

# ENVIRONMENTAL RESEARCH AND MONITORING NEEDS IN NEW YORK STATE



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High Peaks Morning

A Multi-Year Research Plan for the  
New York State Energy Research and Development Authority's  
Environmental Monitoring, Evaluation, and Protection Program

April 1, 2002



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## **ACKNOWLEDGMENTS**

NYSERDA would like to acknowledge the invaluable input and review provided by the members of the Environmental Research Plan Working Groups, and the Environmental Monitoring, Evaluation and Protection Program (EMEP) Science Advisors and Program Advisory Group.

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# INTRODUCTION

## BACKGROUND

In 2001 NYSERDA initiated a comprehensive planning effort to provide direction for environmental research in New York State over the next five years, with a focus on pollution associated with the generation of electricity. Potential users of the plan include the New York State Energy Research and Development Authority (NYSERDA), other New York State/regional/national research funding organizations, the scientific community, public benefit organizations and policy makers. The goal and philosophy of this effort is to identify critical research which:

- Is policy-relevant
- Is inter-disciplinary/multi-media
- Will be useable for New York State - not just NYSERDA's **New York Energy \$mart<sup>SM</sup>** Environmental Monitoring, Evaluation and Protection Program (EMEP), and
- Takes advantage of related national research plans and programs to address regional/State needs.

Implementation of the plan's recommendations will help maximize the use of limited resources to serve the needs of New York State and others. Within the plan, NYSERDA has identified and prioritized key research areas which are suitable to be addressed through the EMEP program, as well as in collaboration with other funding organizations.

## EMEP OVERVIEW

EMEP is funded through the system benefits charge (SBC) under the New York Energy \$mart<sup>SM</sup> Program. The primary mission of EMEP is to support research to address environmental issues related to the generation of electricity. Since its inception in 1998, the EMEP program has provided objective and policy-relevant research to:

- Improve the scientific understanding of electricity-related pollutants in the environment;
- Assess the environmental impact of electricity generation relative to other sources of pollution;

- Help develop approaches to mitigate impacts of electricity generation and improve environmental quality.

EMEP has also supported development of advanced environmental instrumentation.

The EMEP program currently supports research in four critical regional environmental issues related to electricity generation: ozone, fine particles, acid deposition, and mercury (see Appendix A). Approximately \$15 million is available through 2006. Program Opportunity Notices (PONs) are issued periodically to seek proposals which address targeted research areas. Projects are reviewed and selected through this competitive process. The program is guided by a steering committee comprised of representatives from the New York State Departments of Environmental Conservation (DEC), Health (DOH), and Public Service (DPS); the U.S. Environmental Protection Agency (U.S. EPA); the New York Academy of Sciences; a university; a utility association; and three environmental/public interest groups. Also, a science advisory committee provides program support and periodic review in critical disciplines.

Under EMEP, NYSERDA sponsors conferences and workshops for policy-makers and scientists to share information. They cover a wide range of topics, from asthma in New York City to mercury in remote regions of the Adirondacks. NYSERDA also plans to commission papers to "translate" scientific results into a form useful for policy-makers. As research reports become available, NYSERDA and its research partners will post information on-line (see [www.nyserda.org](http://www.nyserda.org)). Program Opportunity Notices and information about ongoing projects may also be found on the website.

## RESEARCH PLANNING PROCESS

NYSERDA convened working groups of science and policy experts to help identify critical gaps and research needs in New York State. Research needs were organized into the following focus areas, representing the major issues related to pollution associated with the generation of electricity:

- Atmospheric Deposition of Sulfur (S), Nitrogen (N), and Mercury (Hg), and Ecosystem Response (*Section A*)
- Air Quality and Related Health Research: Particulates (PM), Ozone and Co-Pollutants (*Section B*)
- Crosscutting Topics (*Section C*)

**Policy objectives** were identified to guide the research scoping process so that the research would be most useful and applicable to environmental management challenges facing New York State. The overarching policy objectives of the planning process were to identify gaps in the research/information needed to:

- Develop and evaluate the effectiveness of pollution control strategies for acid deposition, mercury, ozone and co-pollutants, and particulate matter including providing the scientific basis for a PM<sub>2.5</sub> State Implementation Plan (SIP);
- Quantify local sources versus regional transport of fine particles, ozone, ozone precursors, mercury, and acid deposition precursors to develop more equitable pollution control strategies;
- Assess the relationships between fine particles, ozone, and co-pollutants with health effects to support development of control strategies to effectively mitigate health impacts;
- Identify alternative environmental protection and mitigation strategies to reduce the impacts of acidification and exposure to mercury in New York; and
- Develop emerging multi-media/multi-pollutant environmental protection strategies.

The potential **scientific scope** was broad and included: biogeochemical cycling and ecosystems impacts of S, N, Hg species; factors limiting or promoting recovery of acidification; relative environmental impacts of atmospheric deposition compared to other sources; economic damage assessments and economic impacts of potential strategies; characterization of atmospheric aerosols, co-pollutants and aerosol precursors; fate and transport of primary and secondary particulate matter, ozone, ozone precursors and co-pollutants with respect to sources and receptors; and relationship of atmospheric concentrations, compositions, and size to human health and other environmental concerns.

Potential priority research areas were identified and

presented at the EMEP conference in Albany, NY to over 200 participants for additional input. The draft plan was distributed to the EMEP Program Advisory Group for final review.

## **NEXT STEPS - IMPLEMENTING THE RESEARCH PLAN**

Solicitations under EMEP are scheduled to be issued starting in early 2002, targeting the research areas prioritized through this planning effort. EMEP solicitations will generally follow the implementation schedule in the plan, with high priority and high urgency projects solicited in 2002 and other initiatives solicited in 2003 and beyond, if funding resources are available (see Table 1). It should be noted that the research needs for New York State identified in this plan far exceed the funding currently available under EMEP. As such, in order to complete the work identified in this plan, cofunding of research projects will be required and coordination, collaboration, and leveraging with other state and federal agencies will be necessary.

## **SCIENCE AND POLICY INTEGRATION**

Although sound scientific research may increase the knowledge base of energy-environmental systems, the true test of success is the utilization of findings by policy makers to improve both environmental quality and human health. To achieve this goal, research findings need to be synthesized and translated into understandable formats, forums must be provided for scientists and policy makers to discuss issues, and funding organizations must seek opportunities for collaboration, as noted above.

There is an increasing awareness of the need for research funding organizations to support these synthesis and communication activities in addition to traditional scientific pursuits. For example, the National Council for Science and the Environment has issued a report entitled, "Improving the Scientific Basis for Environmental Decisionmaking." This report contains the recommendations of more than 450 decisionmakers and scientists who participated in a recent National Conference on Science, Policy and the Environment. Key recommendations include:

- Sound environmental decisionmaking is dependent on an effective interface between

scientists and policymakers based on reliable and timely “translation” of information and views between the two communities;

- There is a crucial need for periodic knowledge assessments that can provide scientists and policymakers with reliable and timely “state of the science” reports on the environment as a whole as well as on particular topics;
- Interdisciplinary and multidisciplinary approaches are essential for successful environmental decision-making;
- Coordinating the missions and efforts of organization involved in environmental decisionmaking is necessary to decrease the likelihood of voids or duplications in necessary programs.

The EMEP program is attempting to support these challenging goals and approaches to producing useful and policy relevant environmental research in New York State. While the plan presented here will serve as the scientific basis for future EMEP initiatives, and possibly other initiatives in New York, EMEP is developing an aggressive communication and outreach policy to further support the goals of science-policy integration and to ensure that the results of the research program are *used*.

### **WORK-IN-PROGRESS**

This plan should be viewed as a work in progress. As research findings become available and policies are implemented, it will be necessary to continually re-visit and revise this plan to ensure that it effectively addresses the current and future environmental issues of concern.



## SUMMARY AND HIGHLIGHTS OF PRIORITY RESEARCH AREAS

Critical research and monitoring needs identified in the planning process are summarized in Table 1. A priority ranging from 1 to 3 was assigned for each research activity, with 1 being most important. In addition, an attempt was made to denote the urgency for the research and approximately how long the research endeavor would take to produce results. A ballpark estimate of cost was also identified. These attributes help define an implementation schedule for the research initiatives.

