard that is PM1 (i.e., 1 micron) in the future? Should we have a particle-number-based standard? We do not yet know the answers to these questions, but looking back five years we have made fundamental progress in understanding how PM interacts with biological systems and I am confident that with adequate research investment we can address these critical policy questions.

In terms of ***Control Technology Options***, over history we have seen that innovation in control technology can precede establishment of regulation. However, sometimes innovation and reduction in control cost follows regulation. We need to keep this historical experience in mind as we consider various policies in the future to reduce particulate matter and co-pollutants.

We also need to ensure that we understand how the different pollution control technologies affect other constituents in the PM soup. Does a new device or new technology increase the number of particles? Does it increase the elemental carbon fraction? We have to continue to ask these questions. We have learned that lesson from our endeavors to reduce ozone pollution.

In the ***Ecosystem*** session we struggled with a fundamental question. Are we observing recovery from acidification? What does the recovery mean? How much improvement is needed to declare recovery? How long will it take? We are seeing a reduction in sulfate deposition and we are seeing the beginning of minor, yet statistically significant increases in measured pH in many lakes. We're headed in the right direction, but it's only the beginning.

Another very important lesson we can learn from our efforts to address the acid rain problem is that we should not be too quick to think we've solved the problem. Recall back in the early 1990s there was little funding for acid rain research because the conventional wisdom was that the newly passed Clean Air Act Amendments would solve the problem.

States such as New York and others launched monitoring and assessment programs to see if the data support that hypothesis, and they created the Adirondack Lake Survey Corporation and the National Acid Deposition Program. What we have found is that we've not completely resolved the problem, but we are now moving slowly in the right direction. The lesson here is that we need to ensure that we have the continued, long-term monitoring and baseline data to systematically evaluate our policies throughout implementation and ensure that we have some scientifically defensible accountability when environmental policies are legislated. In order to sustain effective policy we need to keep working on documenting the relationship between emissions and deposition, the measurement of deposition and its effects, and the tracking of change over space and over time.

The conference also has had an important session on ***Nitrogen in the Environment***, the ultimate crosscutting pollutant. We need it to live and to grow, but nitrogen is involved in a "cascade" of environmental maladies ranging from acidification (nitric acid), to particulates (ammonium nitrate), to ozone formation (nitrogen oxides), to groundwater contamination (nitrate), eutrophication of ecosystems, and degradation of coastal zones and coastal habitats (ammonium), and of course climate change (nitrous oxides). There will be significant increases in global energy production and fertilizer use over the next twenty years, which will add considerably to the amount of human-induced reactive nitrogen that is released into the environment. Therefore, this is truly a local, a regional, and a global issue that will require cooperation between scientists and decision makers to develop effective integrated approaches to the problem.

And finally, during the concluding session we had a thought-provoking exchange on improving communication between scientists and policy makers and the scientific basis for environmental policy. The overarching goal of this conference - Linking Science and Policy - is a laudable goal, but one that will take continued perseverance and creativity from the many stakeholders involved in the process of scientific discovery and policy formulation.

This conference has covered the gamut, with stimulating discussions, a tremendous amount of data, and many remaining challenges. We've gone from remote lakes in the Adirondacks to air quality problems in the Lower East Side. We've seen glimpses of progress and environmental improvement throughout. We've seen puzzles starting to be pieced together and as a result we are seeing an increase in the knowledge base with which we manage our natural resources for this generation and for the next- and that is most encouraging.

Conferences such as this play an important role in bringing together, at one time and in one place, the latest updates on research to inform policy. Twenty years ago the Center for Environmental Information (CEI), with which I've been involved, began to organize the first state-wide conference on acid rain in a public forum with the Department of Environmental Conservation, which had designated CEI as the State's acid rain information clearinghouse. The awareness generated by the conference planning, and then the subsequent collaboration with the efforts of state agencies, environmental organizations, and the researchers who participated in that conference in April of 1984, led directly to passage the following month of the nation's first state acid rain control legislation. And relentlessly, by conference, by data, by dialogue, by involvement of environmental groups, state agencies, scientists, and citizens, we got to the point of the 1990 Clean Air Act Amendments. But by the time we got around to addressing SO_X and a little bit of NO_X in the 1990's, climate change, mercury accumulation, and the nitrogen cascade effects were emerging as linked problems related to our use and dependence on fossil fuels, and, as it turns out, to our food production processes.

Linkages among effects require a multi-pollutant strategy for controls. The strategies and the controls are examples of the policy process, but helping decision makers to understand those linkages among effects is the responsibility of the science community and all the participants at this conference.

I would like to conclude with a quote from Edna St. Vincent Millay's poem "Huntsman What Quarry," in which she said, "Wisdom enough to teach us of our ill is daily spun, but there exists no loom to weave it into fabric." Our task is to do a better job of constructing that loom in order to weave what scientists know into a fabric that policy makers can use.

Conference Sponsors

New York State Energy Research and Development Authority • New York State Department of Public Service • New York State Department of Environmental Conservation • New York State Department of Health • U.S. Environmental Protection Agency • U.S. Geological Survey • Adirondack Council • Center for Clean Air Policy • Clean Air Task Force • Environmental Energy Alliance of New York • New York Academy of Sciences • Northeast States for Coordinated Air Use Management

Environmental Monitoring, Evaluation, and Protection In New York: Linking Science and Policy

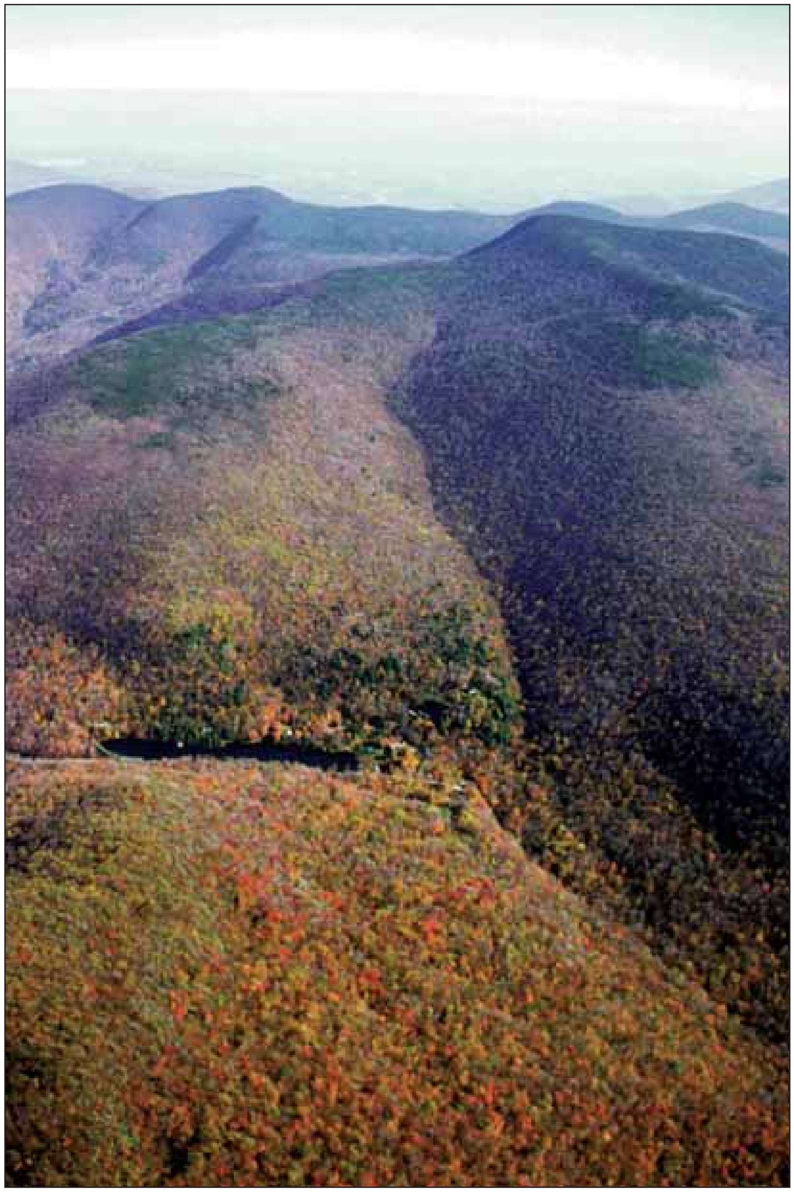


Photo by Michael McHale

Winnisook watershed, Catskill Mountians

New York Energy $mart℠

EMEP

Environmental Monitoring, Evaluation, & Protection

October 7-8, 2003

Albany Marriott • 189 Wolf Road • Albany, NY

This conference brings together scientists and policy makers to share information on environmental research in New York State and its implications for policy making. The New York Energy $mart℠ Environmental program supports policy-relevant research in order to enhance understanding of energy-related environmental issues. The program will highlight research on air quality and related health issues, ecosystem responses to atmospheric pollutants, and proposed pollution control policies affecting New York State. A series of panels, breakout and plenary sessions will focus on four key areas: particulate matter, acid deposition, ozone and mercury. Results of NYSERDA/EMEP-sponsored and related research projects will be presented in poster sessions throughout the two-day event. The plenary sessions will draw attention to major energy-related environmental issues of the 21st century and offer recommendations for improving the effectiveness of science-based policy.

Environmental Monitoring, Evaluation, and Protection In New York: Linking Science and Policy

October 7-8, 2003

Albany Marriott • 189 Wolf Road • Albany, NY

Tuesday, October 7, 2003

8:00 a.m.	**Registration and Continental Breakfast**

8:30 a.m.

- **Welcome and Opening Remarks**

  Peter R. Smith, Acting President
  New York State Energy Research and Development Authority (NYSERDA)

  Erin Crotty, Commissioner
  New York State Department of Environmental Conservation (NYS DEC)

9:00 a.m.

- **Overview of the New York Energy $mart℠ Environmental Monitoring, Evaluation and Protection (EMEP) Program**
  Janet Joseph, Program Manager, NYSERDA

9:30 a.m.

- **State of the Environment: Major Energy-Related Environmental Issues of the 21st Century**
  John Bachmann, Associate Director for Science Policy and New Programs, U.S. Environmental Protection Agency (U.S. EPA)

  This presentation will provide an overview of the major environmental issues facing New York and the nation. The presentation will review progress made to date in the environmental arena and will identify scientific and policy challenges ahead. The presentation will underscore the linkages between research progress and policy developments.

10:00 a.m.	**Break**

10:15 a.m.

Panel: Energy-Related Environmental Policy Initiatives Affecting New York State and the Region
Chair: John Bachmann, Associate Director for Science Policy and New Programs, U.S. EPA

- Electricity and the Environment - Emerging Issues and New Initiatives
  James Gallagher, Director, Office of Electricity and Environment, NYS Department of Public Service

- Ozone/Fine Particle State Implementation Plan, Low-Sulfur Fuels and Diesel Rules
  Carl Johnson, Deputy Commissioner, Air and Waste Management, NYS DEC

- Collaboration for Regional Haze and Fine Particle Planning
  Susan Wierman, Executive Director, Mid-Atlantic Regional Air Management Association (MARAMA)

- Local/Regional Initiatives and Emerging Opportunities
  Ken Colburn, Executive Director, Northeast States for Coordinated Air Use Management (NESCAUM)

  The panelists will present brief summaries of environmental policy initiatives relevant to New York and the region. The panelists will provide an update of these initiatives and will identify information/research needs to support the policy initiatives. The presentations will be followed by a 20-minute question/answer period.

12:00 - 1:30 p.m.	**Luncheon and Poster Session**

1:30 p.m.	**Update of the Latest Research on Major Energy-Related Environmental and Public Health Issues in New York State**	
	Session A **AIR QUALITY AND RELATED HEALTH RESEARCH: PARTICULATES (PM) AND CO-POLLUTANTS** *This session will focus on key science/policy questions associated with PM: What are the health effects? Where does the PM come from? What is the picture in New York State?* Session Co-Chairs: Jim Vickery, Acting National Program Director of PM Research, U.S. EPA, and Ellen Burkhard, Project Manager, NYSERDA	**Session B** **ECOSYSTEM RESPONSE TO DEPOSITION OF SULFUR, NITROGEN AND MERCURY** *This session will focus on ecosystem response to changing levels of sulfur, nitrogen, and mercury in New York State and will address the extent to which "recovery" of acidification is being observed in New York State.* Session Co-Chairs: Kathleen Weathers, Forest Ecologist, Institute of Ecosystem Studies, and Mark Watson, Senior Project Manager, NYSERDA
1:30 p.m.	Overview of State of Science and Policy Implications: NARSTO PM Assessment Jim Vickery, Acting National Program Director of PM Research, U.S. EPA	Overview of State of Science and Policy Implications - Kathleen Weathers, Forest Ecologist, Institute of Ecosystem Studies
2:00 p.m.	EMEP Project Activity and Road Map Ellen Burkhard, Project Manager, NYSERDA	EMEP Project Activity and Road Map Mark Watson, Senior Project Manager, NYSERDA
2:15 p.m.	New York PM Supersite Update: What Have We Learned/Where Do We Need to Go? Ken Demerjian, Director, Atmospheric Sciences Research Center, University at Albany	Changes in Water Quality in Adirondack Lakes and Streams - Karen Roy, Program Manager, Adirondack Lakes Survey Corporation
2:45 p.m.	Sources of PM and Precursor Gases in New York State - Phil Hopke, Director for the Center for Air Resources Engineering and Science, Baryard D. Clarkson Distinguished Professor, Clarkson University	An Integrated Assessment of the Recovery of Surface Waters from Reduced Levels of Acid Precipitation in the Catskills and Adirondacks - Doug Burns, Research Hydrologist, U.S. Geological Survey
3:15 p.m.	**Break**	**Break**
3:30 p.m.	Latest Findings on PM Health Effects Mort Lippman, Professor of Environmental Medicine, New York University Medical Center	Has There Been a Biological Response to Reduced Emissions?- Sandra Nierzwicki-Bauer, Director, Darrin Fresh Water Institute, Rensselear Polytechnic Institute
4:00 p.m.	Clinical and Mechanistic Health Studies with PM: New Findings and Research Directions Mark Utell, Professor of Medicine and Environmental Medicine, University of Rochester	Inputs, Transport and Transformations of Mercury in Forest-Wetland-Lake Ecosystems Charles Driscoll, Professor and Director of the Center for Environmental Systems Engineering, Syracuse University
4:30 p.m.	Panel Questions and Answers	Panel Questions and Answers
5:00 - 7:30 p.m.	**Reception and Poster Session**	

Wednesday, October 8, 2003

8:00 - 8:30 a.m.	**Continental Breakfast**	
8:30 a.m.	**Session C:** **Control of Particulate Matter and Co-Pollutants: Technology Options and Costs** *This session will focus primarily on approaches to controlling particulate emissions and co-pollutants, and will address economic implications of control.* Session Chair: Sandra Meier, Associate Director, Environmental Energy Alliance of New York	**Session D:** **Crosscutting Science and Policy Issues Related to Nitrogen in the Environment** *This session will focus on the impact of nitrogen compounds on human health, ecosystems and climate, and potential control options.* Session Chair: Rick Haeuber, Environmental Protection Specialist, Clean Air Markets Division, U.S. EPA
8:30 a.m.	Status of PM Emission Inventories Philip Lorang, Supervisory Environmental Engineer, U.S. EPA	Overview of Nitrogen and the Energy and Industry Connection - William Moomaw, Professor of International Environmental Policy Tufts University
9:15 a.m.	Utility PM and Precursor Emissions and Multi-Pollutant Control Options: Regulatory Landscape, Technology and Cost - Praveen Amar, Director of Science and Policy, NESCAUM, and Rui Afonso, President, Energy and Environmental Strategies	Status and Effects of Nitrogen Pollution in the Northeast - Kathy Lambert, Consultant, Hubbard Brook Research Foundation
10:00 a.m.	**Break**	**Break**

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10:30 a.m.

Session C: (continued)

Motor Vehicle PM and PM Precursor Emissions and Control Options - Tim Johnson, Emerging Technologies and Regulations Director, Corning Environmental Technologies

Session D: (Continued)

Case Study: Nitrogen Sources and Impacts to Rivers and Estuaries of New York State - Elizabeth Boyer, Assistant Professor, College of Environmental Science and Forestry at Syracuse

11:15 a.m.

Session C: The Emission Reduction Credit Process and Smaller-Scale Combined Heat and Power Projects - Tom Bourgeois, Senior Economist, PACE University

Session D: Benefits of Reduced Air Pollution in the United States - Dallas Burtraw, Senior Fellow, Resources for the Future

12:00 p.m.

Luncheon and Keynote: Congressional Update and Perspective on Environmental Policy and Science - John Mimikakis, Deputy Chief of Staff, House Committee on Science

1:45 p.m.

Improving the Scientific Basis for Environmental Policy
Daniel Greenbaum**,** President, Health Effects Institute

2:15 p.m.

Plenary Discussion: Increasing the Effectiveness of Science-Policy Communication - How Do We Get on the Same Page? Chair: Joanne Fox-Przeworski, Director of the Bard Center for Environmental Policy, Bard College

Panelists will offer insights on how the scientific and policy communities can improve the exchange of information for more effective policies. Examples of successful environmental science-policy transfers will be highlighted.