Many of the science and policy stakeholders strongly recommended that EMEP's first priority should be to support an **assessment of the adequacy of the existing air quality monitoring networks and research field sites** to identify monitoring redundancies and gaps from the perspective of geographic distribution of sites and parameters measured. This high priority item will be pursued in early 2002, as its results will drive other research/monitoring initiatives.

While routine environmental monitoring needs are significant for a multitude of reasons, the general consensus of the participants in the planning process was that the most appropriate EMEP role in the area of monitoring is in:

- Assessing adequacy of existing networks and field stations;
- Supporting long-term study sites; and
- Developing advanced analytical methods and instrumentation.

In the air quality arena, the foremost priority identified was the need for research that will provide the scientific foundation to develop a State Implementation Plan (SIP) for complying with the PM<sub>2.5</sub> ambient air quality standard. This SIP will need to be developed in the 2005-2008 timeframe. Work related to this policy objective includes:

- Increased effort on PM<sub>2.5</sub> **source characterization** and **source-receptor modeling** so that sources of PM<sub>2.5</sub> (both emitters of primary particulates and precursors to secondary particulates) can begin to be identified and control strategies can be developed;
- Increased research related to **ammonia and organic contribution to ambient particulate**

**aerosols** (which contribute a significant portion of PM<sub>2.5</sub> mass in New York);

- Increased **integration of PM health research and field studies** (especially building on the wealth of data that are being collected under the New York PM Supersite program); and
- An **Integrated Assessment of PM<sub>2.5</sub>** to bring the PM field studies, survey/monitoring work, and health studies together and to synthesize the information into a form that will be most useful to policy makers. This would build on the PM Supersite program and start in the 2003-2004 timeframe, when more PM data will be available.

The issue of **co-pollutant interactions** was identified as a critical research gap and a priority at the national level. The specific role and contribution of a New York State research effort in this area is dependent on many other related research developments, and it was determined that such research should be pursued in the 2003 timeframe after some model development work takes place on the national level.

Significant research/information gaps that were identified in the areas of acidification and mercury include the following:

- In order to better assess the impact of atmospheric loadings on the State's ecosystems, develop methodologies to improve the accuracy of **dry deposition** measurements, since dry deposition often constitutes 50% or more of total deposition of S or N to an ecosystem;
- Increased effort on baseflow and **episodic stream chemistry in sensitive watersheds** Statewide to assess the extent and severity of effects, and establish a baseline from which to assess future recovery;
- A better **characterization of current soil conditions** to assess effects on sensitive soils, and in doing so, develop a soil database that supports other terrestrial/aquatic effects studies;
- To assist in mercury source reduction initiatives,

**identify multiple sources and relative contributions of mercury, and determine mercury ecosystem fluxes, transformation and transport;**

- Continue **synthesis studies** to integrate existing data and information on the inputs, outputs and effects of sulfur, nitrogen and mercury deposition in New York State.

One important cross-cutting energy-related issue that was identified was the need to better understand the **environmental implications of distributed generation**. As a result of deregulation and the current energy situation, a variety of distributed generation equipment is being installed in New York State. The New York State Department of Environmental Conservation has recently initiated a rule-making on emissions from such sources. Timely research/analysis on this issue could be extremely useful in the development of effective policies and regulations that balance both energy and environmental objectives.

In addition, the need for more pro-active initiatives targeting **environmental improvements** were also suggested, including research on **mitigation** of acidified lakes, and the role of **biofuels** in improving air quality.

A description and rationale for each priority research need is presented in the following sections, along with a summary of the New York State relevance and relation to other research in the region and nation.

**TABLE 1. DEVELOPING AN ENVIRONMENTAL RESEARCH AND MONITORING STRATEGY FOR NEW YORK**  
**Outline of *Potential* Priority Research Areas**

**A. Atmospheric Deposition of Sulfur, Nitrogen, and Mercury, and Ecosystem Response**

Activity	Importance for NYS	Timing		EMEP Priority and Role
		Urgency	Duration (to results)	
<b>1.0 Baseline Monitoring/Characterization/Surveys</b>				
1.1. Characterize current conditions with respect to baseflow and episodic stream chemistry in sensitive watersheds Statewide to assess the extent and severity of effects, and to establish a baseline from which to assess future recovery.	1	1	3-5 yr	Build on current work in Catskills.
1.2. Characterize current soil conditions to assess effects and recovery potential of sensitive soils, and develop a soil database that supports other terrestrial and aquatic effects studies. Use historic soil data, where possible, to evaluate long-term changes in soil chemistry.	1	1	2-3 yr	Coordinate with ongoing federal and State activities.
1.3. Develop a strategic monitoring and assessment program on long term trends of mercury deposition and effects, Statewide, to understand the health and environmental consequences of mercury deposition.	1	1	TBD	Build on assessment in C1.
1.4. Monitor biota to evaluate recovery of aquatic food webs from plankton to piscivorous birds.	1	1-2	5+ yr	Coordinate with Adirondack Effects Assessment Program.
1.5. Assess the extent of effects of deposition on forest health in geologically sensitive areas of New York State.	1	2	3-5 yr	Leverage resources with USFS work nationally and locally.
1.6. Develop methodologies to improve accuracy of dry deposition measurements.	1	1	TBD	TBD
<b>2.0 Process-level Studies/Fate and Transport/Ecosystem Cycling/Modeling/Effects</b>				
2.1. Conduct assessments of the effects of acid deposition and Hg on biota and food webs; examine the effects of food web structure on elemental transfers to document biological effects of acid deposition.	1-2	1-2	2 - 4 yrs	Current EMEP project may begin Hg zoo-plankton analysis.
2.2. Identify multiple sources (including sources outside of NYS) and relative contributions of mercury; determine mercury ecosystem fluxes, transformation and transport, to assist in source reduction initiatives.	2	2	TBD	Wait on AER and SUNY results for source and transport
2.3. Examine interaction of biogeochemical cycles of nutrients (N, S, C, P, Ca) to identify potentially important but indirect effects of acid deposition.	2	2	2 - 4 yrs	TBD
<b>3.0 Synthesis/Integration Studies</b>				
3.1. Investigate landscapes as integrated ecological units by (1) describing linkages among their physical components; (2) examining approaches to extrapolating from small watershed or plot scales to larger units; (3) determining whether the small number of well-studied sites in some parts of New York are representative of larger areas.	1	1-2	2 -3 yrs	Good opportunity to expand on intensive site research in NYS
3.2. Synthesis and assessment of current information and study site data regarding key issues related to the effects from acid rain and mercury.	1-2	1-2	2 - 3 yrs	Hubbard Brook has ongoing N project, may be early for Hg
3.3. Comprehensive, state-of-science synthesis of acid rain and mercury impacts in New York State.	3	2-3	2 - 4 yrs	Will there be enough Hg data for synthesis?

Activity	Importance for NYS	Timing		EMEP Priority and Role
		Urgency	Duration (to results)	
<b>4.0 Other (Mitigation, Policy/Economic Assessments, Technology Transfer)</b>				
4.1. Conduct modeling to determine critical and target loads.	1-2	1-2	3 yrs	Build on NE/Canada and DEC project
4.2 Assess the effectiveness of cross-sector pollution control strategies in reducing ecological impacts and enhancing recovery.	1-2	1-2	2-3 yrs	TBD
4.3. Assess the economic value of natural resource improvements (aquatic and terrestrial) associated with air pollution control.	2	1-2	2-3 yrs	Coordinate with Resources for the Future project
4.4. Demonstrate techniques for accelerated recovery.	1-2	1-2	3-5 yrs	TBD

## B. Air Quality and Related Health Research: Particulate Matter, Ozone and Co-Pollutants

Activity	Importance for NYS	Timing		EMEP Priority and Role
		Urgency	Duration (to results)	
<b>1.0 Ambient Monitoring and Evaluation</b>				
1.1. Develop and integrate improved measurement technologies, including technologies for higher time-resolution composition measurements into network design (2-3 key locations).	2	2 (driven by C.1 outcome)	2-3 yrs	TBD
1.2. Develop coarse particle (PM10-PM2.5) monitoring data and source-receptor relations for to help New York State comply with likely coarse particle standard.	2-3	2 (need measurement protocol)	3 yrs to useful data; duration of monitoring TBD	TBD
1.3. Analyze long-term archived PM filter samples to establish long-term trends, baselines, support source apportionment and transport assessments.	3	2	1-2 yr	TBD
<b>2.0 Fate and Transport</b>				
2.1. Develop, apply and interpret PM/Ozone models and data analysis methods to support policy formulation for PM and ozone management.	1	1 (model evaluation priority)	2-3 yrs for model application/ evaluation using existing data; 3-5 yrs+ for dev. of adv. modeling systems	Build on Supersites and other PM field studies.
2.2. Improve understanding of the role of primary & secondary organics in PM in New York State.	1	1 (method development priority)	3-5 yrs for lab/mechanism studies; 3-5 yrs for methods dev.; 1-2 yrs for selected source characterization; 3-5 yrs for field measurements	Build on Supersite and other PM field studies.

Activity	Importance for NYS	Timing		EMEP Priority and Role
		Urgency	Duration (to results)	
2.3. Improve understanding of transport phenomena, specifically aloft and at night.	1	2	1-3 yrs using existing data; 1-2 yr for field study (cloud convection, PBL dynamics, and nocturnal flow)	Would require national cofunding given fundamental nature of research.
2.4. Explore co-pollutant interaction and multi-pollutant effects related to pollution control.	2	2 (driven by dev. under B2.1)	2-3 yrs for existing data analysis, model appl. & dev. of optimized control scenarios; 3-5 yrs for lab/field studies; 5yrs + for augmented field measurements for tracking effectiveness	Build on current national efforts to develop integrated modeling framework.
2.5. Explore feasibility of alternative air quality management strategies on different time scales (e.g., forecasting and real-time control).	2-3	2	2 yrs to demo forecast model using existing data; 2-3yrs to dev. real-time emission projections capability; 3-5 yrs to bring models into use	TBD
<b>3.0 Health Effects</b>				
3.1a. Support the integration and analysis of relevant PM Supersite/network data with exposure/health effects studies.	1	1-2 (dep. on data avail.)	2-3 yrs per study	Build on Supersites and other PM field studies.
3.1b. Support the integration of source attribution methods of PM into exposure/health effects studies (methods development, technology transfer) [relates to 2.1].	1	1-2	TBD	TBD
3.2. Explore feasibility of a targeted cohort study to examine exposure and health effects to “line exposure” from mobile sources.	1	1-2	2-3 yrs	TBD
3.3. Better understand the patterns of, and factors influencing, dose and human exposures to pollutants of ambient origin.	1-2	1-2	TBD	Coordinate with ongoing studies
3.4. Support critical research to identify causal components in PM.	2	2	3-5 yrs	Significant national investment ongoing.
3.5. Develop long-term data for black carbon as surrogate for diesel exposures/Develop exposure data for diesel PM urban environments.	3	2	2 yrs for exploratory studies; +3 yrs for more def. analysis	TBD
<b>4.0 Source Emissions, Technology and Policy Analysis</b>				
4.1. Support method development and characterization of sources of primary and secondary PM emissions impacting NYS.	1	1	2-3 yrs	Build on current EMEP project.
4.2. Integrated assessment of PM in NYS to provide scientific foundation for SIP development.	1	2 (data avail.)	TBD	Build on Supersite/ regional field studies.

Activity	Importance for NYS	Timing		EMEP Priority and Role
		Urgency	Duration (to results)	
4.3. Develop standard test method for particle size distribution for mobile sector emissions: test stand and in-use	2	1	TBD	Significant DEC test program.

### C. Research Needs Crosscutting the Topics of Air Quality, Health and Ecosystem Response

Activity	Importance for NYS	Timing		EMEP Priority and Role
		Urgency	Duration (to results)	
1. Assess adequacy of existing monitoring networks as they relate to (i) source attribution, (ii) determining transport, (iii) evaluating health and environmental effects, and (iv) verifying the impacts of changes to pollution controls strategies on air quality.*	1	1	1 yr	Would require regional/national coordination to maximize value.
2. Evaluate Environmental Effects and Strategies for Mitigation of Electricity Generation	1	1	TBD	Primary EMEP priority
3. Evaluate the environmental and energy implications of the distributed generation of electricity in New York State.	1	1	1 yr	TBD
4. Maintain and initiate, where necessary, measurements of fine particulates/precursors, wet and dry deposition of sulfur and nitrogen, and base cations at specific long-term study sites, building on assessment in C1 above.*	1	2 (driven by C1 outcome)	TBD	Would build on existing networks and require regional/ national coordination to maximize value.
5. Identify multiple sources and relative contributions of fixed nitrogen, including ammonia, to NYS ecosystems; examine watershed retention of nitrogen, to assist in source reduction initiatives; improve understanding of the sources of ammonia and role in aerosol formation in NYS - including inventory development and exploration of mitigation options.	1	1	TBD	Build on work underway at Hubbard Brook, Supersite, and MARAMA.
6. Develop evaluation protocols to verify the impacts of pollution control strategies.	2	2	TBD	TBD
7. Assess the feasibility and cost effectiveness of multi-pollutant control strategies for existing generation infrastructure in NYS.	2	1-2	2-3 yrs	Should build on national evaluations and focus on NYS.
8. Evaluate potential effects of emissions trading (e.g. Hg, PM precursors, etc.) on local/regional impacts.	3	2	2-3 yrs	TBD
9. Evaluate the environmental impacts of biodiesel in NYS	2	2	<1yr	EMEP focus on stationary

\*EMEP focus would be on evaluating networks, developing advanced measurement methods, and supporting intensive study sites.

Importance: 1 = critical/extremely important; 2 = important; 3 = moderately important

Timing/Urgency: 1 = immediate need; 2 = intermediate term need; 3 = deferred need

# A. Atmospheric Deposition of Sulfur, Nitrogen, and Mercury, and Ecosystem Response

## SECTION A1.0 - BASELINE MONITORING/CHARACTERIZATION/SURVEYS

**Topic A1.1 Characterize current conditions with respect to baseflow and episodic stream chemistry in sensitive watersheds Statewide to assess the extent and severity of effects, and establish a baseline from which to assess future recovery.**

Description and Rationale: Episodic acidification in streams has been generally accepted as having an effect on aquatic biota that is similar to chronic acidification. The majority of the acid export from watershed to stream in any given year occurs during high-flows, so traditional methods of periodic stream sampling at base flow do not adequately measure the extent of acidification in New York watersheds. Accurate characterization of stream chemical condition within New York State therefore requires a comprehensive monitoring and survey strategy that captures trends in both base flow and storm flow chemistry. This type of sampling program in New York has been limited, and therefore the extent of stream-water acidification in New York remains uncertain, but could be large. A recent assessment of the Neversink River in the Catskill region found that only 16% of the stream reaches were acidified at baseflow, whereas at high flow 82% of the stream reaches are acidic. This action item would promote projects to develop a network of stations for assessing the current status of base-flow and episodic acidification in New York State.

New York State Relevance: New York State receives among the highest rates of acidic deposition in the United States, and also contains many watersheds with soils that lack sufficient acid neutralizing capacity to protect stream streams from acidification. The Adirondack and Catskill Mountains of New York have been focal points for acid deposition research in the United States because of the extensive evidence of damage by acidification in those areas.

Relation to Other Research in the Region and Nation: The proposed network should parallel integrated monitoring efforts underway in the Catskill Mountains. The Collaborative Environmental Monitoring and Research Initiative (CEMRI) is being piloted in the Delaware River Basin as a potential national integrated monitoring strategy. In addition, the Adirondack Lakes Survey Corporation (ALSC) is currently conducting some limited episodic acidification studies.

**Topic A1.2 Characterize current soil conditions to assess effects on sensitive soils, and in doing so, develop a soil database that supports other terrestrial and aquatic effects studies. Use historic soil data, where possible, to evaluate long-term changes in soil chemistry.**

Description and Rationale: Monitoring and assessment of acidic deposition effects in New York State has focused on the chemistry of lakes, and to a lesser extent, streams, which, although related to soil chemistry, are often not an accurate reflection of the soil chemistry within a watershed. Characterization of soil chemistry in New York has generally been done only in selected, intensive study watersheds or plots, or in the U.S. EPA Direct Delayed Response Program (DDRP), which included the entire Northeast, but at a sampling density that was insufficient to characterize soils within the sensitive areas of New York. Because an assessment of soil chemistry in the acid-sensitive regions of New York has not been undertaken, the extent of acid rain effects on terrestrial ecosystems remains uncertain, as does the response of soils to declining levels of deposition over the past 3 decades.