- Millie Baird, Project Manager, Environmental Defense
- Rona Birnbaum, Chief, Assessment and Communications Branch of the Clean Air Markets Division, U.S. EPA
- David Shaw, Acting Director, Division of Air, NYS DEC
- David Allen, Director, Center for Energy and Environmental Resources, University of Texas at Austin
- Andrew Revkin, Science Writer, New York Times

4:15 p.m.

Wrap Up and Closing Comments
Elizabeth Thorndike, Founder and Director, Center for Environmental Information and Member of NYSERDA Board

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New York Energy Smart[SM]

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NYSERDA

Photo by Mark Watson

Wet deposition monitor, Whiteface Mountain

Program Contact

Technical or program issues:
Mark Watson: voice - (518) 862-1090, ext. 3314; fax - (518) 862-1091; mw1@nyserda.org

For Additional Information

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www.nyserda.org

New York State Energy Research and Development Authority
17 Columbia Circle
Albany, New York 12203-6399

toll-free • 1-(866) NYSERDA
locally • (518) 862-1090
info@nyserda.org

Photo by Mark Watson

SUNY ESF student researchers, Arbutus Lake

New York Energy $mart℠
EMEP
Environmental Monitoring, Evaluation, & Protection

POSTER PRESENTATIONS

New York Energy $mart℠ Environmental Monitoring, Evaluation, and Protection (EMEP) and Related NYSERDA Research

Air Quality and Related Health Research: Particulates and Co-Pollutants	
Clinical Studies of Exposure to Ultrafine Particles	University of Rochester Medical Center
Source Apportionment of Fine Particulate Matter in Manhattan Following the World Trade Center Disaster	New York University Medical Center
Assessing the Effects of Transboundary Pollution on New York's Air Quality	NYS Department of Environmental Conservation
Development of a Sample Equilibration System for the R&P TEOM Ambient Particulate Monitor	Rupprecht & Patashnick Co., Inc.
Development and Demonstration of an Innovative Instrument for Ambient Particulate Matter Mass Measurement Standard	Rupprecht & Patashnick Co., Inc.
Fine/Ultrafine Particulate Emissions Profiles	Gas Technology Institute; GE Energy & Environmental Research
Fine PM Precursor Emissions from Biofuel Combustion and Distributed Generation Sources	GE Energy & Environmental Research
Sampling and Analysis of Acidic Organic Compounds for Source Apportionment in the New York City Area	Rutgers University; Drexel University

Formation Mechanism of Nucleation Mode Particles in Motor Engine Exhaust	SUNY Albany
Intercomparison of Semi-Continuous Particulate Sulfate and Nitrate Measurement Technologies at New York State Urban and Rural Locations	SUNY Albany, Atmospheric Sciences Research Center
Semi-Continuous PM2.5 Sulfate and Nitrate Measurements in New York City and Whiteface Mountain	SUNY Albany, Atmospheric Sciences Research Center
Aerosol Size Distributions: A Comparison of Measurements From Urban and Rural Sites	SUNY Albany, Atmospheric Sciences Research Center
Measurements of Carbon Particulate Matter in the Adirondack Region of Upstate New York	SUNY Albany, Atmospheric Sciences Research Center
Aerosol Laboratory Evaluations of PM2.5 Measurement Technologies	SUNY Albany, Atmospheric Sciences Research Center
Recent Developments in the Field Evaluation of TEOM Based PM2.5 Monitoring Technologies	SUNY Albany, Atmospheric Sciences Research Center
Pollutant Concentrations and Temporal Patterns in Manhattan and the Bronx, New York	NYS Department of Health
Center for Air Resources Engineering and Science: The NYSTAR Environmental Quality Systems Center at Clarkson University	Clarkson University
Effect of Gaseous Pollutants and Meteorological Parameters on Nucleation and Growth of Ultrafine Particles in Urban Ambient Air	Clarkson University; University of Rochester Medical Center; NYS Department of Environmental Conservation
Application of Receptor Modeling to Atmospheric Constituents at Potsdam and Stockton, NY	Clarkson University
Validation of the Potential Source Contribution Function Using the July 2002 Quebec Fire Episode	Clarkson University
Long-Term Measurement of Ultrafine Particle Number Concentration in Rochester, NY	Clarkson University; University of Rochester Medical Center; NYS Department of Environmental Conservation
Portable Testing into the Future	Clean Air Technologies, Inc.

Research of Ecosystem Response to Deposition of Sulfur, Nitrogen and Mercury

Long-Term Monitoring Program for Evaluating Changes in Water Chemistry in Adirondack Lakes and Streams	Adirondack Lakes Survey Corporation (ALSC)
Mercury in Adirondack/Catskills Wetlands, Lakes and Terrestrial Systems	Tetra Tech; Syracuse University; U.S. Geological Survey; Smith College
Status and Effects of Nitrogen Pollution in Northeastern United States	Hubbard Brook Research Foundation
Regional-Scale Modeling of the Emissions, Transport and Fate of Atmospheric Mercury in New York State	Research Foundation of SUNY
Deposition and Effects of Air Pollution in the Hudson Valley	Institute of Ecosystem Studies
Assessment of Extent to Which Intensively Studied Lakes are Representative of the Adirondack Mountain Region	E&S Environmental Chemistry, Inc.; RPI; University of Virginia; Syracuse University; University of Maine; Oregon State University; SUNY ESF; Dartmouth College; NYS Department of Environmental Conservation
The Potential Recovery of Water Chemistry and Stream Biota from Reduced Levels of Acid Deposition at a Sensitive Watershed in the Catskill Mountains	U.S. Geological Survey; NYS Department of Environmental Conservation

Long-term Monitoring and Assessment of Mercury Based on Integrated Sampling Efforts Using the Common Loon, Prey Fish, Water, and Sediment	Adirondack Cooperative Loon Program/Wildlife Conservation Society; Biodiversity Institute; New York State Department of Environmental Conservation
Strategic Monitoring of Mercury in New York State Fish	New York State Department of Environmental Conservation; Adirondack Lakes Survey Corporation
Assessment of Chemistry and Benthic Communities in Streams of the Oswegatchie-Black River Basins of the Adirondack Region	U. S. Geological Survey; NYS Department of Environmental Conservation; University of Texas; Adirondack Lakes Survey Corporation
Northeastern Ecosystem Research Cooperative*	Institute of Ecosystem Studies
Monitoring at the Arbutus Watershed in the Adirondack Mountains of New York: Role of Climate and Atmospheric Deposition	SUNY College of Environmental Science and Forestry
Model Simulations of Ambient Mercury Concentrations and Wet Deposition over the Eastern U.S.	NYS Department of Environmental Conservation; National Oceanic and Atmospheric Administration
Research Crosscutting the Topics of Air Quality, Health and Ecosystem Response	
Quantifying Atmospheric Nitrogen Sources with New Stable IsotopeTechniques	U.S. Geological Survey; SUNY College of Environmental Science and Forestry; University of California; Electric Power Research Institute
Multi-Pollutant Policies for the Electricity Sector: Electricity Cost and Environmental Quality in the Empire State	Resources for the Future; Georgia Institute of Technology
Analysis of a New Pollution Control Strategy Utilizing Emission Reduction Credits and Small Scale Combined Heat and Power Units	Navigant Consulting; Pace Energy Project
Quantifying the Environmental Benefits of Increased Deployment of Combined Heat and Power Technologies in New York State and the Impact of Proposed Emissions Standards for Small Distributed Generation	Navigant Consulting
Benefits Associated with Co-Firing Willow Biomass and Wood Residuals with Coal	SUNY College of Environmental Science and Forestry; ANTARES Group, Inc.
An On-Line Analyzer for Low Content Sulfur Measurements in Petroleum Products	X-Ray Optical Systems, Inc.
High-Efficiency Heating with Low Sulfur Fuel	Brookhaven National Laboratory; Energy Research Center, Inc.; Buhrmaster Energy Group; National Oil Heat Research Alliance
New York City Private Ferry Emissions Reduction Program	NYC Department. of Transportation; Seaworthy Systems, Inc.
Development of a Self-Regenerating Particulate Trap for Emission Control	Rochester Institute of Technology
New York State Truck Stop Electrification	Niagara Mohawk Power Corp.; NYS Thruway Authority; NYS Department. of Transportation; Antares Group, Inc.
Clean Air School Buses	Various New York State municipalities

* This program does not directly receive NYSERDA funding.

Overview of the New York Energy $mart℠
Environmental Monitoring, Evaluation and Protection Program

Janet Joseph
Program Manager, NYSERDA

A brief history of the Environmental Monitoring, Evaluation, and Protection (EMEP) program will be presented. The goals and strategies of the program will be reviewed, and potential future directions of the program will be discussed. The presentation will also include an overview of the goals of the conference as it relates to the EMEP program.

The **New York Energy $mart℠** EMEP program supports policy-relevant research to enhance understanding of energy-related environmental impacts. The primary goal of the program is provide the scientific foundation upon which effective air-quality management strategies can be developed.

The program is funded by a surcharge on the sales of electricity in New York State, referred to as the System Benefits Charge. The EMEP program has been funded at approximately $3 million per year from its inception in 1998 through 2006. EMEP is one of several public-benefit programs established by the New York Public Service Commission and administered by NYSERDA. Other **Energy $mart℠** programs address energy efficiency, alternative energy, and energy research and development.

The EMEP program focuses on critical regional environmental issues including ozone, fine particles, acid deposition, and mercury. The program is guided by an Advisory Group comprised of representatives of State and federal government, public interest groups, academics, and industry. The program also relies on an independent science advisory committee for input in a variety of technical disciplines. The program seeks to leverage limited dollars with federal/private resources to maximize the value of the State investment. EMEP also seeks to build on those research institutions in New York State to help address critical environmental issues in the region. The program supports a variety of efforts to ensure that there is a robust exchange of information between scientists and policy makers.

Over the next 2–3 years, the program will be focusing on synthesis projects and translating studies into a form useful for policy makers. EMEP will continue to support research to provide the scientific foundation to address fine particulate matter and better understand how to reduce related health impacts in New York. On the ecosystems front, EMEP will continue to support research and monitoring efforts aimed at evaluating the impact of acid rain and other control strategies on the recovery of our critical ecosystems in New York. EMEP will continue to support cross-cutting/multimedia/multi-pollutant research.

Other background material on the EMEP program can be found in the program fact sheet enclosed with the conference materials.

State of the Environment: Major Energy and Air Related Environmental Issues of the 21st Century

John Bachmann
Associate Director for Science and Policy
U.S. Environmental Protection Agency

This presentation will provide an overview of the major environmental issues facing New York and the nation that arise from energy-related effects on the atmosphere. The presentation will review progress made to date on air quality on a local, regional, and international scale, and will identify some of the scientific and policy challenges ahead. The presentation will underscore the linkages between research progress and policy developments, with particular emphasis on emissions and issues related to power generation.

Collaboration for Regional Haze and Fine Particle Planning

Susan S.G. Wierman
Executive Director, Mid-Atlantic Regional Air Management Association (MARAMA)

This presentation will focus on regional haze requirements and the need for New York and other states to develop sound technical information to support a shared, regional consensus on policy issues. The regional haze rules are intended to improve air quality at major national parks and wilderness areas (Class I areas). While all of these areas are outside New York, emissions from major sources in New York contribute to regional haze affecting Class I areas. New York is participating in a regional approach to understanding regional haze and developing plans to reduce it. MARAMA is helping to build the technical foundation for regional haze plans.

Overview of State of Science and Policy Implications: NARSTO PM Assessment

James S. Vickery
US EPA, Research Triangle Park, NC

NARSTO has just completed a state-of-science assessment on the atmospheric processes and source-to-receptor relationships of particulate matter (PM) across North America. The assessment has gone through rigorous peer and policy relevant review and was released in April of this year. Its audience is the government and industry policy community now considering how to meet national PM air quality standards. This briefing will present insights from the atmospheric sciences in answering the pressing policy questions, “Where do we have a problem?” “What are its sources?” “What approaches might fix it?” “What is the relationship between the PM problem and other air issues?” and “How will we measure progress?” The full complement of disciplines is brought to bear, from measurements and trends, to processes and modeling, to emissions and source apportionment.

EMEP Project Activity and Road Map: Air Quality and Related Health Research: Particulates and Co-Pollutants

Ellen Burkhard
Project Manager, NYSERDA

NYSERDA's Environmental Monitoring, Evaluation, and Protection (EMEP) Program supports research to increase the scientific understanding of the behavior, cycling, and interaction of primary and secondary pollutants related to electricity generation in the environment so that policy makers can identify effective strategies for mitigating the impacts of energy production and use.

This presentation will provide an overview of air quality and related health effects projects in the EMEP program, as well as projects in other NYSERDA programs that mitigate energy-related pollution. Efforts include aerosol characterization, source characterization and apportionment, health-effects studies related to fine particulates ($PM_{2.5}$), and research and development of pollution monitoring and control technologies.

A key goal of the EMEP program is to provide a sound scientific basis for informed, effective decisions in the management of air quality in New York that will benefit its citizens both environmentally and economically. State policy makers will be developing the State Implementation Plan (SIP) for complying with the ambient air quality standard for $PM_{2.5}$ in 2005–2008. Research projects focusing on aerosol characterization are fundamental to meeting this objective. Source characterization and apportionment studies identifying sources of primary particles and precursors to secondary particles are important to updating emission inventories and identifying $PM_{2.5}$ control strategies. Health-effects research is essential to identifying the component or components of aerosols that are biologically active, so that policy makers can identify the control strategies that are effective in protecting human health. Finally, potential future directions in EMEP's air quality research will be presented.

New York PM Supersite Update: What Have We Learned/Where Do We Need to Go?

Kenneth L. Demerjian
Atmospheric Sciences Research Center, University at Albany, SUNY

Recent results from the Joint Enhanced Ozone and $PM_{2.5}$ Technology Assessment and Characterization Study in New York (PMTACS-NY), a so-called $PM_{2.5}$ Supersite co-funded by NYSERDA, NYS DEC, and the U.S. EPA, are discussed in the context of science-policy highlights and their relevance to New York State regulators and policy makers. Specific topics include the following:

1. The benefits to be derived from the introduction of low-sulfur fuels (diesel and gasoline) on local PM sulfate production. PMTACS-NY measurements in New York City (NYC) suggest that local production of summertime sulfate from the reaction of SO_2 and OH can represent a significant fraction of the total observed PM sulfate concentration during high photochemical PM production periods. The observed levels and diurnal patterns of SO_2 concentrations in NYC suggest that mobile-source combustion contributes significantly to these levels. The regulatory/policy implications of these findings suggest that

a. There will be benefits in PM mitigation as a result of the implementation of federally mandated low sulfur rules, which address on-road mobile sources and have recently proposed off-road mobile sources (construction, farm, marine equipment);

b. There may also be benefits from the NYS Acid Deposition Reduction initiative, which could result in decreased use of high-sulfur residual fuel in utilities in the city/region; and

c. Every effort should be made to track and reduce the sulfur levels in the distillate fuel that is burned in the city/region for stationary applications, which is not currently being addressed by the proposed federal rules.

2. The benefits and potential air-quality issues associated with alternate fuels (CNG) and diesel control technologies (DF-CRT) for bus and truck fleets. The application of a new instrumentation technology for direct measurement of in-use vehicle emissions has provided an extensive database characterizing gaseous and PM emissions from a variety of standard diesel-powered trucks and buses, (CNG) fueled and diesel PM retrofit control technologies (DF-CRT) buses. These in-use emission findings indicate that Continuous Regenerating Technology (CRT) carbon particle trap control technology does effectively reduce PM emissions and that Compressed Natural Gas (CNG) powered vehicles also have significantly lower PM emissions than their standard diesel counterparts. PM emission estimates based on on-road measurements of a series of vehicle-chase studies performed in NYC during the fall of 2000 and summer of 2001 indicate a wide variation in PM emissions across the broad vehicle categories. Results of chase comparisons between MTA standard Series 50 diesel and CNG power and CRT retrofitted-diesel buses indicate major improvements in PM emissions (60–70% reductions). These reductions are consistent with those observed in chassis dynamometer tests performed on a limited number of MTA vehicles (~90% reductions observed), but real-world in situ emission measurements suggest significantly more variation in emissions than observed in dynamometer testing. In addition, measurements were carried out to identify unintended emissions that might negate improvements from the new technologies. These include changes in the NO_2/NO_x emission fraction of DF-CRT retrofitted diesel buses, where ~ 30% of the NO_x was emitted as NO_2 in CRT-equipped diesels, as compared to <5% NO_2 in standard diesel buses. In another series measurement, exhaust plumes of CNG buses showed high levels of formaldehyde, ~5–10 times levels observed in standard diesel bus and truck plumes. The high formaldehyde emissions suggest that either combustion modification or the addition of an oxidative catalysis will likely be required if CNG fueled vehicles are to become a significant portion of the mobile fleet. Finally, PM emission and ambient size and composition studies using Aerosol Mass Spectrometer (AMS) measurement technology indicate that

a. A significant fraction of the organic PM mass observed in the city originates from mobile sources; and

b. Observed PM organic particles with a mean mode diameter of ~70 nm are associated with primary particulate matter consisting of condensed lube oil formed in combustion exhaust, which is not limited to diesel emissions only, but can be found in poorly maintained (oil-burning) spark ignition gasoline engines.

3. The Supersite program has tested and evaluated a variety of new measurement technologies (Sample Equilibration System [SES]; Filter Dynamic Measurement System [FDMS]; Electrostatic Precipitation [ESP] TEOMs for $PM_{2.5}$ and PM_{10} mass; R&P 8400NS for $PM_{2.5}$ nitrate and sulfate; and R&P 5400 for $PM_{2.5}$ carbon) in the laboratory at ASRC's Aerosol Generation and Calibration Facility, as well as at rural and urban monitoring sites. The demonstration of operationally robust measurement technologies and their technology transfer to monitoring networks is a major objective of the Supersite program. Field and laboratory tests have provided NYS DEC with advanced knowledge of the performance and operational issues associated with these instrument technologies, which has resulted in significant cost savings of thousands of dollars with respect to instrumentation purchases and personnel expense in their testing and operational deployment.

Sources of PM and Precursor Gases in New York State

Philip K. Hopke
Center for Air Resources Engineering and Science and Bayard D. Clarkson Distinguished Professor, Clarkson University

In the next year, areas will be determined to be in non-attainment of the National Ambient Air Quality Standard (NAAQS) for particulate matter. As a result of these designations, it will be necessary to prepare State Implementation Plans (SIPs) that outline an air-quality management strategy to bring the areas in question to attainment of the national standard. To ensure that an effective and efficient strategy is developed, it is important to identify the major sources of the particulate matter and the precursor gases that can be oxidized to produce additional $PM_{2.5}$ mass. Receptor models applied to a variety of air-quality data can help to develop that strategy by identifying the source types, and by combining these results with back-trajectory ensemble methods also identify the likely locations of those sources. Factor analysis in the form of positive matrix factorization (PMF) was used to obtain information about possible sources of the aerosol. Potential source contribution function (PSCF) analysis, which combines the aerosol data with the air-parcel backward trajectories, was applied to identify possible source areas and pathways from these sources at the two sites. Analyses of data from various locations that are relevant to New York State will be presented.

Latest Findings on PM Health Effects†

Morton Lippmann, Ph.D.
NYU School of Medicine, Tuxedo

The current state of knowledge on the health effects associated with exposure to particulate matter (PM) of ambient-air origin in the peer-reviewed literature through 2002 has been summarized in the fourth draft (June 2003) of EPA's PM Criteria Document (PMCD). The implications of this literature for the selection of National Ambient Air Quality Standards (NAAQS) for PM, in terms of the form of the NAAQS, the pollutant indicators, the averaging times, and the concentration limits that can protect public health with an adequate margin of safety, have been presented in the first full draft (August 2003) of the EPA Air Program's Staff Paper. These documents present a wealth of evidence that supports the need for NAAQS for fine particles ($PM_{2.5}$) at concentrations at or below the current (1997) NAAQS, in order to minimize PM-associated excess mortality, morbidity, significant functional deficits, and lost time from work or school. They also recommend new NAAQS for thoracic coarse-mode particles ($PM_{10-2.5}$) to replace PM_{10}. This presentation will cover key elements in these recent EPA documents, plus some more recent findings, as well as some of the important remaining gaps in the literature concerning the effects of specific PM components and their sources, and the biological mechanisms that may produce the effects.

Clinical and Mechanistic Health Studies with PM: New Findings and Research Directions

Mark J. Utell
University of Rochester Medical Center

A recent series of epidemiologic reports have shown associations between fine particulate matter (PM) levels and increased cardiovascular and pulmonary morbidity and mortality. Elevated PM levels have been linked with cardiac events, including serious ventricular arrhythmias and myocardial infarction, as well as asthma hospitalizations and alterations in lung function. Given this series of studies, there was a paucity of toxicological and clinical studies looking at possible mechanisms. Firmer conclusions for policy implications appeared to be dependent on finding underlying mechanisms that could explain why one might anticipate these cardiac or respiratory responses.

Recently, several mechanistic pathways have emerged that may underlie the link between PM exposure and adverse health effects. The portal of entry for PM pollution is the lungs, and PM interactions with the respiratory epithelium likely mediate a wide range of effects. Research findings support different pathways by which particles can affect the respiratory tract and cardiovascular system: (1) inflammation, both pulmonary and systemic, with perhaps a key role played by reactive oxygen species; (2) alterations in immune competence; and (3) autonomic nervous system dysfunction. For example, clinical studies of young and elderly subjects exposed to real-world or surrogate particles have shown reductions in heart-rate variability, altered cardiac repolarization, and increases in blood fibrinogen levels. Ultrafine particles (UFPs), by virtue of their extremely small size, may enter pulmonary capillary blood; large reductions in the pulmonary diffusing capacity have been reported after several-hour exposures to UFPs.

Despite major progress, large uncertainties exist with regard to the scope and significance of experimental data in explaining the epidemiological findings on the risk of PM. Furthermore, the most hazardous components of PM remain to be identified; although the field has been narrowed, a large list of potential candidates exists. Answering the key questions concerning the hazardous components of PM will be a central focus of the next generation of research studies. It is unlikely that a single component will be responsible for causing the range of clinical effects described to date, but rather, it may be that different components will be linked with specific health outcomes. The identification of these hazardous components will have important and immediate regulatory impact as adverse health outcomes are attributed to specific sources.

Emissions and Deposition of Atmospheric Pollutants: An update

Kathleen C. Weathers, Thomas J. Butler, Gene E. Likens and Gary M. Lovett
Institute of Ecosystem Studies, Millbrook, NY

Nitrogen oxide (NO_x) emissions in the eastern United States show very little decline from 1991-2000. In contrast, there has been a 30% decline in sulfur dioxide (SO_2) emissions for the same 31-state source region from 1991-2000. Of three main emitter categories (utilities, vehicle and other), the biggest declines for both SO_2 and NO_x were in electric utility emissions. The relative contribution of vehicle sources for NO_x has increased.

There is a statistically significant relationship between SO_2 emissions and volume-weighted sulfate

($SO_4^{=}$) concentrations in precipitation in the eastern United States; emission reductions result in lower sulfur (S) concentration in precipitation. There is also a statistically significant relationship between SO_2 emissions and dry deposition species (SO_2 and particulate $SO_4^{=}$; Butler et al. 2001). Concentrations and deposition of S in cloud water at Whiteface Mountain, NY, however, do not appear to be related to emission declines.

Until recently, no strong relationship between NO_X emission and nitrogen (N) concentration in precipitation or air had been identified. However, recent results (Butler et al. 2003) show that a 50% decline in total (all sources) NO_X emissions should lead to an approximately 38% decline in nitrate (NO_3^-) concentration in precipitation and deposition. Results from this same study suggest that a 50% decline in non-vehicle emissions (=23% decline in total NO_X emissions) would lead to a 19-22% decline in NO_3^- concentration in precipitation. Thus, reducing NO_X emissions is predicted to have a 75% or 95% efficiency in reducing precipitation NO_3^- concentration, depending upon the source of the reduction.

Although relationships between emissions and precipitation or air concentrations can be demonstrated, total deposition (wet +dry+ cloud inputs) is still quantified only crudely for most regions in the country. The inaccuracy in quantifying total deposition results from the scarcity of dry deposition data, and because models of dry and cloud deposition are limited by assumptions of flat terrain and homogenous canopy structure. In addition, dry deposition of other substances that are of environmental concern, such as mercury, calcium and magnesium, is not being measured.

EMEP Project Activity and Road Map
Ecosystem Response to the Deposition of Sulfur, Nitrogen, and Mercury

Mark Watson
Senior Project Manager, NYSERDA

A roadmap provides us with a number of routes from which to choose to get us to our destination. For a roadmap to be useful for the issues associated with “Ecosystem Response to the Deposition of Sulfur, Nitrogen, and Mercury”, we must first determine where we want to go, which is not an easy task. While most of us may agree that we should improve the health of our natural resources, the specific attainment goals are certainly open to much debate. Even if we could agree on the endpoints, the matter is complicated by the fact that for environmental issues, we often don’t have enough information to give us confidence that any one specific route or course of action will get us from point A to point B. There are information gaps that must be addressed through research projects designed to address critical questions. The resulting findings, if communicated effectively, may ultimately be used to formulate policies that bring about the desired response—or in other words, reach our destination.

This presentation addresses how EMEP-sponsored research in the areas of monitoring, field and process studies, syntheses and assessments, and modeling is helping to provide the information needed to help us better understand our ecosystems and make effective environmental policy.

Changes in Water Chemistry in Adirondack Lakes and Streams: A Status Report

Karen M. Roy
Adirondack Lakes Survey Corporation, Ray Brook, NY

This report highlights some of the water chemistry findings based upon trend analyses of the lakes and streams monitored by the ALSC through 2000. The Adirondack Long-Term Monitoring (ALTM) program was established in 1982 to assess seasonal and long-term patterns in the chemistry of lakes in the Adirondacks. The program was initiated with 17 lakes and was subsequently expanded in 1992 to 52 lakes, based on the findings of a major synoptic survey of 1469 lakes completed in 1990. Over the course of recent monitoring, four lakes were limed and thus not included in these trend analyses. A total of 16 lakes were analyzed for the longer record from 1982–2000, and 48 lakes were analyzed for the shorter interval from 1992–2000.

Time-series analyses have been completed for these two lake chemistry intervals (Driscoll 2003). Sulfate levels have been decreasing in all of the 16 lakes at a uniform rate (–1.53 to –2.50 _eq/L/yr) during 1982–2000, suggesting that decreases in sulfur dioxide emissions and atmospheric sulfate deposition are responsible for this change. The mean rate of sulfate decline in 44 out of 48 lakes during the 1992–2000 period was greater (–2.57 _eq/L/yr) than that observed for the longer period (–2.06 _eq/L/yr). Changes in nitrate levels, however, have been found to be less consistent in comparison with those of sulfate. While a portion of the lakes are showing decreasing levels of nitrate, this pattern has varied in the past depending on the length of record. There has not been any appreciable change in NO_X emissions or in atmospheric nitrate deposition since lake monitoring began in 1982.

During 1982–2000, changes in both sulfate and nitrate levels resulted in increases in acid neutralizing capacity (ANC) and pH in over half of the ALTM lakes. The mean rate of increase for ANC was 0.78 _eq/L/yr. However, current ANC levels in 2000 remain a concern for aquatic biota, with 34 lakes having a mean ANC value of < 50 _eq/L, including ten lakes with ANC values < 0 _eq/L. Similarly, 23 lakes had mean pH values < 5.5, including 13 with pH < 5.0. Since there is considerable interest in quantifying the time-scale of recovery of surface water acidification, extrapolated estimates of linear rates of ANC increase based on time series were tabulated. They suggest that lakes with low ANC values (0–50 _eq/L) that are susceptible to episodic acidification might reach 50 _eq/L values over a period ranging from a few years to 50 years. For lakes that are chronically acidic (ANC < 0), the time required to reach an ANC of 50 was estimated to be between 25 and 100 years.

Trends in toxic inorganic aluminum (Ali) showed a significant decrease in over half of the 48 lakes with a mean rate of decline of –0.31 _mol/L/yr. The trends in aluminum chemistry show a shift in speciation from toxic inorganic forms toward less toxic organic forms with decreases in atmospheric deposition and increases in dissolved organic carbon concentrations. In 2000, 16 out of 48 lakes showed mean Ali concentrations above 2 _mol/L, a level known to be toxic to juvenile forms of Adirondack fish.

Since 1994, the ALSC has also been sampling 43 Adirondack lakes once per summer as part of the U.S. EPA's Temporally Integrated Monitoring of Ecosystems (TIME) project. A 2003 report on that project indicates results consistent with Adirondack LTM findings (Stoddard 2003), that declines in emissions are translating into reductions in acidic deposition and that changes in deposition are translating into changes in surface water chemistry. Whether biologically relevant water chemistry has improved in acid-sensitive regions is less certain.

Following the completion of EPA's Episodic Response Project (1988–90), weekly measurements were continued on 3 western Adirondack streams to identify trends that might be related to changes in acidic deposition. Trend analyses of stream ANC and pH were completed for October 1991–September 2001 (Lawrence 2003). During that time, the pH of wet deposition increased at all Adirondack sites, with most of the increases occurring from 1991–1995. No trend was evident in the daily mean streamflows of the 1990s, although the frequencies of both extremely high and extremely low flows occurred during the second half of the record. ANC and pH were inversely related to flow in all three streams, but the trends changed uniquely for each stream when the effect of flow variation was removed. For instance, increasing trends in ANC ($p < 0.05$) and possibly pH ($p < 0.10$) were no longer observed in Buck Creek when the effect of flow was considered. Results indicate that long-term flow data are critical to the interpretation of stream chemistry. Unlike the case of lakes, the overall proportion of affected streams and the spatial extent of soil acidification have yet to be determined in the Adirondack Park. The ALSC is participating in the first region-wide characterization of stream chemistry and biota with respect to chronic and episodic acidity, in cooperation with USGS and NYSERDA, over a million-acre portion of the western Adirondacks.

Monthly LTM lake chemistry data (1992–2000) are posted on www.adirondacklakessurvey.org

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http://www.adirondacklakessurvey.org. The Adirondack Lakes Survey Corporation (ALSC) is a not-for-profit research group originally established in 1984 as a cooperative agreement between the Empire State Electric Energy Research Corporation and the NYSDEC to determine the extent and magnitude of surface water acidification in the Adirondack region. The ALSC currently continues the Long-Term Monitoring Program and related projects with support from NYSERDA, NYSDEC, and the U.S. EPA.

An Integrated Assessment of the Recovery of Surface Waters from Reduced levels of Acid Precipitation in the Catskills and Adirondacks

Douglas A. Burns
U.S. Geological Survey

Charles T. Driscoll
Syracuse University

Gary M. Lovett
Institute of Ecosystem Studies

Myron J. Mitchell,
SUNY College Environmental Science and Forestry

Karen Roy
Adirondack Lakes Survey Corporation

Michael R. McHale
U.S. Geological Survey

Kathie Weathers
Institute of Ecosystem Studies

Surface water acidification by atmospheric deposition has been documented in several upland regions of eastern North America, including the Adirondack and Catskill Mountains of New York. Acidification in these two regions has caused high aluminum concentrations in surface waters and resulting toxicity to fish and other biota. During the past 25 years, the acidity of precipitation in New York has decreased as the Clean Air Act and subsequent amendments have been implemented. Decreasing acidity of atmospheric deposition is expected to result in the eventual recovery of sensitive surface waters in New York and throughout the U.S. Research in the Adirondacks and Catskills has included studies of surface water acidification, biological effects, nitrogen cycling, and recovery, but little effort has previously integrated study results across both of these acid-sensitive regions. In this study, three aspects of surface water acidification and recovery were compared across these two regions: (1) changes in chemistry through examination of long-term surface water data sets, (2) examination of key processes that affect the cycling and retention of nitrogen, and (3) modeled recovery under future acid deposition scenarios.

Documentation of recovery included examination of patterns and trends in surface water chemistry at 5 Catskill streams and 12 Adirondack lakes during the period 1992–2001, which is the minimal length of the record at all sites. Results show strong decreases in sulfate concentrations in precipitation and surface water in both regions. These declines in sulfate have resulted in increasing acid-neutralizing capacity (ANC) at the majority of Catskill and Adirondack surface waters examined. Increases in ANC were evident at 7 of 12 Adirondack lakes studied and were generally in the range of 1–2 _eq L-1 yr-1, whereas 3 of 5 Catskill streams showed increases < 0.5 _eq L-1 yr-1. Decreases in surface water nitrate concentrations were also evident at the majority of sites examined in the two regions; these decreases also contribute to increases in ANC. Comparison of detailed soils and vegetation data across these two regions, however, reveals that sugar maple has a significant effect on the rate of nitrogen cycling and on surface water nitrate concentrations. Soils developed under sugar maple stands have high rates of nitrification and nitrate leaching to surface waters, so watersheds dominated by this species may have greater nitrate concentrations. Factors such as beech bark disease, climate change, and soil calcium depletion may affect sugar maple abundance, which in turn may affect long-term trends of nitrate-driven acidification in these regions.

Simulations with PnET-BGC, an integrated biogeochemical model, determined the response of four Adirondack lakes and one Catskill stream to acid deposition. Modeled sulfur budgets indicated little retention of sulfur inputs from deposition, consistent with the parallel trends found between precipitation and surface water sulfate concentrations. Modeled nitrate retention was more variable between sites, a reflection of land-disturbance history and in-lake processes. Modeled ANC budgets indicated that atmospheric deposition was the greatest source of acidity and that cation exchange, mineral weathering, and in-lake processes were the greatest sources of ANC.

Together, these data show that the sulfur cycle responds rapidly to changes in sulfate deposition, whereas the nitrogen cycle is more complex and is driven in part by tree species composition and land disturbance history. Increases in ANC were small during the 1992-2001 period examined, but the increasing trends at the majority of sites studied indicate that surface water chemistry is beginning to respond to decreasing levels of acid deposition in these two regions.