New York State Relevance: New York receives higher levels of acidic deposition than any other state in the Northeast, and is likely to have been most effected (Pennsylvania being a close second). These effects include changes in soils (such as calcium depletion), which are an integral component of the

landscape that plays a major role in controlling surface-water quality and forest nutrition and health. The lack of a comprehensive assessment of soil effects greatly limits our understanding of the overall environmental effects of, and recovery from acid rain in New York.

Relation to Other Research in the Region and Nation: A comprehensive assessment of soils effects in New York would provide important information for national acid rain policy makers by combining with the soil assessment work that is currently being conducted by the U.S. Forest Service in Pennsylvania and New Hampshire. This work might prompt similar work in other states where acid sensitive regions exist. Significant opportunity exists for combining resources to conduct a comprehensive soil assessment in New York through ongoing federal and state activities. Other federal projects are also under way at locations in the Catskill region to investigate relationships between soil chemistry and sugar maple health. Coordination of data collection in these studies could fulfill a significant fraction of the effort needed for a comprehensive statewide assessment of forest soils.

**Topic A1.3      Develop a strategic monitoring and assessment program on long term trends of mercury deposition and effects, statewide, to understand the health and environmental consequences of mercury deposition.**

Description and Rationale: There are several proposals at the national level to establish mercury emission controls in the utility sector. A long-term monitoring program, including baseline evaluation, is essential to assess the consequences of emission controls. Currently the only program in place to evaluate effects of mercury emission controls is the Mercury Deposition Network (MDN). A program is necessary to monitor long-term trends in mercury in the environment. This program would involve the integrated measurement of atmospheric mercury deposition, mercury in soil, mercury in surface waters and mercury in fish and other biota. Additional survey data would be helpful for identifying waters which should have fish consumption advisories, and may pose a threat to wildlife. This mercury monitoring program could be linked to the development and application of mercury cycling models and should be coordinated with the assessment of monitoring networks and needs in Topic C1a above.

New York State Relevance: Many lakes in New York have advisories due to high levels of mercury in fish tissue. This problem is particularly widespread in the Adirondack and Catskill regions. As in the case of acid deposition, New York is likely to be a receptor area for mercury from Midwestern coal-fired power plants. At the same time, coal-fired power plants in New York State are sources for the state and downwind regions. Mercury also clearly is transported into New York State from Canada (Olmez *et al.*, Environ. Sci. Technol. 1998, 32, 3048-3054) and thus, policy makers in New York State must be able to determine the relative contributions of in-state, out-of-state sources, and global sources to the observed mercury species concentrations. Information on mercury levels from specific waters in the State will directly assist local residents, resource consumers and the NYSDEC in making wise decisions on the use of the resource.

Relation to Other Research in the Region and the Nation: The national program for research on the transport, fate and effects of mercury in the environment is supported by the U.S. Environmental Protection Agency STAR program. Through this program several major research initiatives on mercury are underway. The U.S. EPA also funds relevant research on mercury through the REMAP program. Weekly precipitation samples are currently being monitored for mercury concentrations at the MDN site at Huntington Forest in the Adirondacks. A second site is scheduled to be added in the Catskills. Mercury data in New York State are being collected at Sunday Lake, Potsdam, Stockton, and a few other sites in the Adirondacks, with EMEP support. The USEPA and other states have used New York fish contaminant monitoring data for numerous reports and studies (NESCAUM Mercury Study, USEPA Mercury Report to Congress)



**Topic A1.4 Monitor biota to evaluate recovery of aquatic food webs from plankton to piscivorous birds.**

Description and Rationale: The examination of recovery in aquatic systems from damage caused by atmospheric deposition has focused almost exclusively on water chemistry. As more aggressive emission controls are implemented, the assessment of aquatic biota will be essential in order to determine whether ecosystem recovery has been achieved. This effort would examine different levels of biota that live in, and depend on, aquatic systems impacted by acid deposition to document short-term and long-term changes in ecosystem structure and function as deposition is reduced and recovery progresses.

New York State Relevance: New York State has suffered a tremendous amount of ecosystem damage from acidic deposition. Although chemical recovery of aquatic ecosystems is important, it is only part of the recovery process. Changes in the structure and function of aquatic biota will signal the return of healthy ecosystems.

Relation to Other Research in the Region and Nation: Currently, the Adirondack Effects Assessment Program (AEAP), implemented in 1994, is examining recovery in the biota of aquatic ecosystems impacted by acid deposition. It is focused on the southwest quadrant of the Adirondack Park, and is scheduled to continue monitoring through 2006. The Adirondack Lakes Survey Corporation (ALSC) has also recently conducted surveys to document changes in fish populations in the North Branch Moose River watershed, and is comparing this data to earlier surveys. The effort outlined here should build on the efforts achieved by the AEAP during the period 1994-2006, the ALSC and others.

**Topic A1.5 Assess the effects of deposition on forest health in geologically sensitive areas of New York State.**

Description and Rationale: Acid rain effects research has demonstrated that (1) acid fog damages foliage, (2) depletion of Ca and Mg (essential tree nutrients) from the soil, has been documented within New York State, (3) biochemical indicators of stress in foliage of red spruce trees are found in soils with low amounts of available Ca, (4) trends in Ca concentrations in wood tissue of red spruce trees are consistent with theorized changes in soil chemistry over the past 100 years, and (5) nitrogen, normally a growth limiting nutrient for forests, is accumulating to levels at which nitrification is stimulated, a condition which leads to surface water acidification and negative effects on tree growth. This information strongly suggests that acid rain is affecting tree growth in New York. The degree to which this is occurring is uncertain, but could be significant because much of the New York Forest grows in the geologically sensitive areas of the Adirondacks, Catskills and Allegheny plateau.

New York State Relevance: Effects on tree growth are important in New York for its substantial forest products industry and the protection of water quality for both recreational uses and drinking water supplies.

Relation to Other Research in the Region and Nation: Other states in the Northeast and Mid-Atlantic have reported dieback of species such as sugar maple and red spruce that is likely to be related to additional stress caused by acidic deposition. Assessment work in New York would support and be supported by effects studies on trees that are underway in northern New England, and Pennsylvania. There is significant potential for leveraging resources through collaboration with several U.S. Forest Service Research Projects that are active in the southwest Catskills and Allegheny Plateau, as well as the national survey's that the U.S. Forest Service is conducting that include New York.

**Topic A1.6 Develop methodologies to improve accuracy of dry deposition measurements.**

Description and Rationale: Oxides of nitrogen (N) and sulfur (S) are emitted to the atmosphere and are deposited downwind of their sources via wet (rain and snow), dry (gases and particles) and in some locations cloud or fog deposition. Dry deposition often constitutes 50% or more of total deposition of S or

N to an ecosystem. The technologies currently available to measure dry deposition are inadequate resulting in measurements with large uncertainties. Better methodologies and protocols are needed in the near term. Also, due to an insufficient number of dry deposition monitoring stations in New York State, additional sites should be installed, using accepted protocols.

New York State Relevance: The density of dry deposition monitoring stations in New York is inadequate, and not all are operated by the same organization. There are no current efforts to increase the density of dry deposition monitoring networks in New York. In addition, the inability to estimate total deposition to complex terrain severely constrains the ability to accurately assess atmospheric loading to ecosystems. The success of efforts to expand dry deposition in New York State and provide reliable data are dependent on the better measurement techniques and protocols.

Relation to Research in other Regions and Nation: (See relation statement in Topic C1)

## **SECTION A2.0 - PROCESS-LEVEL STUDIES/FATE AND TRANSPORT/ECOSYSTEM CYCLING/MODELING/EFFECTS**

### **Topic A2.1 Conduct assessments of the effects of acid deposition and mercury on biota and food webs; examine the effects of food web structure on element transfer to document biological effects of acid deposition.**

Description and Rationale: Much of the current research effort and monitoring underway in New York and throughout the US emphasizes the effects of acid precipitation and mercury deposition on water chemistry and the biogeochemical cycling of elements and nutrients. Little of this work involves studies of biota such as fungi, phytoplankton, and zooplankton. A clearer indication of the impacts of atmospheric deposition in New York may be obtained by examining the cascading effects of acid and mercury deposition on biota as they are linked through the food web. This research will need to be placed within the context of the role of biota in the biogeochemical cycling of elements that regulate acidification processes, mercury transport, and the resulting deleterious impacts on ecosystem health and water quality. A project goal should be to provide a greater understanding of the biological resources at risk as a result of atmospheric deposition of acids and mercury to provide a stronger basis for effective management strategies. There is also a need to integrate existing data on biota with what is known about acidification processes, and other documented effects of acid deposition.

New York State Relevance: The number of biological resources at risk from current levels of atmospheric deposition of acids and mercury will provide a stronger basis for potential future emissions reductions. Resource managers need to know if reductions in atmospheric sulfur deposition will lead to reductions in mercury methylation and reduced mercury levels in fish and other aquatic organisms.

Relation to Research in other Regions and Nation: This research should build on existing work in New York State, and include significant leveraging of funds. Similar research is needed and is likely to proceed in other regions with sensitive ecosystems such as mountainous areas of the southeast, mid-Atlantic states, and Colorado.

### **TOPIC A2.2 Identify multiple sources and relative contributions of mercury; determine mercury ecosystem fluxes, transformation and transport, to assist in source reduction initiatives. Use data collection and modeling to predict environmental responses under different deposition scenarios.**

Description and Rationale: Mercury is emitted to the atmosphere from fossil fuel combustion and other anthropogenic (e.g., incineration, chlor-alkali facilities) and natural processes. Subsequent atmospheric deposition of mercury contributes to the supply of mercury to surface waters and sediments. It is evident

that considerable mercury has accumulated in soil as a result of atmospheric deposition, although the ultimate fate of this mercury is unclear. Under reducing conditions sulfate reducing bacteria convert inorganic mercury to methyl mercury, which bioconcentrates within the aquatic food chain. Methyl mercury is a powerful neurotoxin and human exposure largely occurs through the consumption of fish. There are important linkages between acidic deposition and mercury. For example, in regions experiencing surface water acidification, concentrations of mercury in fish increase with decreases in lake pH. A better understanding is needed of the transformation of atmospheric sources of mercury into biologically active methyl-mercury, and the role of sulfur from acid deposition in the methylation process. Models could be useful in assessing the fate and effects of atmospheric mercury deposition on natural resources and predicting the response of ecosystems to mercury emission controls.

New York State Relevance: As part of the Clean Air Act Amendments of 1990, New York State has reduced emissions of mercury from municipal and medical waste combustion and other sources. However, fish consumption advisories have been issued by the New York State Department of Health for 30 bodies of water throughout the state. Additional testing of fish may reveal an even larger number of water bodies for which fish consumption should be restricted. The proposed effort would provide information which could lead to development of more effective mercury control strategies.

Relation to Research in other Regions and Nation: Human health concerns associated with atmospheric deposition of mercury are ubiquitous throughout the United States. Research on mercury performed in New York will complement studies currently underway throughout the U.S.

**Topic A2.3 Examine interaction of biogeochemical cycles of nutrients (N, S, C, P, Ca) to identify potentially important but indirect effects of acid deposition.**

Description and Rationale: Recent research has revealed many second order effects from acidic atmospheric deposition including depletion of soil base cations and consequent deleterious effects on sugar maple. Many of these potential second order effects of acid deposition have yet to be thoroughly investigated, but are important to gain a more complete understanding of the effects of acidic deposition. Studies that examine the linkages between the cycles of multiple nutrients have the potential to more thoroughly evaluate the manner in which acid deposition alters nutrient cycling processes in sensitive ecosystems. Additionally, the recovery of aquatic ecosystems from reduced levels of atmospheric sulfate deposition over the past two decades has been slower than originally predicted, and the interaction of multiple element cycles must be considered to accurately predict future recovery.

New York State Relevance: Ecosystems in New York receive among the highest rates of acidic atmospheric deposition in North America. Additionally, New York contains large areas in the Adirondacks and Catskills that are especially sensitive to acidic deposition. Therefore, New York is one of the most likely locations to experience alteration of nutrient cycles caused by acidic deposition, especially as atmospheric nitrogen inputs become more dominant. Water resource managers in New York State need information on whether current and planned emissions reductions will be adequate to allow previously acidified aquatic and forested ecosystems to recover.

Relation to Research in other Regions and Nation: Other areas with high rates of acidic atmospheric deposition combined with sensitive ecosystems include the Allegheny Highlands of Pennsylvania, the Great Smoky Mountains of Tennessee and North Carolina, and the Blue Ridge of Virginia. Past and current research underway in these regions examining the relation of acid deposition to multiple nutrient cycles will complement work supported under this topic in New York.

## SECTION A3.0 - SYNTHESIS/INTEGRATION STUDIES

**Topic A3.1 Investigate landscapes as integrated ecological units by: (1) describing linkages among their physical components; (2) examining approaches to extrapolating from small watershed or plot scales to larger units; and (3) determining whether the small number of well-studied sites in some parts of New York are representative of larger areas (physiographic unit, state, or region).**

Description and Rationale: Individual studies of air pollution deposition effects are often conducted on the plot or small watershed scale for reasons of convenience (established boundaries for mass-balance accounting) or for the establishment of identifiable geographic entities (single lake, stand of trees, etc.). However, individual elements or sites often have sharply different characteristics, including the potential to act as sources vs. sinks for particular materials. Several approaches have proven useful to "assemble" knowledge of these relatively small units in a way that improves understanding of larger units.

Characterizing a large area with a small number of intensively-studied sites is a common issue and is generally approached through a combination of process studies, surveys, and monitoring. It is important to know whether the sites used to generate some model or relationship span the range in independent variables for the state/region. For both these reasons, being able to place these "intensive" sites in a broader context becomes valuable.

New York State Relevance: Funding agencies have expended resources and researchers have committed time to individual air pollution effects studies in New York and their ultimate value is greatly increased if they can be placed in a broader context. Because of time and money constraints, obtaining the desired coverage of detailed study sites may never be achieved, and developing approaches for extrapolating (or knowing when not to extrapolate) will provide great benefits.

Relation to Other Research in the Region and Nation: Issues of scaling, linkage and representativeness are important nationwide and globally. Efforts along these lines in New York State can benefit from work elsewhere and also contribute fundamentally to solution of these problems.

**Topic A3.2 Synthesis and assessment of current information and study site data regarding key issues related to the effects from acid rain and mercury.**

Description and Rationale: There are several topic areas that are considered key to understanding the air pollution effects in New York that may be associated with sulfur, nitrogen, and mercury deposition. These topics have been and are the subject of intensive research efforts and/or play significant roles in process-based model formulations. Knowledge in these areas is evolving rapidly. The major topic areas of interest include:

- Base cation depletion from forest soils as a consequence of acidic deposition and land use,
- Chemical and/or biological recovery of surface waters in response to decreased sulfur deposition,
- Sources and sinks of mercury,
- Retention of atmospherically-deposited nitrogen in forested and mixed-land use watersheds,
- Interactions between natural sources of acidity (including organic acids associated with wetlands) and atmospheric deposition in acidified watershed systems.

Research is needed to synthesize the results of recent and on-going site-specific studies within New York. The resulting documents will help in the interpretation of the results of individual studies and will be useful to guide additional research.

New York State Relevance: New York is the site of numerous studies, many of which have been long-term and focused on developing a better understanding of the above-indicated topic areas. Model input data, for multiple biogeochemical air pollution effects models, are available for many watersheds that receive significant deposition of sulfur, nitrogen, and mercury. Thus, New York is an appropriate state in which to continue such studies and for which synthesis efforts will be timely and useful.

Relation of Other Research in the Region and Nation: Research on these topics is being carried out in many areas, including the Appalachian Mountain region, northern New England, and throughout northern Europe. A major synthesis and modeling effort is currently underway, as part of the Southern Appalachian Mountains Initiative (SAMI). Commonalities and differences elsewhere will provide a valuable basis for assessment within New York.