The Adirondack Effects Assessment Program

S. A. Nierzwicki-Bauer, C. W. Boylen, L. Eichler
Darrin Fresh Water Institute & Department of Biology, Rensselaer Polytechnic Institute

In 1994, the Adirondack Effects Assessment Program (AEAP) began a synoptic sampling program of physical and chemical parameters, bacterioplankton, phytoplankton, zooplankton, macrophytes, and fish on 30 ponded waters. The 30 waters are a subset of the waters included in the Adirondack Lakes Survey Corporation's Long-Term Monitoring (LTM) program of water chemistry. In addition, the AEAP has been expanded to support both selected NADP deposition sites in New York State and event-based tributary sampling. Designed to assess the current state of different biological trophic levels as an estimate of ecosystem health, the AEAP has provided baseline data upon which to evaluate long-term (temporal) changes of future recovery of lake communities in this region. After nine years of simultaneously evaluating the effects of acidification on multiple trophic levels in several types of lake systems, patterns can be correlated between various chemical and biotic variables. Quantitative data on biotic variables have provided insight into the interactive relationships between environmental factors and species abundance, biodiversity, and possible indicator species. A case study for one of the AEAP waters, Brooktrout Lake, is also presented.

Inputs, Transport, and Transformations of Mercury in Forest-Wetland-Lake Ecosystems

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

Mercury is a neurotoxin. Exposure of humans and wildlife to mercury occurs largely through the consumption of fish. Historically, advisories on fish consumption regarding mercury were largely associated with water bodies that experienced industrial discharges. However, over the last 15 years, concern over fish contamination has shifted from point sources to atmospheric deposition. Studies across eastern North America have shown widespread contamination of mercury in fish in remote lakes, including the Adirondack region of New York State. Atmospheric emissions of mercury originate from several sources, including electric utilities and incinerators. Emitted mercury is deposited to the land surface through wet and dry deposition. Deposition of mercury has increased markedly over the last 100 years, with some decreases occurring during the last 20 years. In forest ecosystems, dry deposition of mercury exceeds wet deposition. Within forest ecosystems inorganic mercury can be converted to methyl mercury, particularly in wetland environments. Relatively low concentrations of methyl mercury bioconcentrate along the aquatic food chain, such that concentrations of methyl mercury in are 1–10 million times greater than values in water. Acidification of lakes, such as has occurred in the Adirondacks, has increased fish mercury concentrations. There are currently several proposals for controls of atmospheric emissions of mercury from electric utilities.

Status of PM Emission Inventories

Phil Lorang
Office of Air Quality Planning and Standards
U.S. EPA

Because a large portion of ambient $PM_{2.5}$ is secondary sulfate and nitrate, the generally good quality of the available emission inventories for SO_2 and NO_x are good news for the $PM_{2.5}$ emission inventory picture. Emissions of ammonia and of primary $PM_{2.5}$ are also of interest. Inventory efforts on these pollutants on the state and local levels have a shorter history, as most areas have never been designated non-attainment or had to operate a control program for either total PM or PM_{10}, and no areas have yet been designated non-attainment for $PM_{2.5}$. The U.S. EPA has estimated emissions for all $PM_{2.5}$ components and precursors since 1990, applying adjustment factors and other approximations where needed to fill in gaps in available inventory data. States are now much more engaged in $PM_{2.5}$ inventory development than in the recent past, especially through multistate organizations that receive grants from the EPA for the development of plans to address regional haze problems. States are also subject to a new requirement to submit $PM_{2.5}$ and ammonia inventories to the EPA in June 2004 for the year 2002. EPA has been developing tools that will assist states in preparing this submission and similar submissions that will be required at three-year intervals.

Utility PM and Precursor Emissions and Multi-pollutant Control Options: Regulatory Landscape, Technologies and Costs

Praveen Amar
NESCAUM

Rui Afonso
Energy and Environmental Strategies

Electric utility plants are a major source of emissions of oxides of nitrogen, sulfur dioxide, particulate matter, mercury, and other hazardous air pollutants. The source category includes large coal-, oil-, and gas-fired electricity-generating units. For example, power plants emit more than five million tons of NO_x per year (about 1/4 of US emissions), over 10 million tons of SO_2 per year (about 2/3 of U.S. SO_2 emissions), and about 50 tons of mercury per year (about 40% of U.S. anthropogenic emissions). This presentation will first go over the current regulatory and legislative landscape in the U.S., with special emphasis on the Northeast. Various current and proposed legislation(s) and regulations at federal and state levels will be briefly described. The talk also will explore the long-term history of the extremely positive and encouraging relationship between environmental regulation and technology innovation in the area of combustion controls from stationary sources.

The presentation then will cover various technologies that have been successfully and cost effectively applied to various utility sources of PM and its precursors, as well as new promising technologies at varying levels of development. It appears that a more stringent control of primary PM emissions (including trace toxic metals such as cadmium and mercury) may require retrofitting existing infrastructure (especially large utility coal-fired boilers that already have ESPs) with baghouses. Individual pollutant control technologies such as SCR for NO_x, wet and dry scrubbers for SO_2, activated carbon injection technology for mercury, as well as multipollutant technologies will be discussed in terms of technical, cost, and strategic considerations.

State of the Art in Diesel Emission Control Systems

Timothy V. Johnson
Corning Inc.

Tightening diesel tailpipe regulations are resulting in rapidly developing engine and emission control technologies. This presentation focuses on the most recent advances in the field of diesel emission control.

Heavy-duty diesel regulations in Japan in 2005 and the U.S. in 2007 will require the use of diesel particulate filters (DPF). Despite being commercially available for upwards of 20 years, filters are still going through a rapid period of development. Efforts are being made to quantify performance, allow reliable regeneration, and improve strength and gas-flow characteristics. Filters are removing 50–99% of the soot, as measured by particulate number count, depending on filter characteristics. Filter regeneration strategies incorporate tight integration with engine management and filter catalyst properties. Filter porosity is being adjusted to enable both low back pressure, now –70% of the norm of only two years ago, and good durability and performance.

To hit 2005 European regulation levels, advanced NO_x control is being chosen. Selective catalyst reduction has been tested on vehicles for almost 10 years, and the technology is being specified now for the first commercial sales. Tighter control strategies are being developed to maximize emissions reductions and to minimize ammonia slip. Systems are achieving 80% reduction at less than 10 ppm ammonia slip. Lean NO_x trap (LNT) systems are in a rapid state of development, but are achieving about 80% NO_x removal at fuel penalties of about 3%.

Finally, integrated NO_x /PM systems will be needed in light-duty applications in about 2006–07 in Europe and the U.S., and in the heavy-duty sector in 2010. In spite of this, the first DPF/LNT commercial application is emerging in Japan this year. Prototype light-duty systems are demonstrating the U.S. fleet average NO_x level of 0.05 g/mile. Heavy-duty DPF/SCR systems are on the road, and DFP/LNT systems are being demonstrated on engine dynamometers.

The Emission Reduction Credit Process and Smaller-Scale Combined Heat and Power Projects

Tom Bourgeois
Pace University

This paper will investigate the emissions reduction credit process as it pertains to small distributed-generation projects. We will define emissions reduction credits (ERCs) and explain the criteria for establishing ERCs. In order to be certified as an ERC, the reductions in question must be

- Real
- Quantifiable
- Surplus
- Permanent
- Enforceable

We will discuss some of the protocols utilized in quantifying the ERC. In so doing, we will provide some case studies that demonstrate the concepts of Baseline Emissions Level, Strategic Emissions Levels, and the net available emission reduction credit.

We will address the potential for obtaining ERCs from CHP facilities, discussing the types of technologies that would be replaced (the baseline technologies) and the end-use sectors that these technologies might be found in.

One of the particular concerns of our research is the higher transaction costs, on a per-unit basis, that may occur in obtaining ERCs from smaller scale combined heat and power (CHP) and distributed generation (DG) projects. This paper will suggest some alternatives for streamlining ERC creation from smaller scale generation sources, while at the same time protecting the integrity and rigor of the program.

Finally, we will examine the emissions of particulate matter from CHP and DG sources. We will devote some time to discussing the control costs for smaller sized distributed generation projects.

Overview of Nitrogen and the Energy and Industry Connection

William Moomaw
The Fletcher School, Tufts University

While the largest quantity of nitrogen is inert and resides in the atmosphere, it is the much smaller and multifaceted forms of reactive nitrogen that make life possible, and simultaneously wreak havoc on natural and human ecosystems. Artificial fertilizer and the planting of legumes dramatically enhance the productivity of human agriculture. However, the runoff from agricultural nitrogen fertilizer, combined with human and animal waste and effluents from industry, electric power generation, and transportation already pose major threats to the natural environment and human wellbeing. The cascading of nitrogen destructively through the atmosphere, the land, and aquatic systems is now responsible for major economic damage. While flows of reactive nitrogen have more than doubled on a globally averaged basis, there are regional hotspots where the increase is by factors of 10 or 100. Our policies have produced some success in reducing the growth and emission levels of some forms of reactive nitrogen, but overall have failed to stem the tide. This paper will present some of the latest information about the nitrogen cascade, and provide some projections of potential nitrogen releases into the future. It will conclude with an analysis that suggests ways in which cost-effective reductions can be achieved through multipollutant and cross-sectoral strategies.

Status and Effects of Nitrogen Pollution in the Northeast

K. Fallon Lambert
Consultant, Hubbard Brook Research Foundation

The northeastern United States receives elevated inputs of anthropogenic nitrogen (N) largely from net food imports and atmospheric deposition, with lesser inputs from fertilizer, net feed imports, and N fixation associated with leguminous crops. Ecological consequences of elevated N inputs to the Northeast include tropospheric ozone formation, ozone damage to plants, the alteration of forest N cycles, acidification of surface waters, and eutrophication of coastal waters. Calculations with PnET-BGC suggest that aggressive reductions in N emissions alone will not result in marked improvements in the acid-base status of forest streams. WATERSN calculations show that management scenarios targeting the removal of N by wastewater treatment produce the largest reductions in estuarine N loading. Addressing both the forest and coastal impacts of elevated N inputs will require policy actions to reduce atmospheric emissions of N and discharges of N from wastewater treatment plants.

Nitrogen Sources to Rivers and Estuaries of New York State

Elizabeth W. Boyer
State University of New York, College of Environmental Science & Forestry

Richard B. Alexander
U.S. Geological Survey

Robert W. Howarth
Cornell University

Carol Kendall
U.S. Geological Survey

Human activities have greatly altered the nitrogen (N) cycle, accelerating the rate of N fixation in landscapes and the delivery of N to water bodies. Inputs of N to aquatic and terrestrial ecosystems in New York have increased during recent decades, primarily from the production and use of fertilizers, the planting of N-fixing crops, and the combustion of fossil fuels. The role of atmospheric N sources is of particular concern in New York, as rates of atmospheric N deposition in the Northeast are among the highest in the nation, arising from industrial, automotive, and agricultural emissions. We have used two modeling approaches to quantify anthropogenic N sources to the landscape and associated transport and transformations of N. First, we used a mass balance modeling approach to quantify N inputs and riverine N losses for several major catchments situated, at least in part, within the State that encompass a range of land use and climatic variability. The catchments include the Seneca/Oswego basin draining to Lake Ontario, the Upper Susquehanna basin draining to the Chesapeake Bay, the Hudson River basin draining to New York Bight, and the Connecticut River basin draining to Long Island Sound. We quantified N inputs to each catchment from atmospheric deposition, application of nitrogenous fertilizers, biological nitrogen fixation in crop lands and forests, and imports of N in agricultural products (food and feedstocks). We consider the fate of the N inputs into the landscape, estimating storage in soils, vegetation, & groundwater; losses via denitrification & volatilization; and transport to waterways via riverine export. Second, we use spatially referenced regression modeling to consider the role of atmospheric N deposition and to quantify total N fluxes in riverine systems throughout New York State, providing estimates of incremental (local) yields to each stream reach and total yields delivered downstream to coastal waters. Simulations provide information about the role of delivery of atmospheric N from the terrestrial landscape to surface waters, and the role of in-stream processing in altering N loads during transport. Both modeling approaches indicate that atmospheric N is a significant source for deposition in land and water in NYS. Further, we are studying several New York catchments in process studies designed to elucidate N sources to the landscape and the coupled hydrological, biological, and geochemical controls on its transport. This involves monitoring of N dynamics under varying hydrological regimes, such as events and seasons, and involves characterization of flow paths and N sources with chemical and isotopic tracers. Our collective work provides information regarding the relative contributions of atmospheric N, which is necessary to develop sound strategies for understanding and managing the effects of these and other N inputs.

Benefits of Reduced Air Pollution in the United States

Dallas Burtraw
Senior Fellow, Resources for the Future

Integrated assessment extends cost-benefit analysis to account for uncertainties in the links between environmental science and economics. We use the Tracking and Analysis Framework to couple a detailed simulation model of the U.S. electricity markets with an integrated assessment model that links changes in emissions with atmospheric transport, environmental endpoints, and valuation of impacts. This framework has been used to evaluate the 1990 Clean Air Act Amendments, and to develop new estimates of "economically efficient" emission caps for sulfur dioxide (SO2) and nitrogen oxides (NOX) in the U.S. electricity sector.

We find that plausible values drawn from the mainstream literature for uncertain variables in the integrated assessment lead to a variation in the estimation of the benefits of emission reduction of nearly an order of magnitude. Nonetheless, this independent assessment confirms the general relation between benefits and costs asserted by the EPA regarding changes in emissions from the electricity sector. The major emission reductions for SO2 and NOX that would be achieved under the various multipollutant proposals now before Congress all appear justified on the basis of cost-benefit analysis.

Previous analysis of the benefits and costs of reducing power-plant emissions identified the air-health pathway, and especially the reduction of secondary particles, as the dominant source of benefits of emission reductions. In previous work, the estimable economic benefits from reducing acidification were small in comparison, although this was highlighted as a major uncertainty. New research has added estimates of the willingness to pay to improve natural resources in the Adirondacks and indicates economic benefits associated with nonuse values for these resources that accrue in addition to health-related benefits.

Ongoing work funded by NYSERDA examines the benefits and costs of the specific multipollutant proposals in greater detail, and focuses on the benefits and costs that accrue in New York State and the Northeast region. In addition, this work explores whether regional differentiation of caps for different pollutants is likely to enhance efficiency and protect local hot spots, such as the Adirondack area.

Improving the Scientific Basis for Environmental Policy

Dan Greenbaum,
President, Health Effects Institute

In theory, and frequently in legislation, every major environmental policy is supposed to be based on the best available scientific understanding. In practice, scientists and decision makers work in very different worlds, which are based on different time frames, incentives, and even languages. Add to that that the interpretation of science in the decision-making world is often filtered through a complex mix of stakeholders and the media, and the challenges of ensuring that the best science helps make environmental decision better are enormous. This talk will briefly review the key differences among the science, stakeholder, media, and decision-maker communities, identify the challenges, and use some recent examples to suggest ways in which the scientific community could improve the way in which communicates its results to decision makers.

Increasing the Effectiveness of Science-Policy Communication: How Do We Get on the Same Page?

Joanne Fox-Przeworski
Bard Center for Environmental Policy, Bard College

A good deal of attention has been directed to understanding the role of science in policy making. Five years ago a report to Congress by the House Committee on Science Unlocking our Future: Toward a New National Science Policy argued that the role of science should include “helping society make good decisions,” especially on “difficult decisions related to the environment.” (September 23,1998) Policies concerning environmental issues—because of their complex and multi-disciplinary nature—need to be informed by research from the natural sciences, but also from the social and behavioral sciences.

The topic of the final afternoon’s discussion concerns how best to do this: How can we improve the scientific basis for policy making and increase the effectiveness of science-policy communication? In other words, how might scientific research agendas better address urgent environmental issues, and in turn, what might facilitate the better use of research results in public policies and guide policy makers where decisions need to be made, even under conditions of incomplete information and uncertainty?

Three basic questions will be addressed by the panel during the final afternoon session:

- Where does the science-policy connection break down?
- Where does it work well?
- What links are missing to make a better connection?

Science, Policy, and Musical Chairs

Millie Baird
Environmental Defense

Good environmental policy depends on sound science. Policy makers need to understand the science behind environmental problems and potential solutions, and thus, their interaction with scientists should play an important role in developing environmental policy. But often other less objective parties take the chairs when the music stops, leaving scientists standing.

The more an environmental issue is politically charged, the harder it is for scientists’ voices to be heard over the clamor. Sometimes the science is not fully incorporated into environmental policy because scientists are too passive with the knowledge that they have gained, so they fail to take their research outside of scientific circles. Or scientists may not convey information in ways that policymakers can understand. Yet, scientists have a responsibility to make sure that their work is heard and understood in the policy decision-making process. Scientists should take the time to translate their research into a form that policymakers can digest, and they should make it clear that they are a resource in the policymaking process.

A challenge for scientists over the next decade is to participate in the policy debate on critical environmental issues such as nitrogen deposition and climate change. All too often, well-funded special interest groups dominate the dialogue with policymakers. Scientists must ensure that the results of their research are inserted into the policymaking debate, and more importantly than ever, they must find their seat before the music stops.