### **Topic A3.3 Comprehensive, state-of-the-science synthesis of acid rain and mercury impacts in New York State.**

Description and Rationale: There is a need to undertake efforts to synthesize and integrate existing data and information on the inputs, outputs and effects of sulfur, nitrogen and mercury deposition in New York State. While primary research is critical to advancing scientific understanding of biogeochemical cycles, synthesis activities are needed to summarize this understanding in a way that is clear and accessible to the research community and policymakers. Three state-of-the-science products are needed, two targeted to the research community and one targeted to policy makers and the public:

- State-of-science synthesis on nitrogen and sulfur deposition and effects (chemical and biological) in the Adirondack and Catskill Mountains,
- State-of-science synthesis on mercury deposition, cycling, and effects throughout New York, and
- Outreach summary (interpretive report geared to a nontechnical audience) regarding policy-relevant aspects of mercury fluxes, transformations, and health implications.

Products should emphasize what is known, what is not known, spatial patterns, temporal (long-term, annual, seasonal, episodic) trends, on-going monitoring efforts, monitoring needs, research needs, and major knowledge gaps.

New York State Relevance: As a state that receives high deposition of these pollutants, New York State has an interest in furthering the scientific understanding of these issues. Moreover, the New York legislature, administration, and congressional delegation are very active in advancing pollution control policies to benefit New York State. Such activities serve to elucidate the nature and extent of the problem, guide research activities, educate policymakers and the public, and provide a tool to evaluate the effectiveness of potential policy options. In some cases, synthesis activities are combined with outreach work to translate and disseminate the findings.

Relation to Other Research in the Region and Nation: Synthesis projects specific to New York State would relate to ongoing and completed projects undertaken by EPA, USGS, NYSDEC, NAPAP, Adirondack Park Agency, Hubbard Brook Research Foundation, Institute of Ecosystem Studies and others in recent years. EMEP is currently supporting two synthesis projects - one focusing on nitrogen pollution in the Northeast, the other focusing on acid rain in New York. The proposed effort would build on these studies.

## **SECTION A4.0 - OTHER (MITIGATION, POLICY/ECONOMIC ASSESSMENTS, TECHNOLOGY TRANSFER)**

### **Topic A4.1 Conduct modeling to determine critical and target loads.**

Description and Rationale: In the U.S., pollution regulations have been geared toward controls on emissions. However, the ecologically important measurement to achieve recovery is the amount of deposition a landscape or water body receives. In Europe, the critical loads approach has been used to determine what loading rates are critical to sustaining a healthy ecosystem. Advances have been made in understanding the relevance of this approach to the U.S. and more has been learned about the application of critical loads to forest ecosystems. This analysis would apply state of the art deposition modeling to determine critical loads for N, S and mercury from an ecosystem perspective and then use input and information from policy experts and/or economists to recommend a target load for those elements. The target load is that load which regulators will aim to achieve given the ecological, policy and economic factors.

New York State Relevance: This work could provide information to help with the development of a total maximum daily load (TMDL) program in New York State for critical waterbodies.

Relation to Other Research in the Region and Nation: The New England Governors and Eastern Canadian Premiers have initiated a forest mapping project in the Northeast and Eastern Canada to determine critical loads for forests in this region. New York State Department of Environmental Conservation (NYSDEC) is currently supporting a pilot TMDL study for an acidified lake in the Adirondacks.

### **Topic A4.2 Assess the effectiveness of cross-sector pollution control strategies in reducing ecological impacts and enhancing recovery.**

Description and Rationale: A wide range of pollution control options are under consideration at the state and federal level, yet there does not exist an assessment of the relative value of each in reducing ecological impacts. This assessment would consider the merits of controls on various sources (generating plants versus mobile sources), the potential ecological impacts of trading of S, N and mercury, and the effect of short and long-term implementation plans on recovery of terrestrial and aquatic ecosystems in New York State. This project would also investigate the effects of various pollution control options on ecological structure and function. Other co-benefits, (e.g. effect on visibility/haze) should also be addressed, if possible. A multidisciplinary team will likely be needed to conduct this work.

New York State Relevance: New York State ecosystems have been adversely affected by mercury and acidic deposition. Information about the relationships between pollution control strategies and ecosystem effects could assist in an expedited resource recovery, resulting in healthier and more diverse biological communities.

Relation to Other Research in the Region and Nation: Information from this effort would be useful for policy makers and resource managers in other northeastern states, Canada and other countries.

### **Topic A4.3 Assess the economic value of natural resource improvements (aquatic and terrestrial) associated with air pollution.**

Description and Rationale: Considerable effort has been made to understand and document the ecological impact of atmospheric deposition on aquatic and terrestrial ecosystems as well as on physical infrastructure and human health. However, little emphasis has been placed on understanding and quantifying the economic effect of these impacts. This project would examine the natural resource

economics to describe and quantify the cost of long-term pollution with respect to aquatic, terrestrial, health and materials resources. This information will be critical to understanding the societal impact of atmospheric deposition.

New York State Relevance: A more complete picture of the value of reduced pollution in New York State would be helpful to policy makers and researchers as mitigation options are being considered.

Relation to Other Research in the Region and Nation: Researchers at Resources for the Future are working to quantify in monetary terms the change in total economic value (the sum of use and non-use value) that would result from a change in the attributes of the Adirondack Park that might be affected by increased or diminished air pollution deposition.

#### **Topic A4.4 Demonstrate techniques for accelerated recovery.**

Description and Rationale: As pollution controls are implemented and acidic deposition reduced, it is an opportune time to consider options for accelerating the recovery of aquatic and terrestrial organisms, and forest ecosystems in New York State. This project would experiment and demonstrate various options for accelerating recovery, such as calcium additions, re-introductions, and forest/watershed management strategies. This could include addressing other related water quality issues such as nitrogen leaching. Alternative strategies for improving water quality would be evaluated. Lessons should be shared with other resource managers to encourage proactive improvement of environmental conditions as deposition reductions are achieved.

New York State Relevance: Aquatic resources in New York State have been adversely affected by acidic deposition and calcium concentrations in watersheds have decreased due to long-term acidification impacts. If the rate of recovery can be increased, then the resource would be restored sooner, resulting in healthier and more diverse biological communities. The 30 to 40 ponds already in the NYSDEC liming program provide additional waters for recreational fishing which would not otherwise be available. The liming program is intended to be a management tool and not an alternative to emission reductions.

Relation to Other Research in the Region and Nation: Research findings from efforts to accelerate recovery of aquatic ecosystems would be useful for resource managers in other northeastern states, Canada and other countries. Other regions have also been impacted by acidic deposition and would benefit from information on restoring these ecosystems as quickly as possible.

## **B. Air Quality and Related Health Research: Particulate Matter, Ozone, and Co-Pollutants**

### **SECTION B1.0 - AMBIENT MONITORING AND EVALUATION**

#### **Topic B1.1 Develop and integrate improved measurement technologies, including technologies for higher time-resolution composition measurements, into network design.**

Description and Rationale: Highly time resolved data representative of the area in which people are exposed are needed to examine the relationship between constituents in airborne particulate matter and health effects. The National Ambient Air Quality Standard for fine particulate matter (PM<sub>2.5</sub>) arose primarily because of observed statistical relationships between measured PM<sub>2.5</sub> concentrations and reported mortality and morbidity. Recent toxicology experiments in which animals are exposed to concentrated ambient PM<sub>2.5</sub> have shown different level of effects, suggesting that specific constituents in the particles are the cause of the observed effects. To assess these relationships, it is necessary to collect data over a

sufficiently long interval that there are an adequate number of reported health effects. In prior studies, this minimum time is of the order of three years.

One of the significant problems with regulating PM is the integrating time for which the standard is set. The bulk of the existing data is for 24 hour intervals. Only recently has the technology been available for continuous mass monitoring of airborne particles and some specific constituents (SO<sub>2</sub>, NO<sub>x</sub>, OC/EC/TC). There have also been some initial studies indicating that exposure to short duration and high concentrations are related to health effects (Dolphin *et al.*, 1998; Morgan *et al.*, 1998; Simpson *et al.*, 1997). Thus, we need both composition data on a highly time resolved basis.