Linking Science and Policy – Research, Monitoring, and the Policy Process

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

Effective communication between the science and policy communities can greatly enhance the environmental policy process. When the relationship between the two communities functions well, science plays important roles in the development, implementation, and assessment of environmental policy. Effective assessment efforts by the scientific community can assist in policy formulation through using well-developed and tested analytical tools to evaluate the impacts of potential policy options. In the implementation phase, continued research and monitoring is essential to track results for program/policy accountability. Based on monitoring data, post-implementation assessment provides feedback to determine whether policies are successful or need revision. Examples from over a decade of air-quality policy will be used to illustrate that science-policy communications work best when assessment questions are clear and policy-relevant, and communication of results is considered up-front.

The Texas Air Quality Study: Improving the State of the Science of Air Quality in Texas and Informing Public Policy Decisions

David Allen
Department of Chemical Engineering and Center for Energy and Environmental Resources
University of Texas

The Texas Air Quality Study (TexAQS) was the largest air-quality field study ever undertaken in Texas and one of the largest ever done anywhere in the United States. During August and September of 2000, approximately 300 air quality investigators from around the world converged on Houston Texas. Five aircraft were deployed; five major ground chemistry sites were established, and approximately 20 peripheral sites were established for collecting additional meteorological and chemical data. The scope, goals, and preliminary results are available at the study web site (www.utexas.edu/research/ceer/texaqs).

This presentation, by one of the four lead investigators for TexAQS, will provide an overview of the study and will discuss, in greater detail, the policy implications of the study.

Environment and Media

Andrew C. Revkin
The New York Times

Andrew C. Revkin will speak on the many impediments to effective media coverage of environmental issues—both inside and outside the newsroom.

Mr. Revkin will address one of the weakest links in the chain between basic science and environmental policy: media coverage of environmental science. He will described some fo the many impediments to conveying scientific findings through the filter of 'news.' Many of the hurdles are in the newsroom itself Others are outside, with the biggest, perhaps, being the persistent lack of basic scientific literacy on the part of Americans.

Finally, Mr. Revkin will discuss how to overcome those hurdles, all of which require much more interaction between journalists and scientists, outside the immediate glare of breaking news.

Conference Participants

Rui Afonso
Principal
Energy and Environmental Strategies
50 Old Faith Road
Shrewsbury, MA 01545
tel: (508)756-5522 fax: (309)410-8631
e-mail: Rui.Afonso@EES-Consultants.com

Syed Alam
Environmental Engineer
New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233-3251
tel: (518)402-8396 fax: (518)402-9035
e-mail: snalam@gw.dec.state.ny.us

Ray Albrecht
Senior Project Manager, Buildings Research
New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203
tel: (518)862-1090 fax: (518)862-1091
e-mail: rja@nyserda.org

David T. Allen
Director, Center for Energy & Environmental Resources
University of Texas at Austin
Chemical Engineering Building
Austin, TX 78712-1062
tel: (512)471-0049 fax: (512)417-7060
e-mail: allen@che.utexas.edu

Praveen K. Amar
Director, Science and Policy
Northeast States for Coordinated Air Use Management
129 Portland Street
Boston, MA 02114-2014
tel: (617)367-8540 fax: (617)742-9162
e-mail: pamar@nescaum.org

Jeffrey Ambs
Senior Mechanical Engineer
Rupprecht & Patashnick Co., Inc.
25 Corporate Circle
Albany, NY 12203
tel: (518)452-0065 fax: (518)452-4495
e-mail: ,,jambs@rpco.com

Sally Atwater
Principal
Editorial Arts
2621 West Lake Road
Skaneateles, NY 13152
tel: (315)685-8083 fax: (315)685-8083
e-mail: satwater@adelphia.net

Jason Babbie
Environmental Policy Analyst
New York Public Interest Research Group
9 Murray Street, 3rd Floor
New York, NY 10007
tel: (212)349-6460 fax: (212)349-1366
e-mail: jkb@nypirg.org

John D. Bachmann
Associate Director for Science Policy and New Programs
U.S Environmental Protection Agency
Office of Air Quality Planning
USEPA Mailroom, C404-04
Research Triangle Park, NC 27711
tel: (919)541-5359 fax: (919)541-2464
e-mail: bachmann.johnd@epamail.epa.gov

Millie Baird
Project Manager
Environmental Defense
257 Park Avenue South, 17th Floor
New York, NY 10010
tel: (212)505-2100

Rachael Baker
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Robert Baker
Environmental Engineer
New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233
tel: (518)402-8485
e-mail: rabaker@gw.dec.state.ny.us

Stuart Banashek
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Spencer Banzhaf
Resources for the Future
1616 P Street, N.W.
Washington, DC 20009
tel: (202)328-5077

Cherise Barsell
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Jonathan K. Bass
Environmental Specialist 2
New York State Department of Transportation
Environmental Analysis Bureau
1220 Washington Avenue
Albany, NY 12232-0473
tel: (518)485-5315 fax: (518)457-6887
e-mail: jbass@gw.dot.state.ny.us

John Batey
Professional Engineer
Energy Research Center/National Oil Heat Research Alliance
35 Fawn Road
Easton, CT 06612
tel: (203)459-0353 fax: (203)459-0282
e-mail: erc@optonline.net

Ellen Baum
Ecosystem Consultant
Clean Air Task Force
269 White Road
Bowdoinham, ME 04008
tel: (207)666-5676 fax: (207)666-8841
e-mail: ellen@ngfx.com

Eric H. Bauman
Regional Manager - Environment
Electric Power Research Institute
9488 Good Lion Road
Columbia, MD 21045
tel: (410)740-3455 fax: (410)740-4233
e-mail: ebauman@epri.com

Sue Bayat
Environmental Engineer
EnTech Engineering, P.C.
285 Mill Road
Staten Island, NY 10306
tel: (718)668-3896 fax: (718)668-3895
e-mail: sbayat@enTech-PC.com

Michelle Bicek
Program Associate
Environmental Defense
257 Park Avenue South
New York, NY 10010
tel: (212)616-1220 fax: (212)533-6748
e-mail: mbicek@environmentaldefense.org

Rona Birnbaum
Chief, Assessment & Communications
US Environmental Protection Agency
Clean Air Markets Division
401 M. Street, SW
Washington, DC 20460
tel: (202)564-9076 fax: (202)565-2140
e-mail: birnbaum.rona@epa.gov

Jay Bloomfield
Research Scientist, Lake Services
New York State Department of Environmental Conservation
Watershed Management
625 Broadway
Albany, NY 12233
tel: (518)402-8107
e-mail: jabloom@gw.dec.state.ny.us

Patrick Bolton
Associate Project Manager, Energy Efficiency Services
New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203
tel: (518)862-1090 fax: (518)862-1091
e-mail: ppb@nyserda.org

Thomas Bourgeois
Senior Economist and Director of Research
Pace University School of Law
Pace Energy Project
78 North Broadway
White Plains, NY 10603-3710
tel: (914)422-4013 fax: (914)422-4180
e-mail: tbourgeois@law.pace.edu

Catherine Bowes
Bard Center for Environmental Policy
c/o 10 MSGR Crosby Avenue
Montpelier, VT 05602
tel: (802)223-5343

Elizabeth W. Boyer
Assistant Professor
SUNY College of Environmental Science and Forestry
1 Forestry Drive
204 Marshall Hall
Syracuse, NY 13210
tel: (315)470-4818 fax: (315)470-6956

Charles W. Boylen
Associate Director
Darrin Fresh Water Institute
Rensselaer Polytechnic Institute
110 8th Street, MRC 201
Troy, NY 12180-3590
tel: (518)276-8430 fax: (518)276-2696
e-mail: boylec@rpi.edu

Elvira Brankov
Air Pollution Meteorologist
New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233
tel: (518)457-3547 fax: (518)485-8410
e-mail: exbranko@gw.dec.state.ny.us

Donald Brooks
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Carolyn Brown
Policy Director
Independent Power Producers of NY
19 Dove Street, Suite 302
Albany, NY 12210-1810
tel: (518)436-3749 fax: (518)436-0369
e-mail: carolyn@ippny.org

Jay Burdett
X-Ray Optical Systems, Inc.
15 Tech Valley Drive
East Greenbush, NY 12061
tel: (518)880-1500 fax: (518)880-1520
e-mail: jburdett@xos.com

Ellen Burkhard
Project Manager, Environmental Research
New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203
tel: (518)862-1090 fax: (518)862-1091
e-mail: egb@nyserda.org

Douglas A. Burns
Research Hydrologist
U.S. Geological Survey
Watersheds Research Section
425 Jordan Road
Troy, NY 12180-8349
tel: (518)285-5662 fax: (518)285-5601
e-mail: daburns@usgs.gov

Dallas Burtraw
Senior Fellow
Resources for the Future
Quality of the Environment Division
1616 P Street NW
Washington, DC 20036
tel: (202)328-5087 fax: (202)939-3460
e-mail: burtraw@rff.org

Thomas Butcher
Division Head, Energy Resources
Brookhaven National Laboratory
12 North Sixth Street, Building 526
P.0. Box 5000
Upton, NY 11973-5000
tel: (631)344-7916 fax: (631)344-2359
e-mail: butcher@bnl.gov

Jessica Butts
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Mark Buzel
Director, Environmental Affairs
AES-NY
720 Riverside Drive
Johnson City, NY 13790
tel: (607)729-6950 fax: (607)729-0540
e-mail: mark.buzel@aes.com

Christopher Byrd
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Roger Caiazza
Environmental Manager
NRG Energy Inc.
261 Washington Boulevard
Oswego, NY 13126
tel: (315)349-1361 fax: (315)349-2248
e-mail: roger.caiazza@nrgenergy.com

Shari Calnero
Environmental Associate
Scenic Hudson
One Civic Center Plaza, 2nd Floor
Poughkeepsie, NY 12601
tel: (845)473-4440 fax: (845)452-7567
e-mail: scalnero@scenichudson.org

Susan Capone
Field Operations Manager
Adirondack Lakes Survey Corp.
P.O. Box 296
Ray Brook, NY 12977
tel: (518)897-1354
e-mail: sxcapone@gw.dec.state.ny.us

Meredith Chadwick
Adirondack Council
342 Hamilton Street
Albany, NY 12210
tel: (518)432-1770

Allison Chatrchyan
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Cliff Chen
Research Associate
Synapse Energy Economics, Inc.
22 Pearl Street
Cambridge, MA 02139
tel: (617)661-3248 fax: (617)661-0599
e-mail: cchen@synapse-energy.com

Kevin L. Civerolo
Research Scientist II
New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233
tel: (518)402-8383 fax: (518)402-9035
e-mail: kxcivero@gw.dec.state.ny.us

Elizabeth Clark
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Tom Coates
Regional Manager Environmental
NRG Energy, Inc.
261 Washington Boulevard
Oswego, NY 13126
tel: (315)349-2231 fax: (315)349-2360
e-mail: tom.coates@nrgenergy.com

Kenneth A. Colburn
Executive Director
NESCAUM
12 Portland Street
Boston, MA 02114
tel: (617)367-8540 fax: (617)742-9162
e-mail: kcolburn@nescaum.org

Chris Crane
Pace University School of Law
78 N. Broadway
White Plains, NY 10603
e-mail: ccrane@law.pace.edu

Erin M. Crotty
Commissioner
NYS Department of Environmental Conservation
625 Broadway
Albany, NY 12233-1016
tel: (518)457-3446 fax: (518)457-7744
e-mail: ecrotty@gw.dec.state.ny.us

James De Waal Malefyt
Environmental Supervisor
New York State Department of Public Service
3 Empire State Plaza
Albany, NY 12223
tel: (518)486-2941
e-mail: jim_de_waal_malefyt@dps.state.ny.us

Steven DeSantis
Research Scientist
New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233-3254
tel: (518)402-4303
e-mail: sxdesant@gw.dec.state.ny.us

Kenneth Demerjian
Director
Atmospheric Sciences Research Center, SUNY Albany
ASRC, CESTM Building, Room L119
251 Fuller Road
Albany, NY 12203
tel: (518)437-8705 fax: (518)437-8711

Peter B. Desrochers
Principal Engineer
Spectra Environmental Group, Inc.
19 British American Boulevard
Latham, NY 12110
tel: (518)782-0882 fax: (518)782-0973
e-mail: pdesrochers@spectraenv.com

Suresh Dhaniyala
Assistant Professor
Clarkson University
P.O. Box 5725
Potsdam, NY 13699-5725
tel: (315)268-6574 fax: (315)268-7698
e-mail: sdhaniya@clarkson.edu

Richard Drake
Program Manager, Transportation and Power Systems Research
New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203
tel: (518)862-1090 fax: (518)862-1091
e-mail: rld@nyserda.org

Charles T. Driscoll
Director
Syracuse University, Center for Environmental Systems Engineering
231 Hinds Hall
Syracuse, NY 13244-1190
tel: (315)443-3434 fax: (315)443-1243
e-mail: ctdrisco@mailbox.syr.edu

Hua Du
Atmospheric Sciences Research Center - University at Albany
251 Fuller Road
Albany, NY 12203
tel: (518)437-8703

Marilyn DuBois
Senior Policy Analyst
NYS Legislative Commission on Toxic Substances & Hazardous Wastes
4 Empire State Plaza, 5th Floor
Albany, NY 12248
tel: (518)455-3711 fax: (518)455-3837

Bob Duff
Spectra Environmental Group, Inc.
19 British American Boulevard
Latham, NY 12110
tel: (518)782-0882

Jed Dukett
Assistant Program Manager
Adirondack Lakes Survey Corp.
P.O. Box 296
Ray Brook, NY 12977-0296
tel: (518)897-1375 fax: (518)897-1364
e-mail: jxdukett@gov.dec.state.ny.us

Vincent A. Dutkiewicz
Research Scientist
New York State Department of Health
Wadsworth Center
Empire State Plaza
Albany, NY 12201
tel: (518)474-7999 fax: (518)473-3895
e-mail: dutkiew@wadsworth.org

Dustin Edwards
Fish & Wildlife Technician
New York State Department of Environmental Conservation
Rome Field Station
8314 Fish Hatchery Road
Rome, NY 13440
tel: (315)337-0910 fax: (315)337-0988
e-mail: dj2219@aol.com

Lawrence Eichler
Research Scientist
Darrin Fresh Water
5060 Lakeshore Drive
Bolton Landing, NY 12814
tel: (518)644-3541 fax: (518)644-3640
e-mail: eichll@rpi.edu

Amanda Elliott
Research Assistant
Institute of Ecosystems Studies
Box AB
Millbrook, NY 12545
tel: (845)677-7600
e-mail: elliotta@ecostudies.org

Glenn C. England
Vice President
Performance Engineering
GE Energy and Environmental Research Corporation
18 Mason
Irvine, CA 92618
tel: (949)859-8851 fax: (949)859-3194
e-mail: glenn.england@ps.ge.com

Daniel Falk
Associate Director
Camp Huntington
58 Bruceville Road
High Falls, NY 12440
tel: (845)687-4596
e-mail: dfalk@hvc.rr.com

Stuart E. Findlay
Aquatic Ecologist
Institute of Ecosystem Studies
Box AB
Millbrook, NY 12545
tel: (845)677-5343 fax: (845)677-5976
e-mail: FindlayS@ecostudies.org

William F. Fitzgerald
Professor
University of Connecticut
Department of Marine Sciences
1084 Shennecossett Road
Groton, CT 06340
tel: (860)405-9158 fax: (860)405-9153
e-mail: william.fitzgerald@uconn.edu

Joan Fleser
Environmental Chemist
New York State Department of Environmental Conservation
625 Broadway, BAQS, 3rd Floor
Albany, NY 12233-3256
tel: (518)525-2724 fax: (518)525-2730
e-mail: jmfleser@gw.dec.state.ny.us

Steve Flint
Environmental Engineer
NYS Department of Environmental Conservation
625 Broadway
Albany, NY 12233
tel: (518)402-8292 fax: (518)457-8831
e-mail: seflint@gw.dec.state.ny.us

Robert Foster
State Program Director
Citizens Campaign for the Environment
170 Washington Avenue
Albany, NY 12210
tel: (518)434-8171 fax: (518)434-8172
e-mail: rfoster@citizenscampaign.org

Joanne Fox-Przeworski
Director
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7067 fax: (845)758-7636
e-mail: jfp@bard.edu

Kenneth Fradkin
Environmental Engineer
U.S. Environmental Protection Agency, Region II
290 Broadway, 25th Floor
New York, NY 10007-1866
tel: (212)637-3702
e-mail: fradkin.kenneth@epa.gov

Lauren Franke
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Ward Freeman
Acting District Chief
U.S. Geological Survey
425 Jordan Road
Troy, NY 12180-8349
tel: (518)285-5665 fax: (518)285-5601
e-mail: wfreeman@usgs.gov

James Gallagher
Director, Office of Electricity and Environment
New York State Department of Public Service
3 Empire State Plaza, 8th Floor
Albany, NY 12223-1350
tel: (518)473-7248 fax: (518)486-1672
e-mail: james_gallagher@dps.state.ny.us

Gary H. Ganoung
Dynegy Northeast Generation
992 River Road
Newburgh, NY 12550
tel: (845)563-4936
e-mail: gary.h.ganoung@dynegy.com

Ning Gao
Senior Research Scientist
X-Ray Optical Systems, Inc.
15 Tech Valley Drive
East Greenbush, NY 12061
tel: (518)880-1500 fax: (518)880-1520
e-mail: ngao@xos.com

Lisa Garcia
New York Public Interest Research Group
9 Murray Street, 3rd Floor
New York, NY 10007
tel: (212)349-6460 fax: (212)349-1366
e-mail: lgarcia@nypirg.org

Thomas Gentile
Division of Air Resources,
Stationary Sources
New York State Department of Environmental
Conservation
625 Broadway
Albany, NY 12233
tel: (518)402-8403 fax: (518)402-9035
e-mail: tjgentil@gw.dec.state.ny.us

Richard E. Gibbs
Director, Bureau of Mobile Sources
NYS Department of Environmental Conservation
625 Broadway
Albany, NY 12233
tel: (518)402-8292 fax: (518)402-9035
e-mail: regibbs@gw.dec.state.ny.us

David M. Gibson
President
X-Ray Optical Systems, Inc.
15 Tech Valley Drive
East Greenbush, NY 12061-5169
tel: (518)464-3334 fax: (518)464-3335
e-mail: dgibson@xos.com

Carissa Gigliotti
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Dereth Glance
CNY Program Coordinator
Citizens Campaign for the Environment
466 Westcott Street, Second Floor
Syracuse, NY 13210
tel: (315)472-1339 fax: (315)472-1179
e-mail: dglance@citizenscampaign.org

Deborah G. Grantham
Senior Extension Associate
Cornell Cooperative Extension
Cornell University Department of Crop & Soil Sciences
307A Rice Hall
Ithaca, NY 14853-5601
tel: (607)255-4931 fax: (607)255-4662
e-mail: dgg3@cornell.edu

Daniel S. Greenbaum
President
Health Effects Institute
120 2nd Avenue
Boston, MA 02129
tel: (617)886-9330 fax: (617)886-9335
e-mail: dgreenbaum@healtheffects.org

Jake Griffin
Research Assistant II
Institute of Ecosystem Studies
Box AB
65 Sharon Turnpike
Millbrook, NY 12545-0129
tel: (845)677-5343
e-mail: griffinj@ecostudies.org

Richard Haeuber
U.S. Environmental Protection Agency
Clean Air Markets Division
401 M Street, SW (6204J)
Washington, DC 20460
tel: (202)564-2667 fax: (202)565-2140
e-mail: haeuber.richard@epa.gov

Winston Hao
Research Scientist
NYS Department of Environmental Conservation
625 Broadway
Albany, NY 12233
tel: (518)402-8402 fax: (518)402-9035
e-mail: whao@dec.state.ny.us

Julie Hart
Research Assistant
Institute of Ecosystem Studies
65 Sharon Turnpike
P.O. Box AB
Millbrook, NY 12545-0129
tel: (845)677-5343 fax: (845)677-5976
e-mail: hartj@ecostudies.org

Glenn C. Havens
Territory Manager
Cummins Northeast
101 Railroad Avenue
Albany, NY 12205
tel: (518)459-1710 fax: (518)459-0095
e-mail: glenn.c.havens@cummins.com

Melissa Head
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

John Henkes
Environmental Engineer II
New York State Department of Environmental Conservation
625 Broadway, 2nd Floor
Albany, NY 12233-3254
tel: (518)402-8403 fax: (518)402-9035
e-mail: jlhenkes@gw.dec.state.ny.us

Robert E. Henshaw
Henshaw & Associates
91 Louis Drive
West Sand Lake, NY 12196-3011
tel: (518)283-0415 fax: (518)283-0415
e-mail: rhensahw@att.net

George M. Hidy
Principal
Aerochem Associates
6 Evergreen Drive
Placitas, NM 87043-8903
tel: (505)771-4083 fax: (505)771-4083
e-mail: dahidy@aol.com

Roger Hinrichs
Co-Director
Institute in Energy Education
Snygg Hall
SUNY College at Oswego
Oswego, NY 13126
tel: (315)312-2679 fax: (315)312-5424
e-mail: hinrichs@oswego.edu

Christian Hogrefe
Research Scientist
New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233-3259
tel: (518)402-8402 fax: (518)402-9035
e-mail: chogrefe@dec.state.ny.us

Olga Hogrefe
Research Scientist
Atmospheric Sciences Research Center, SUNY
251 Fuller Road
Albany, NY 12203
tel: (518)437-8722 fax: (518)437-8758
e-mail: olga@asrc.cestm.albany.edu

John G. Holsapple
Director
Environmental Energy Alliance of New York
1125 Broadway
Albany, NY 12204
tel: (518)433-3306 fax: (518)433-3716
e-mail: john.holsapple@us.ngrid.com

Philip K. Hopke
Director, Center for Air Resources
Clarkson University
Engineering and Science
Box 5708
Potsdam, NY 13699-5708
tel: (315)268-3861 fax: (315)268-4410
e-mail: hopkepk@clarkson.edu

Nathan Houck
Database Manager
Adirondack Lakes Survey Corp.
P.O. Box 296
Ray Brook, NY 12977
tel: (518)897-1360
e-mail: nlhouck@gw.dec.state.ny.us

Ray Hull
Sr. Technical Information Specialist
New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203
tel: (518)862-1090 fax: (518)862-1091
e-mail: rwh@nyserda.org

Liaquat Husain
Research Scientist
NYS Department of Health, Wadsworth Center
Empire State Plaza, Room D224A
P.O. Box 509
Albany, NY 12201-0509
tel: (518)473-4854 fax: (518)473-3895
e-mail: husain@wadsworth.org

James Hyde
Research Scientist
New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233-3255
tel: (518)402-8292
e-mail: jdhyde@gw.dec.state.ny.us

Peter Iwanowicz
Director of Environmental Health
American Lung Association of New York State
3 Winners Circle, Suite 300
Albany, NY 12205-1161
tel: (518)459-4197 fax: (518)489-5864
e-mail: peteri@alanys.org

Peter Jaques
Assistant Professor, Biology
Clarkson University
203 Camp Building
P.O. Box 5805
Potsdam, NY 13699-5805
tel: (315)268-4174
e-mail: pjaques@clarkson.edu

Carl Johnson
Deputy Commissioner, Air and Waste Management
New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233-1010
tel: (518)402-8549 fax: (518)402-9016
e-mail: cxjohnso@gw.dec.state.ny.us

Timothy Johnson
Manager, Emerging Technologies and Regulations
Corning Environmental Technologies
Houghton Park HP-CB 2-1
Corning, NY 14831
tel: (607)974-7184

Jennifer Jones
Research Assistant
Atmospheric Sciences Research Center
251 Fuller Road
Albany, NY 12203-3649
e-mail: jonesjm@clarkson.edu

Janet Joseph
Program Manager, Environmental Research
New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203
tel: (518)862-1090 fax: (518)862-1091
e-mail: jj2@nyserda.org

Mary Julian
Director of Operations
Clean Air Technologies International, Inc.
819 East Ferry Street
Buffalo, NY 14211
tel: (716)893-5800 fax: (716)893-0547
e-mail: mjulian@cleanairt.com

Ingrid N. Kelley
Project Manager
Energy Center of Wisconsin
455 Science Drive, Suite 200
Madison, WI 53711
tel: (608)238-8276 fax: (608)238-8733
e-mail: ikelley@ecw.org

James H. Kellogg
Aquatic Biologist
Vermont Department of Environmental Conservation
103 South Main Street
Waterbury, VT 05676
tel: (802)241-1366 fax: (802)241-3008

Victoria R. Kelly
Research Assistant
Institute of Ecosystems Studies
Box AB, 65 Sharon Turnpike
Millbrook, NY 12545
tel: (845)677-5343 fax: (845)677-5976
e-mail: kellyv@ecostudies.org

Carol Kendall
Hydrologist
U.S. Geological Survey
345 Middlefield Road, MS 434
Menlo Park, CA 94087
tel: (650)329-4576 fax: (650)329-5590
e-mail: ckendall@usgs.gov

Helen Kim
Project Manager, Energy Analysis
New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203
tel: (518)862-1090 fax: (518)862-1091
e-mail: hk1@nyserda.org

Heidi Kromphardt
Senior Program Manager
NYS Assembly Commission on Critical Transportation Choice
Agency Building 4, 5th Floor
Empire State Plaza
Albany, NY 12248
tel: (518)455-4031 fax: (518)455-4859
e-mail: kromphh@assembly.state.ny.us

Michael Ku
Research Scientist
New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233
tel: (518)402-8402 fax: (518)402-9035
e-mail: mku@air.dec.state.ny.us

Gil La Duke
Environmental Engineer
New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233
tel: (518)402-8292
e-mail: ghladuke@gw.dec.state.ny.us

G. Garland Lala
Senior Research Associate
Atmospheric Sciences Research Center
251 Fuller Road
Albany, NY 12203
tel: (518)437-8703 fax: (518)437-8711
e-mail: lala@asrc.cestm.albany.edu

Kathleen F. Lambert
Executive Director
Hubbard Brook Research Foundation
16 Buck Road
Hanover, NH 03755-2127
tel: (603)653-0390 fax: (603)653-0391
e-mail: klambert@hbresearchfoundation.org

Thomas R. Lanni
Research Scientist
New York State Department of Environmental Conservation
625 Broadway, 2nd Floor
Albany, NY 12233
tel: (518)402-8292
e-mail: trlanni@gw.dec.state.ny.us

Erik Latremore
Fish and Wildlife Technician, Aquatic Toxicology Unit
New York State Department of Environmental Conservation
Rome Field Station
46 Knapp Road
Constantia, NY 13044
tel: (315)623-7389
e-mail: latremoree@yahoo.com

Gregory B. Lawrence
Physical Scientist
U.S. Geological Survey
Water Resources Division
425 Jordan Road
Troy, NY 12180-8349
tel: (518)285-5664 fax: (518)285-5601
e-mail: GLAWRENC@USGS.GOV

Hanniel Levenson
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Tom Lewis
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Preston Lewis
Environmental Engineer
New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233-3256
tel: (518)402-8501 fax: (518)402-8507
e-mail: gplewis@gw.dec.state.ny.us

Yongquan Li
Postdoctoral Associate
Atmospheric Sciences Research Center, SUNY
251 Fuller Road
Albany, NY 12203
tel: (518)437-8723 fax: (518)437-8711
e-mail: yongquan@asrc.cestm.albany.edu

Barry Liebowitz
Senior Project Manager, Environmental Research
New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203
tel: (518)862-1090 fax: (518)862-1091
e-mail: bnl@nyserda.org

Morton Lippmann
Professor of Environmental Medicine
New York University
Dept. of Environmental Medicine
57 Old Forge Road
Tuxedo, NY 10987
tel: (845)731-3558 fax: (845)351-5472
e-mail: lippmann@env.med.nyu.edu

Philip A. Lorang
Emission Factor and Inventories Group Leader
US Environmental Protection Agency
Air Quality Planning and Standards, Emissions Monitoring/Analysis
MD D205-01
Research Triangle Park, NC 27711
tel: (919)541-5463 fax: (919)541-0684
e-mail: lorang.phil@epa.gov

Jeff Loukmas
Biologist
New York State Department of Environmental Conservation
Fish, Wildlife & Marine Resources
625 Broadway
Albany, NY 12233-4756
tel: (518)402-8980 fax: (518)402-8925
e-mail: jjloukma@gw.dec.state.ny.us

Gary M. Lovett
Ecosystem Ecologist
Institute of Ecosystem Studies
Box AB
65 Sharon Turnpike
Millbrook, NY 12545-0129
tel: (845)677-5343 fax: (845)677-5976
e-mail: LovettG@ecostudies.org

Scott Lowe
Lawler, Matusky & Skelly Engineers
One Blue Hill Plaza, 12th Floor
Pearl River, NY 10965
tel: (845)735-8300 fax: (845)735-7466
e-mail: slowe@lmseng.com

Daniel A. Luttinger
Research Scientist
NYS Department of Health
Bureau of Toxic Subst. Assessment
547 River Street, Room 330
Troy, NY 12180-2216
tel: (518)402-7820 fax: (518)402-7819
e-mail: dal02@health.state.ny.us

Mary Beth Malmsheimer
Principal
Desktop Solutions
134 Lincklaen Street
Cazenovia, NY 13035
tel: (315)655-4110 fax: (315)655-9694
e-mail: mmalmshe@syr.edu

Parker D. Mathusa
16 Sutherland Court
Delmar, NY 12054-2403
tel: (518)439-2403 fax: (518)475-9798
e-mail: parker-mathusa@webtv.net

Monica A. Mazurek
Assistant Professor
Rutgers University
Department of Civil & Environmental Engineering
623 Bowswer Road
Piscataway, NJ 08854-8014
tel: (732)445-3673 fax: (732)445-0577
e-mail: mmazurek@rci.rutgers.edu

Todd McDonnell
SUNY College of Environmental Science and Forestry
1 Forestry Drive
Syracuse, NY 13210
e-mail: toddm933@aol.com

Thomas J. McGuire
Associate Attorney, Office of the General Counsel
NYS Department of Environmental Conservation
625 Broadway
Albany, NY 12233-1500
tel: (518)402-9212 fax: (518)402-9018
e-mail: tjmcguir@gw.dec.state.ny.us

Michael McHale
Hydrologist
U.S. Geological Survey
425 Jordan Road
Troy, NY 12180-8349
tel: (518)285-5675 fax: (518)285-5601
e-mail: mmchale@usgs.gov

Brett McLeod
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Aubrey McMahon
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Gillian Means
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Sandra Meier
Associate Director
Environmental Energy Alliance of NY
1125 Broadway
Albany, NY 12204
tel: (518)433-3042 fax: (518)433-3716
e-mail: sandra.meier@us.ngrid.com

Victor-Pierre Melendez
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Bernard Melewski
Deputy Director
Adirondack Council
342 Hamilton Street
Albany, NY 12210
tel: (518)432-1770 fax: (518)449-4839
e-mail: bmelewski@adirondackcouncil.org

Brent Mellen
Research Assistant
Institute of Ecosystem Studies
Box AB
Millbrook, NY 12545
tel: (845)677-5345 fax: (845)677-5976
e-mail: mellenb@ecostudies.org

Toby Michelena
Senior Environmental Analyst
Novus Engineering, P.C.
3 Normanskill Boulevard
Delmar, NY 12054-1308
tel: (518)439-8235 fax: (518)439-8592
e-mail: tmichelena@novusengineering.com

Mike Miliani
Environmental Engineer
NYS Department of Environmental Conservation
625 Broadway
Albany, NY 12233
tel: (518)402-8396
e-mail: mfmilian@gw.dec.state.ny.us

Percival Miller
Senior Research Analyst
NYS Legislative Committee on Solid Waste Management
4 Empire State Plaza, 5th Floor
Albany, NY 12248
tel: (518)455-3711 fax: (518)455-3837
e-mail: millerp@assembly.state.ny.us

John Mimikakis
Deputy Chief of Staff
House Committee on Science
2320 Rayburn House Office Building
Washington, DC 20515
tel: (202)225-8844
e-mail: john.mimikakis@mail.house.gov

William Moomaw
Professor of International Environmental Policy
Tufts University
Cabot Building, 160 Packard Avenue
Medford, MA 02155
tel: (617)627-2732 fax: (617)627-3712
e-mail: william.moomaw@tufts.edu

Ronald Munson
MFG/Tetra Tech
800 Vinial Street, Building A
Pittsburgh, PA 15212
tel: (412)321-2278 fax: (412)321-2283
e-mail: ron.munson@tetratech.com

John Munn
Environmental Chemist
New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233-3255
tel: (518)782-7245 fax: (518)782-7255
e-mail: jrmun@gw.dec.state.ny.us

Peter S. Murdoch
Hydrologist
U.S. Geological Survey
Watersheds Research Section
425 Jordan Road
Troy, NY 12180-8349
tel: (518)285-5663 fax: (518)285-5601
e-mail: pmurdoch@usgs.gov

Carole Nemore
184 Roweland Avenue
Delmar, NY 12054-4125
tel: (518)439-1985
e-mail: carolen@highstream.net

Sandra A. Nierzwicki-Bauer
Director
Darrin Fresh Water Institute
Rensselaer Polytechnic Institute
MRC 3
Troy, NY 12180-3590
tel: (518)276-2696 fax: (518)276-2696
e-mail: nierzs@rpi.edu

Nancy Nowicki
SUNY College of Environmental Science and Forestry
1 Forestry Drive
Syracuse, NY 13210
e-mail: nnowicki@syr.edu

Barbara Nuffer
Environmental Program Specialist
New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233
tel: (518)402-8432 fax: (518)402-9305
e-mail: bjnuffer@gw.dec.state.ny.us

Kathleen O'Connor
Associate Project Manager, Environmental Research
New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203
tel: (518)862-1090 fax: (518)862-1091
e-mail: kmo@nyserda.org

Ali Ogut
Professor, Mechanical Engineering
Rochester Institute of Technology
James E. Gleason Building
76 Lomb Memorial Drive
Rochester, NY 14623-5604
tel: (716)475-2542 fax: (716)475-7710
e-mail: adoeme@rit.edu