New sampling and analysis techniques permit the estimation of elemental compositions on time scales of as little as 15 minute intervals. Real-time monitoring of ultrafine particle (diameters less than 0.1 μm) number concentration (NC) is also needed to assess health effects. Wichmann *et al.* (2000) found significant associations of elevated cardiovascular and respiratory disease mortality with various fine (and ultrafine) particle concentration indices evaluated in Erfurt, Germany. In this study, significant associations were found between mortality and ultrafine particle number concentration (NC), ultrafine particle mass concentration (MC), fine particle mass concentration, or SO<sub>2</sub> concentration. The correlation between MC0.01- 2.5 and NC0.01- 0.1 is only moderate, suggesting it may be possible to partially separate effects of ultrafine and fine particles.

New York State Relevance: Augmenting monitoring programs associated with exposure and other health-related research may be useful in indicating possible causal linkages as described in Topics B3.3 and B3.4. This coupled with source/receptor modeling may provide information to base source-specific emission control regulations by NYSDEC as part of SIPs.

Relation to Other Research in the Region and Nation: There are measurements using such techniques as part of the various supersite efforts that are taking place in New York City, Pittsburgh, Baltimore, St. Louis, Houston, Fresno, and Los Angeles. These measurements are also on-going in the Southeastern Aerosol Research Characterization (SEARCH) Program (Atlanta, Birmingham, Gulfport, and Pensacola and paired rural sites), and by the Harvard School of Public Health (HSPH) in Cambridge, and Philadelphia. With the exception of SEARCH and HSPH, the measurements are being conducted over a relatively short time interval (1 to 1.5 years). Although the New York City Supersite activity is planned to continue, there has not yet been a single fixed site that will be maintained over an extended time period.

**Topic B1.2      Develop coarse particle (PM<sub>10</sub>-PM<sub>2.5</sub>) monitoring data and source-receptor relations for to help New York State comply with likely coarse particle standard.**

Description and Rationale: The US EPA will be changing its NAAQS for coarse particles in 2003 and will likely promulgate a PM(10-2.5) standard to replace the current PM<sub>10</sub> standard. At this time there is relatively sparse data available on the concentration and composition of coarse particles (that deposit in the thorax) in New York State and nationwide. In advance of the development of new sampling technology for a new coarse particle fraction (PM<sub>10</sub>-PM<sub>2.5</sub>), current generation dichotomous samplers could be deployed at one location in New York State to provide information on the concentrations and compositions of PM(10-2.5) particles in ambient air in New York State. Co-locating these samplers at sites with concurrent measurement of concentration of and composition of PM<sub>2.5</sub> and PM<sub>10</sub> that are linked to health effect studies would increase what can be learned.

New York State Relevance: Provide needed information to assess impact of potential new regulations on State Implementation Plans. Since New York State is a leading manufacturer of air monitoring equipment, efforts to develop improved sampling methods for PM(10-2.5) could provide significant economic benefits though the commercialization of new sampler developments.

Relation to Other Research in the Region and Nation: Currently, this activity is not being undertaken in the region nor nationally. The EPA plans for compliance monitoring for their new coarse particle NAAQS will be to site two samplers (PM<sub>10</sub> and PM<sub>2.5</sub>) side-by-side and estimate the coarse particle concentration



by difference. This, however, will not provide samples of coarse particles for chemical or biological characterization. There are no continuous monitors currently available for PM(10-2.5) measurement. If a new coarse particle standard is proposed, research funds may be provided by EPA to support ambient monitoring activities.

**Topic B1.3 Analyze long-term archived PM filter samples to establish long-term trends, baselines, support source apportionment and transport assessments.**

Description and Rationale: Archived filter samples from past monitoring programs may provide a means to establish long-term trends, baselines and to support source apportionment and transport assessments. It is important to know if actions taken to improve air quality actually result in the expected changes in atmospheric concentrations. Given the natural variability of the atmosphere, it is generally necessary to collect data over a long time in order to ascertain trends.

New York State Relevance: Re-analysis of archived samples can provide long term trend information on number of parameters such as metals which can be used for source apportionment as well.

Relation to Other Research in the Region and Nation: (See relation statement in Topic C1)

## **SECTION B2.0 - FATE AND TRANSPORT**

**Topic B2.1 Develop, apply and interpret PM/Ozone models and data analysis methods to support scientifically sound policy formulation for PM and Ozone Management.**

Description and Rationale: Recent extensive research measurements underway as part of NYSERDA and cooperative federal and state-sponsored programs (i.e. PMTACS-NY Supersite and other regional Supersites (in Baltimore and Pittsburgh) and the network of Speciation Sites in the northeastern U.S.) will provide a rich data base for the evaluation and further development of photochemical air quality simulation models (PAQSM) anticipated for use in formulating air quality management plans for PM and ozone. Current PAQSM have undergone testing and evaluation with regard to ozone prediction, but require method development to discern the anthropogenic signal in ambient pollutant data to better quantify the impact of emission controls on air quality. In addition, little if any performance testing has been considered for PM. The present generation PAQSM have rudimentary aerosol process modules that treat PM mass and provide limited chemical speciation and particle sizing information. Performance evaluation of the PM components of these models using the enhanced data sets cited above will help identify the most significant sources of error in PM air quality predictions and should provide insights as to the most productive model enhancements needed to minimize these errors. Models are also needed to correlate the urban or regional air quality (measured at monitoring sites or predicted by the PAQSM model) to contaminant concentrations in micro-environments such as urban street level and around buildings. This will facilitate more accurate exposure and health risk assessment, and provide outdoor air quality data that will also be useful for studying the interactions between outdoor and indoor environments. The data also provides an opportunity to test, develop and independently evaluate source apportionment techniques and to provide corroborative analyses in conjunction with PAQSM as to the source contributions to ambient PM. Also of interest is application of these models to evaluate the environmental implications of promising energy-related technologies, such as truck-stop electrification and use of biofuels. Lastly, development and application of models that integrate economic analyses/control costs with air quality are needed.

New York State Relevance: The development of accurate quantitative relationships that couple pollutant emissions, air quality and control costs are essential to sound air quality management practice and effective environmental decision-making. Understanding of the transformation, fate and transport of the primary and secondary pollutant emissions in the atmosphere is essential in the development of both emission-based (e.g. PAQSM) and observation-based (e.g. source-receptor models) air quality models.

New York State must have state-of-the-science tools available to assess the impact of its emissions contributions and those emissions from adjacent regions on its air quality.

Relation to Other Research in the Region and Nation: The U.S. EPA Supersite program will bring together eastern Supersite researchers (New York, Pittsburgh, Baltimore) as well as model developers and data analyst to address a series of science policy questions that are hypothesis driven. Results from these studies will provide insights into the state of our knowledge of the chemical and physical characterization of PM air quality and the developments needed to provide credible PM air quality management tools.

### **Topic B2.2 Improve understanding of the role of primary and secondary organics in PM in New York State.**

Description and Rationale: Recent chemical speciation measurements of PM in New York City indicate that approximately 45% of the total PM mass is carbon based and measurements show little seasonal variation. Unlike sulfate and nitrate, whose composition and precursor sources are generally well known, the composition and sources of carbon based PM, are not well understood. Effective tools for the development of mitigation strategies for PM must have sound quantitative relationships for the sources and formation processes for the carbon component. To develop the necessary understanding, the following research and development is needed: a) perform laboratory studies using representative precursor (biogenic and anthropogenic) compounds to elucidate formation mechanisms for secondary organic aerosols in controlled environments; b) develop analytical methods for laboratory and field measurements of semi-volatile and non-volatile organic aerosols; c) characterize semi-volatile and non-volatile organic compounds in selected high priority sources (i.e. largest potential emitters); and d) perform field measurements of semi-volatile and non-volatile organic compounds in rural and urban environments.

New York State Relevance: Given that approximately half of the PM<sub>2.5</sub> mass observed in New York City is carbon-based, attribution of the primary and precursor sources for this carbon is essential to the development of effective emission controls.

Relation to Other Research in the Region and Nation: (See relation statement in Topic B2.1)

### **Topic B2.3 Improve understanding of transport phenomena, specifically aloft and at night.**

Description and Rationale: The impact of pollutant emissions on air quality is closely tied to transport and dispersion in the atmosphere. Although significant advances have been made in meteorological meso-scale modeling of atmospheric flows, vertical mixing, in terms of planetary boundary layer growth and cloud convection, and nocturnal jets and nighttime shear flows are not adequately understood in current generation coupled meteorological-photochemical air quality simulation models (PAQSM). Improved understanding of the overnight transport and downward mixing of pollutants trapped aloft in the previous day's residual layer have significant implications on urban and regional air quality (O<sub>3</sub>, PM and acid deposition) and the contributions of out-of state sources to in-state air quality.