Dianne O'Neal
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Scott V. Ollinger
Research Assistant Professor
University of New Hampshire
Complex Systems Research Center
Morse Hall
Durham, NH 03824
tel: (603)862-2926 fax: (603)862-0188
e-mail: scott.ollinger@unh.edu

Blair Page
Research Assistant
SUNY College of Environmental Science and Forestry
129 Illick Hall
1 Forestry Drive
Syracuse, NY 13210
tel: (315)470-4781
e-mail: bdpage@syr.edu

Larry Pakenas
Program Manager, Energy Analysis
New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203
tel: (518)862-1090 fax: (518)862-1091
e-mail: ljp@nyserda.org

Laurie Palchik
Policy Analyst - Environmental Lead
Wisconsin Department of Administration, Division of Energy
101 East Wilson Street, 6th Floor
P.O. Box 7868
Madison, WI 33707
tel: (608)267-2706 fax: (608)267-6931
e-mail: laurie.palchik@doa.state.wi.us

Harvey Patashnick
President
Rupprecht & Patashnick Co., Inc.
25 Corporate Circle
Albany, NY 12203-5154
tel: (518)452-0065 fax: (518)452-0067
e-mail: hpatashnick@rpco.com

John H. Paul
Vice President
Center for Energy and Economic Development
801 Asbury Avenue, Suite 400
Ocean City, NJ 08226
tel: (609)525-0926 fax: (609)525-0927
e-mail: Jpaul@ceednet.org

Debbie Peck Kelleher
Senate Encon Committe Director
Senator Carl Marcellino's Office
Room 812
Legislative Office Building
Albany, NY 12247
tel: (518)455-2390 fax: (518)426-6975
e-mail: peck@senate.state.ny.us

Heather Pembrook
Environmental Technician, Water Quality Division
Vermont Department of Environmental Conservation
DEC Lab 103 South Main Street
Waterbury, VT 05671
tel: (802)241-1369 fax: (802)241-3008

Thomas J. Peters
Executive Vice President
Empire State Petroleum Association, Inc.
111 Washington Avenue, Suite 203
Albany, NY 12210-2208
tel: (518)449-0702 fax: (518)449-0779
e-mail: tpeters@espa.net

Jennifer Phillips
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Scott O. Quinn
Research Scientist
New York State Department of Environmental Conservation
Division of Water
625 Broadway
Albany, NY 12233-1050
tel: (518)402-8107
e-mail: soquinn@gw.dec.state.ny.us

Frank Ralbovsky
Project Manager, Transportation & Power Systems Research
New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203
tel: (518)862-1090 fax: (518)862-1091
e-mail: fsr@nyserda.org

Bahareh Rashidi
Bard Center for Environmental Policy
P.O. Box 5000
Annandale On The Hudson, NY 12504-5000
tel: (845)758-7162
e-mail: bahareh@bard.edu

Oliver Rattigan
Research Scientist
NYS Department of Environmental
Conservation, Div of Air Resources
625 Broadway, 3rd Floor
Albany, NY 12233-3256
tel: (518)402-8484 fax: (518)402-8507
e-mail: ovrattig@gw.dec.state.ny.us

Jim Reagan
Environmental Engineer
New York State Department of Environmental
Conservation
Division of Operations
625 Broadway
Albany, NY 12233-5254
tel: (518)402-9118 fax: (518)402-9053
e-mail: jwreagan@gw.dec.state.ny.us

Fredrik M. Realbito
Director
Audubon Society of New York
46 Rarick Road
Selkirk, NY 12158
tel: (518)767-9051 fax: (518)767-9076
e-mail: frealbito@audubonintl.org

Andrew Revkin
Environment Reporter
The New York Times
229 West 43rd Street
New York, NY 10010
tel: (212)556-7326

Arthur Robinson
Environmental Engineer I
NYS Department of Environmental Conservation, Div. Air
Resources
625 Broadway
Albany, NY 12233
tel: (518)402-8396 fax: (518)402-9035
e-mail: ajrobins@gw.dec.state.ny.us

Bob Rogers
Assistant District Chief
U.S. Geological Survey
425 Jordan Road
Troy, NY 12180-8349
tel: (518)285-5661 fax: (518)285-5601
e-mail: rrogers@usgs.gov

Amy Roschelle
Synapse Energy Economics, Inc.
22 Pearl Street
Cambridge, MA 02139
tel: (617)661-3248 fax: (617)661-0599

Karen M. Roy
Program Manager
Adirondack Lakes Survey Corp.
P.O. Box 296
Route 86
Ray Brook, NY 12977
tel: (518)897-1354 fax: (518)897-1364
e-mail: kmroy@gw.dec.state.ny.us

Utpal K. Roychowdhury
Manager, Research Instrumentation Facility
Atmospheric Sciences Research Center
Whiteface Mountain Field Station
Whiteface Memorial Highway
Wilmington, NY 12997
tel: (518)946-2145 fax: (518)946-7263
e-mail: ukr@whiteface.net

Erich Rupprecht
Director of Business Development
Rupprecht & Patashnick Co., Inc.
25 Corporate Circle
Albany, NY 12203
tel: (518)452-0065 fax: (518)452-0067
e-mail: erupprecht@rpco.com

Richard Saburro
President and CEO
Starfire Systems, Inc
10 Hermes Road, Suite 100
Malta, NY 12020
tel: (518)899-9336 fax: (518)899-7198
e-mail: saburror@starfiresystems.com

Carlton E. Salvagin
Professor
SUNY/Oswego
Department of Technology
Park Hall
Oswego, NY 13126
tel: (315)564-6410 fax: (315)341-3363
e-mail: carl.salvagin@cs.com

Nana Poku Sam
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Suzanne Sanduski
New York State Department of Transportation
State Campus, Building 4, Room G-17
1220 Washington Avenue
Albany, NY 12232-0445
tel: (518)457-2520 fax: (518)457-6246
e-mail: ssanduski@dot.state.ny.us

Steven J. Sanford
Chief
Bureau of Habitat
New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233-4756
tel: (518)402-8997 fax: (518)402-8925
e-mail: sxsanfor@gw.dec.state.ny.us

Peter Savio
Project Manager, Energy Efficiency Services
New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203
tel: (518)862-1090 fax: (518)862-1091
e-mail: pps@nyserda.org

Nina Schoch
Program Coordinator
Adirondack Cooperative Loon Program
P.O. Box 195
Ray Brook, NY 12977-0195
tel: (518)891-6965
e-mail: aclp2@juno.com

James J. Schwab
Research Professor, ASRC
Atmospheric Sciences Research Center, University at Albany
CESTM
251 Fuller Road
Albany, NY 12203-3640
tel: (518)437-8754 fax: (518)437-8758
e-mail: schwab@asrc.cestm.albany.edu

Janea A. Scott
Staff Attorney
Environmental Defense
257 Park Ave South, 17th Floor
New York, NY 10010
tel: (212)616-1267 fax: (212)505-2375
e-mail: jscott@environmentaldefense.org

David Shaw
Acting Director, Division of Air
New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233
tel: (518)402-8448 fax: (518)457-7232
e-mail: djshaw@gw.dec.state.ny.us

Michael Sheehan
Environmental Engineer
New York State Department of Environmental Conservation
Divison of Air Resources
625 Broadway
Albany, NY 12233
tel: (518)402-8396
e-mail: mpsheeha@gw.dec.state.ny.us

Celia Shih
Research Scientist
New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233
tel: (518)402-8402 fax: (518)402-9035
e-mail: cxshih@gw.dec.state.ny.us

Stephen J. Shost
Research Scientist II
State of New York Department of Health
Bureau of Toxic Substance Assess.
Flanigan Square, Room 330
Troy, NY 12180-2216
tel: (518)402-7815 fax: (518)402-7819

Paul Sierzenga
Environmental Engineer 2
NYS Department of Environmental Conservation
625 Broadway, 3rd Floor
Albany, NY 12233-3256
tel: (518)402-8508 fax: (518)402-8507
e-mail: pmsierze@gw.dec.state.ny.us

Howard A. Simonin
Aquatic Toxicology Research Unit Leader
New York State Department of Environmental Conservation
Rome Field Station
8314 Fish Hatchery Road
Rome, NY 13440
tel: (315)337-0910 fax: (315)337-0988
e-mail: hasimoni@gw.dec.state.ny.us

Gopal Sistla
Bureau Director, Air Research
New York State Department of Environmental Conservation
Division of Air Resources
625 Broadway
Albany, NY 12233
tel: (518)402-8394 fax: (518)402-9035
e-mail: gsistla@dec.state.ny.us

William V. Slade
Director, Environmental Division
New York Power Authority
123 Main Street, 15K
White Plains, NY 10601-3104
tel: (914)681-6405 fax: (914)287-3294
e-mail: slade.w@nypa.gov

Peter R. Smith
Acting President
New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203
tel: (518)862-1090 fax: (518)862-1091
e-mail: prs@nyserda.org

Stephen D. Smith
Novus Engineering, P.C.
3 Normanskill Boulevard
Delmar, NY 12054
tel: (518)439-8235 fax: (518)439-8592
e-mail: ssmith@novusengineering.com

Phil Snyder
Laboratory Manager
Adirondack Lakes Survey Corp.
P.O. Box 296
Ray Brook, NY 12977
tel: (518)897-1366 fax: (518)897-1364
e-mail: pxsnyder@gw.dec.state.ny.us

John Stouffer
Legislative Director
Sierra Club, Atlantic Chapter
353 Hamilton Street
Albany, NY 12210-1709
tel: (518)426-9144 fax: (518)427-3052
e-mail: john.stouffer@sierraclub.org

Timothy J. Sullivan
President
E&S Environmental Chemistry
P.O. Box 609
Corvallis, OR 97339
tel: (541)758-5777 fax: (541)758-4413
e-mail: Tim.Sullivan@ESenvironmental.com

Jack Sullivan
New England Fuel Institute, Inc.
P.O. Box 9137
Watertown, MA 02472
tel: (617)924-1000 fax: (617)924-1022
e-mail: nefi@nefi.com

Christopher Tall
Research Assistant
Institute of Ecosystem Studies
Box AB
Millbrook, NY 12545
tel: (845)677-5343 fax: (845)677-5976
e-mail: TallC@ecostudies.org

Shida Tang
Research Scientist
NYS Department of Environmental Conservation
625 Broadway, 2nd Floor
Albany, NY 12233-3255
tel: (518)782-7248 fax: (518)782-7255
e-mail: sdtang@gw.dec.state.ny.us

Joe Tario
Project Manager, Transportation & Power Systems Research
New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203
tel: (518)862-1090 fax: (518)862-1091
e-mail: jdt@nyserda.org

Elizabeth W. Thorndike
President
Ecollaborative
27 Maplewood Road
Ithaca, NY 14850-4209
tel: (607)277-2604 fax: (607)277-2812
e-mail: EWT3@Cornell.Edu

Bruce Tonn
Senior Researcher
Oak Ridge National Laboratory
4500 N, MS 6207
Oak Ridge, TN 37831-6207
tel: (865)574-4041 fax: (865)574-8884
e-mail: bet@ornl.gov

Antony Tseng
US Environmental Protection Agency, Region 2
290 Broadway, 24th Floor
New York, NY 10007-1866
tel: (212)637-3777 fax: (212)637-3889
e-mail: tseng.antony@epa.gov

Bernard Tuchman
Environmental Policy Analyst
Urban Environmental Law Center
240 West End Avenue, #8D
New York, NY 10023-3616
tel: (212)874-4199
e-mail: bdtjpw@rcn.com

Mark J. Utell
Professor of Medicine and Environmental Medicine
University of Rochester Medical Ctr
Pulmonary and Critical Care
601 Elmwood Avenue, Box 692
Rochester, NY 14642-8692
tel: (585)275-4681 fax: (585)273-1058
e-mail: mark_utell@urmc.rochester.edu

Christine Vanderlan
Energy Program Associate
Environmental Advocates of New York
353 Hamilton Street
Albany, NY 12210
tel: (518)462-5526 fax: (518)427-0381
e-mail: cvanderlan@eany.org

James S. Vickery
Assistant Director of Air Exposure Research
US Environmental Protection Agency
National Exposure Research Lab.
NERL, IOD, MD-305-1
Research Triangle Park, NC 27711
tel: (919)541-2184 fax: (919)541-7588
e-mail: vickery.james@epamail.epa.gov

Joseph Visalli
Program Director
New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203
tel: (518)862-1090 fax: (518)862-1091
e-mail: jrv@nyserda.org

Tim Volk
Biomass Program Director
SUNY College of Environmental Science and Forestry
133 Illick Hall
1 Forestry Drive
Syracuse, NY 13210
tel: (315)470-6774 fax: (315)470-6934
e-mail: tavolk@syr.edu

Christopher J. Walcek
Senior Research Associate
SUNY/Albany - Atmospheric Sciences Research Center
251 Fuller Road
Albany, NY 12203-3649
tel: (518)437-8720 fax: (518)437-8758
e-mail: walcek@asrc.cestm.albany.edu

Mark Watson
Senior Project Manager, Environmental Research
New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203
tel: (518)862-1090 fax: (518)862-1091
e-mail: mw1@nyserda.org

Kathleen Weathers
Forest Ecologist
Institute of Ecosystem Studies
Box AB
Millbrook, NY 12545
tel: (845)677-5343 fax: (845)677-5976
e-mail: weathersk@ecostudies.org

James C. White
Professor Emeritus, Cornell University
23 Maplewood Road
Ithaca, NY 14850
tel: (607)273-2514
e-mail: jcwh@aol.com

Susan S. Wierman
Executive Director
MARAMA- Mid-Atlantic Regional Air Management Association
711 West 40th Street, Suite 318
Baltimore, MD 21211-2109
tel: (410)467-0170 fax: (410)467-1737
e-mail: swierman@marama.org

Steven Wilcox
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Lloyd R. Wilson
Research Scientist IV
New York State Department of Health
Bureau of Toxic Substance Assesment
547 River Street
Troy, NY 12180-2216
tel: (518)402-7820 fax: (518)402-7819
e-mail: lrw03@health.state.ny.us

Ann (Beth) E. Wittig
Assistant Professor
City College of New York, Civil & Environmental Engineering
Steinman Hall T104
Convent Avenue and 138th Street
New York, NY 10031
tel: (212)650-8397 fax: (212)650-6965
e-mail: wittig@ce.ccny.cuny.edu

Zywia Wojnar
Bard Center for Environmental Policy
PO Box 5000
Annandale On The Hudson, NY 12504-5000
tel: (845)758-7162
e-mail: wojnar@bard.edu

Steve Wolcott
Supervisory Hydrologist
U.S. Geological Survey
425 Jordan Road
Troy, NY 12180-8349
tel: (518)285-5676 fax: (518)285-5601
e-mail: swolcott@usgs.gov

Erin Wood
Bard Center for Environmental Policy
Bard College
P.O. Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071 fax: (845)758-7636

Michelle Yost
Bard Center for Environmental Policy
Bard College
PO Box 5000
Annandale On Hudson, NY 12504-5000
tel: (845)758-7071

Fangqun Yu
Senior Research Associate
Atmospheric Sciences Research Center, .SUNY Albany
CESTM
251 Fuller Road
Albany, NY 12203-3649
tel: (518)437-8767 fax: (518)437-8758
e-mail: yfq@asrc.cestm.albany.edu

Jian Yu
Rochester Institute of Technology
76 Lomb Memorial Drive
Rochester, NY 14623
tel: (585)675-2157 fax: (585)475-7710
e-mail: jxyeme@rit.edu

Eric Zalewsky
Research Scientist
NYS Department of Environmental Conservation
625 Broadway
Albany, NY 12233
tel: (518)402-8402 fax: (518)402-9035
e-mail: eezalews@dec.state.ny.us

John Zamurs
Head, Air Quality Section, Environmental Analysis Bureau
NYS Department of Transportation
Building 5 - 3rd Floor, Room 303
State Office Building Campus
Albany, NY 12232-0001
tel: (518)457-5646 fax: (518)457-6887
e-mail: jzamurs@gw.dot.state.ny.us

New York Energy $mart℠

EMEP

En ironmental Mo ito ing, Evalua ion, & Protec ion

George E. Pataki, Governor

NYSERDA

New York State Energy Research and Development Authority

17 Columbia Circle
Albany, NY 12203-6399
toll free 1-866-NYSERDA
local (518) 862-1090
fax (518) 862-1091
www.nyserda.org

Water sampling by Adirondack Lakes Survey Corporation workers.

New York State uses more than 4 quadrillion Btus of primary energy (4% of the U.S. total) in the form of petroleum, natural gas, nuclear power, coal, hydropower, and biofuels. About 1.5 quadrillion Btus of this primary energy is used to produce electricity. Although the energy is vital to our economy and quality of life, the process of generating and distributing it can have wide-ranging environmental and public health impacts.

In recognition of the link between energy and the environment, the New York Public Service Commission included an environmental research and monitoring initiative in the **New York Energy $mart℠** public benefits program. **New York Energy $mart℠**, which is administered by the New York State Energy Research and Development Authority (NYSERDA), supports energy efficiency, renewable energy, and environmental programs. The public benefits program is funded by a charge paid by electric distribution customers in New York State. The program began in 1998 and is funded through July 2006.

Program Objective and Focus

New York Energy $mart℠ Environmental Monitoring, Evaluation, and Protection (EMEP) program provides objective and policy-relevant research aimed at two primary goals:

- enhancing understanding of the nature and characteristics of energy-related pollution and its impact on the environment and human health; and
- characterizing sources of energy-related pollution and defining opportunities for emissions reduction.

The program focuses on electricity-related environmental issues in New York State. EMEP is currently supporting a diverse research portfolio in three areas:

- ecosystem response to deposition of sulfur, nitrogen, and mercury;
- air quality and related health research associated with particulate matter, ozone, and copollutants; and
- crosscutting environmental science, technology, and policy projects.

Program Strategy

Research planning. NYSERDA, with the assistance of more than 30 external scientists and policy experts, has completed a multiyear research plan for the EMEP program (available at www.nyserda.org/programs/environment/emepplan.pdf).

Competitive solicitations and science/policy review. EMEP periodically issues Program Opportunity Notices to seek proposals that address targeted research areas. Projects are reviewed and selected through a competitive process. The program is guided by a steering committee of major stakeholder groups. In addition, a separate science advisory committee provides technical review and project input.

Collaborative research. The program supports an interdisciplinary approach to environmental research and seeks to build research capability in New York State to address critical energy-related environmental issues. EMEP has catalyzed numerous multi-institution collaborative efforts, bringing diverse perspectives and expertise into many projects.

Information exchange. EMEP places a premium on information exchange. The program seeks to accelerate the process of introducing the latest scientific findings into the realm of policy formulation, ultimately to increase the effectiveness of environmental control strategies. EMEP sponsors conferences and workshops to bring stakeholders, scientists, and policy makers together to discuss environmental research issues in New York State and the region. EMEP produces a variety of technical reports, publications, and web-based resources (see www.nyserda.org/programs/environment/emep.asp). More than 125 peer-reviewed publications have appeared as a result of EMEP-sponsored research.

Top: U.S. Geological Survey staff installing a mercury deposition monitor in the Catskills.
Center: NYS Department of Environmental Conservation staff sampling fish for mercury analysis.
Bottom: Adirondack Cooperative Loon Program staff releasing a juvenile common loon.

EMEP Program Advisory Group

Andrew Darrell, Environmental Defense
James deWaal Malefyt, New York State Department of Public Service
Dr. Richard Haeuber, U.S. Environmental Protection Agency
Dr. Daniel Luttinger, New York State Department of Health
Dr. Sandra Meier, Environmental Energy Alliance of New York
Dr. S.T. Rao, National Oceanic and Atmospheric Administration
Steven Sanford, New York State Department of Environmental Conservation
Dr. Gopal Sistla, New York State Department of Environmental Conservation
Dr. James Vickery, U.S. Environmental Protection Agency
Dr. Ross Whaley, Adirondack Park Agency
Dr. Lloyd Wilson, New York State Department of Health
Dr. Ronald Wyzga, Electric Power Research Institute

EMEP Science Advisory Committee

Dr. Praveen Amar, Northeast States for Coordinated Air Use Management
Dr. Stuart Findlay, Institute of Ecosystem Studies
Dr. William F. Fitzgerald, University of Connecticut
Dr. George Hidy, Aerochem Associates
Dr. Daniel Jacob, Harvard University
Dr. Patrick Kinney, Columbia University School of Public Health
John S. Irwin, John S. Irwin and Associates
Dr. Scott Ollinger, University of New Hampshire

Research Supported by the EMEP Program:

Air Quality and Related Health Research: Particulates (PM), Ozone, and Co-Pollutants

Clinical Studies of Exposure to Ultrafine Particles*	University of Rochester Medical Center (M. Utell)
Source Apportionment of Fine Particles in New York City	New York University Medical Center (G. Thurston)
Impact of Power Plants on Semivolatile Pollutants and Fine Particles in New York State	Clarkson University (P. Hopke and T. Holsen), State University of New York (SUNY) - Fredonia (M. Milligan)
Analysis of Ozone and Fine Particles in the Northeast*	University at Albany (S.T. Rao)
Effects of Transboundary Pollution on New York's Air Quality*	NYS Department of Environmental Conservation (S.T. Rao)
Enhanced Measurements of Oxidants, Fine Particles, and Precursors	University at Albany (K. Demerjian)
Demonstration of Continuous Ambient Particulate Monitor*	Rupprecht & Patashnick Co., Inc. (J. Ambs)
Demonstration of Innovative Instrument for Ambient Particulate Matter Mass Measurement Standard*	Rupprecht & Patashnick Co., Inc. (J. Ambs)
Fine Particle Constituents and Acute Asthma in Urban Areas	NYS Department of Health (D. Luttinger)
Monitoring Particle Size Distribution in Rochester	Clarkson University (P. Hopke)
Fine/Ultrafine Particulate Emissions Profiles*	GE Energy and Environmental Research Corp. (G. England)
Workshop on Incorporation of Receptor Models into PM and Adverse Health Effects Study	Clarkson University (P. Hopke)
Formation and Transformation of Particles in Motor Engine Exhaust	University at Albany (F. Yu)
Analysis of PM Data in New York Using Advanced Source Apportionment Methods	Clarkson University (P. Hopke)
Assessment of Carbonaceous PM2.5 for New York and the Region	Northeast States for Coordinated Air Use Management (P. Johnson)
Physical and Chemical Characterization of Laboratory-Generated Secondary Semivolatile Organic Particles	University at Albany (K. Demerjian)
Chemical Composition of Fine Organic Particles from Urban Regional Background Locations in New York State	Rutgers University (M. Mazurek)
New York City Exposure/Asthma Panel Study	Electric Power Research Institute (A. Rohr)
Ultrafine Particles and Cardiac Responses: Evaluation in a Cardiac Rehabilitation Center	University of Rochester Medical Center (M. Utell)

Atmospheric Deposition of Sulfur (S), Nitrogen (N), and Mercury (Hg) and Ecosystem Response

Long-Term Monitoring Program for Evaluating Changes in Water Quality in Adirondack Lakes	Adirondack Lakes Survey Corporation (K. Roy)
Evaluation of the Recovery from Acidification of Adirondack Ecosystems	SUNY College of Environmental Science and Forestry (M. Mitchell)
Mercury in Adirondack Wetlands, Lakes, and Terrestrial Systems	Tetra Tech, Inc. (R. Munson), Syracuse University (C. Driscoll), U.S. Geological Survey (M. McHale)
Effects of Atmospheric Deposition of Sulfur, Nitrogen, and Mercury on Adirondack Ecosystems*	SUNY College of Environmental Science and Forestry (D. Raynal)
Contributions of Global and Regional Sources to Mercury Deposition in New York State*	Atmospheric & Environmental Research, Inc. (C. Seigneur)
Integrated Assessment of Recovery of Surface Waters from Reduced Levels of Acid Deposition in the Catskills and Adirondacks	U.S. Geological Survey (D. Burns), Institute of Ecosystem Systems (G. Lovett)
Status and Effects of Nitrogen Pollution in Northeastern United States*	Hubbard Brook Research Foundation (K. Lambert)
Atmospheric Transport and Fate of Mercury in New York State	University at Albany (C. Walcek)
Deposition and Effects of Air Pollution in the Hudson Valley*	Institute of Ecosystem Studies (G. Lovett)

*Completed projects

Projects and Principal Research Partners

Atmospheric Deposition of Sulfur (S), Nitrogen (N), and Mercury (Hg) and Ecosystem Response, continued

Assessment of Extent to Which Intensively Studied Lakes Are Representative of the Adirondack Mountain Region	E & S Environmental Chemistry, Inc. (T. Sullivan)
Potential Recovery of Water Chemistry and Stream Biota from Reduced Acid Deposition at a Sensitive Watershed in the Catskill Mountains	U.S. Geological Survey (D. Burns)
Long-term Monitoring and Assessment of Mercury Using the Common Loon, Prey Fish, Water, and Sediment	Adirondack Cooperative Loon Program/ Wildlife Conservation Society (N. Schoch)
Strategic Monitoring of Mercury in New York State Fish	NYS Department of Environmental Conservation (H. Simonin)
Assessment of Chemistry and Benthic Communities in Streams of the Oswegatchie-Black River Basins of the Adirondack Region	U.S. Geological Survey (G. Lawrence), Adirondack Lakes Survey Corp. (K. Roy), University of Texas (S. Passy)
Forest Health and Stream and Soil Chemistry Using a Multiscale Approach and New Methods of Remote Sensing Interpretation, Catskill Mountains, New York	U.S. Geological Survey (P. Murdoch), USDA Forest Service (R. Hallet)
Assessment of Nitrogen and Acidic Deposition Impacts to Terrestrial and Aquatic Ecosystems of the Tug Hill Region	SUNY College of Environmental Science and Forestry (M. Mitchell and G. McGee)
Assessing the Sensitivity of New York Forests to Cation Depletion	SUNY College of Environmental Science and Forestry (R. Yanai)
Mercury Deposition Monitoring Network: Adirondacks and Catskills	Syracuse University (C. Driscoll), U.S. Geological Survey (M. McHale)

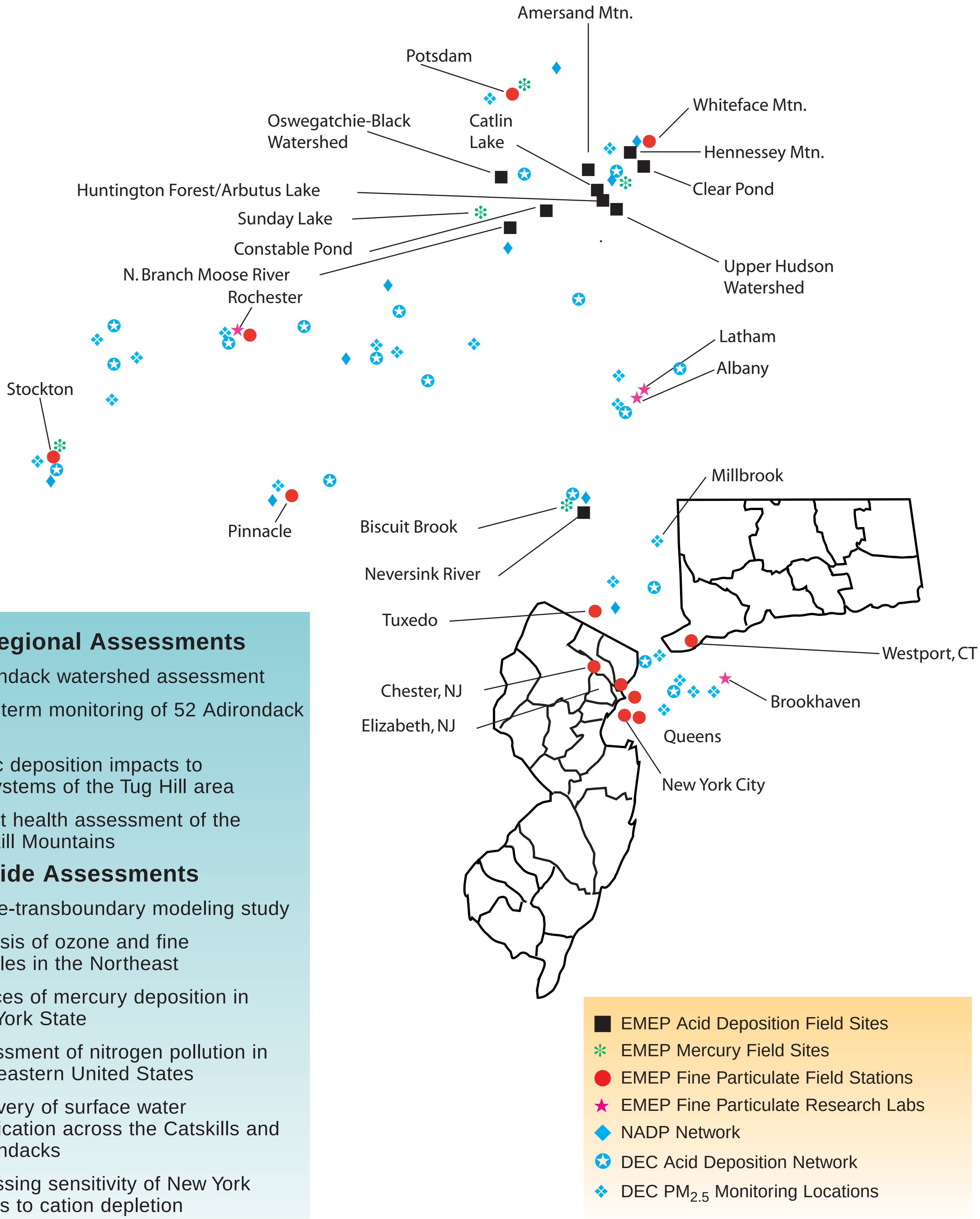
Projects Crosscutting the Topics of Air Quality, Health, and Ecosystem Response

Quantifying Atmospheric Nitrogen Sources with New Stable Isotope Techniques	U.S. Geological Survey (C. Kendall and D. Burns), SUNY College of Environmental Science and Forestry (E. Boyer)
Multipollutant Policies for the Electricity Sector and Environmental Quality in the Empire State	Resources for the Future (K. Palmer)
Analysis of New Pollution Control Strategy Utilizing Emission Reduction Credits and Small-Scale Combined Heat and Power Units	Navigant Consulting (A. Greene)
Quantifying the Environmental Benefits of Increased Deployment of Combined Heat and Power Technologies in NYS and the Impact of Proposed Emissions Standards for Small Distributed Generation	Navigant Consulting (W. Puntel)
Ambient Gaseous Ammonia: Evaluation of Continuous Measurement Methods Suitable for Routine Deployment	University at Albany (J. Schwab)
New York City Regional Heat Island Initiative	SAIC (R. Slosberg), Columbia University (C. Rosenzweig), Hunter College of CUNY (W. Solecki)

SUNY Environmental Science and Forestry students conducting fieldwork at Arbutus Lake.

Adirondack Cooperative Loon Program staff searching for common loons.

NYSERDA's EMEP Program: Field Stations and Research Sites

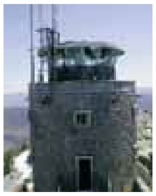


NYS Regional Assessments

- Adirondack watershed assessment
- Long-term monitoring of 52 Adirondack lakes
- Acidic deposition impacts to ecosystems of the Tug Hill area
- Forest health assessment of the Catskill Mountains

Statewide Assessments

- Ozone-transboundary modeling study
- Analysis of ozone and fine particles in the Northeast
- Sources of mercury deposition in New York State
- Assessment of nitrogen pollution in northeastern United States
- Recovery of surface water acidification across the Catskills and Adirondacks
- Assessing sensitivity of New York forests to cation depletion
- Carbonaceous fine particle assessment
- Mercury monitoring in New York fish



For More Information

For more information on the **New York Energy $mart℠** Environmental Program, contact Mark Watson at (518) 862-1090, ext.3314, fax (518) 862-1091; e-mail MW1@nyserda.org; or visit NYSERDA on the web at www.nyserda.org

The New York State Energy Research and Development Authority, a public benefit corporation created in 1975 by the New York State Legislature, works to improve New York State's energy, environmental, and economic future by sponsoring energy analysis, research and development, and efficiency deployment programs. Funding for these programs comes from the State's investor-owned utilities, the federal government, substantial project partner cofunding, and voluntary contributions from the New York Power Authority and Long Island Power Authority. NYSERDA also manages the Western New York Nuclear Services Center at West Valley and coordinates the State's nuclear energy activities.

Highlights from EMEP-Funded Research

Important results have come from the EMEP research program. With EMEP funding, researchers have…

- advanced understanding of the relative importance of local versus long-range transport contributions of ozone (O_3) and fine particulate matter ($PM_{2.5}$);
- substantially improved knowledge about the properties and sources of $PM_{2.5}$, including the organic fraction, in New York City and parts of upstate New York;
- provided unique knowledge about emissions of ultrafine particles (< 0.1 micron in diameter) from combustion sources;
- characterized daily and seasonal patterns of ultrafine particles, including the growth of particles in an urban atmosphere;
- investigated the temporal and spatial variation of atmospheric mercury concentration at two rural locations in New York State to identify their sources;
- advanced knowledge about the effects of ultrafine particles on cardiac health;
- provided a continuing assessment of improvement in watershed chemistry and ecology associated with regional emissions reductions of sulfur and nitrogen oxides;
- gathered critical data about concentrations of mercury in aquatic systems in New York; and
- supported monitoring networks and intensive study sites throughout New York to provide accountability for emissions reduction strategies.

Photos this page:

Top left: NYS Department of Environmental Conservation–SUNY Atmospheric Sciences Research Center monitoring site at Whiteface Mountain.
Middle: NYS Department of Environmental Conservation monitoring site at Queens College.
Left: Field-testing a Rupprecht & Patashnick fine particle monitor.

Environmental Monitoring, Evaluation, and Protection In New York: Linking Science and Policy

October 7-8, 2003

Conference Sponsors

For more information on this
conference, please contact:

Mark Watson
(518) 862-1090, ext. 3314
mw1@nyserda.org