New York State Relevance: The development of accurate quantitative relationships that couple pollutant emissions and air quality are essential to sound air quality management practice and effective environmental decision-making. The accurate depiction of transport phenomena is critical to the development of credible air quality modeling systems for use in air quality impact assessments of the contribution of primary and secondary pollutant emissions within New York State and from surrounding regions. New York State must have state-of-the-science tools that reflect these developments to assure the credibility of its environmental decisions.

Relation to Other Research in the Region and Nation: Recent extensive research measurements underway as part of NYSERDA and cooperative federal and state sponsored programs (i.e. PMTACS-NY Supersite as well as other regional Supersites (in Baltimore and Pittsburgh) and the NE-OPS (Philadelphia study, especially the summer 2001 aircraft data) will provide data bases for the evaluation of the selected

transport phenomenon and enhancements to minimize errors in current PAQSM predictions of concentrations associated with pollutant transport and dispersion. Recently, transport phenomena have gained broad community interest with studies on intercontinental transport of dust and pollutants over space scales >1000 kilometers. This has stimulated interest at NSF, NOAA, DOE and NASA, which may spill over to EPA.

**Topic B2.4 Explore co-pollutant interaction and multi-pollutant effects related to pollution control.**

Description and Rationale: Significant scientific and technical issues surrounding the mitigation of the warm season PM<sub>2.5</sub> /co-pollutant complex and its interdependence with O<sub>3</sub> air quality and acid deposition through coupled photochemical pathways, common precursors, and similar dependencies upon meteorology must be addressed if effective control strategies are to be implemented. In addition, the interdependence of cold season PM<sub>2.5</sub> and acid bearing species through common heterogeneous formation pathways and precursor emissions must also be addressed. Field measurements of primary and secondary pollutants at strategically located field stations across the State in conjunction with data analyses and the application of integrated modeling systems should be applied to demonstrate the effectiveness of instituted emissions controls for PM<sub>2.5</sub>, ozone and acid deposition and to quantify out-of-the-state contributions. These studies could be followed by the development of emission control scenarios designed to optimize mitigation responses for PM<sub>2.5</sub>, ozone and acid deposition simultaneously.

New York State Relevance: Ozone, PM<sub>2.5</sub> and acid deposition represent significant air quality issues in New York State that will require demanding mitigation strategies to achieve federally mandated standards. The development of accurate quantitative tools that couple pollutant emissions across multiple air quality end points will be essential to the implementation of effective emission control strategies within the air quality management framework for PM<sub>2.5</sub>, ozone and acid deposition.

Relation to Other Research in the Region and Nation: It is likely that similar research will be undertaken in other states across the nation, but New York's unique geographical location in the cross roads of regional pollutant transport suggests that it should take a leadership role in this area. The U.S. EPA and NOAA are currently investing in development of an integrated multi-pollutant modeling framework.

**Topic B2.5 Explore feasibility of alternative air quality management strategies on different time scales (e.g., forecasting and real-time control).**

Description and Rationale: The current U.S. EPA air quality management approach applies air quality simulation models to develop control strategies to meet worst-case scenarios that may occur once in three year or even once in ten years. The approach, which establishes across the board emission control limits based on these rare events, is neither practical nor cost effective. Alternate approaches could be explored. One example would be to explore the feasibility of developing an interactive strategic emission control system within an air quality forecast modeling framework to mitigate ozone exceedances in anticipation of forecasted episodic events. The cost benefit of such an approach, if viable, would be substantial. In addition, it would provide a more accurate means for the valuation of emission credits for trading. The current emission trading system does not take into consideration that the value of an emission credit (i.e. the cost of a ton of emission reduced) is very much a function of when and where that reduction occurs.

New York State Relevance: (See relevance in Topic B2.3)

Relation to Other Research in the Region and Nation: The U.S. EPA and NOAA have recently indicated an interest in Air Quality Forecast Modeling Systems.

**SECTION 3.0 - HEALTH EFFECTS**

**Topic B3.1a Support the integration and analysis of relevant PM Supersite data with exposure/health effects studies.**

Description and Rationale: The Supersite in New York, as well as other regional Supersites (in Baltimore and Pittsburgh) and the network of Speciation Sites in the northeastern U.S. will provide, for the first time, a substantial body of data on the chemical composition and particle size distributions of ambient air particulate matter. These data, when combined with human health status data on appropriate population groups in time-series analyses will make it possible to examine the hypothesis that certain specific PM components are more closely associated with adverse health outcomes than others, possibly providing a basis for more targeted and efficient National Ambient Air Quality Standards (NAAQS) and/or emission standards and State Implementation Plans (SIPS). This effort could also include development of databases of key potential health-related PM components (including aldehydes, acid aerosols, and ultrafines) which could be integrated into health studies.

New York State Relevance: New York State, as well as adjacent regions in the northeast and industrial midwest, were found to have substantially higher relative risks for daily mortality and hospital admissions than other parts of the U.S. in the 90-city NMAPS study. This could have been due to several factors, such as a more acidic ambient aerosol or a greater proportion of fine particles (PM<sub>2.5</sub>) within the PM<sub>10</sub> in this region. The validity of these and other hypotheses can be tested with the kinds of analyses being proposed here. Such results could lead to more effective targeted air quality management strategies.

Relation to Other Research in the Region and Nation: It is likely that similar research will be undertaken in other states across the nation, and any commonalities and/or differences in findings elsewhere will provide a valuable basis for hypothesis testing and validation.

**Topic B3.1b Support the integration of source attribution methods of PM into health/exposure studies (methods development, technology transfer).**

Description and Rationale: Atmospheric PM is a complex mixture of chemical compounds resulting from the mixed composition of the major anthropogenic sources, their chemical and physical transformations in and near discharge pipes and stacks, and their further transformations within the atmosphere. Other important PM sources include dusts from construction, demolition, agricultural operations, and resuspension of previously deposited particles by vehicles and natural weather phenomena. It has been hypothesized, based on prior time-series based epidemiological studies, that the relatively freshly generated PM mixture from combustion sources is more toxic than PM from other sources. Because of the physical and chemical complexity of ambient air PM, it may not be possible to separate out the contributions to health effects of individual PM components. It may, however, be more feasible in the future to integrate source apportionment techniques into health studies to identify a limited number of source categories and their contributions to the health effects, since each is expected to have an identifiable "signature" based on differences in its contents of trace elements and compounds. Prior to application of source apportionment methods, some initial work is needed to harmonize techniques and data collection formats, with the goal of facilitating common and combined analysis of the role of different source types in eliciting health effects.

New York State Relevance: (See relevance statement in Topic B3.1a)

Relation to Other Research in the Region and Nation: (See relation statement in Topic B3.1a)

**Topic B3.2 Explore feasibility of a targeted cohort study to examine exposure and health effects to "line exposure" from mobile sources.**

Description and Rationale: Recent research has implicated close proximity to major multi-lane express highways as a risk factor for cardiopulmonary disease morbidity. Pollutants with steep concentration gradients attributable to truck and auto traffic include nitric oxide, carbon monoxide, the number concentration of particles (ultrafines), and re-suspended road dust (coarse particles). An observational study of a population cohort of residents living in close proximity to express roadways and one or more matched reference populations living in the same general neighborhood but at greater distances from express roads, coupled with representative measurements of pollutant concentrations and time activity patterns for the cohort could provide a needed test of the hypothesis that freshly-generated primary pollutant emissions from motor vehicles are important risk factors for cardiopulmonary disease and/or its exacerbation. Given the resources required for this type of project, a phased approach with a feasibility study followed by implementation is recommended. Significant leveraging of funds will be required.

New York State Relevance: New York State may be an ideal model location to undertake a multi-center (in this case, multi-New York-cities) study to assess the association between daily rates of symptoms, pulmonary function, cardiac function, and/or absence from school or work and particle number concentration (in comparison with PM<sub>2.5</sub> mass). PM<sub>2.5</sub> monitoring is supported by the State and a number of monitoring programs (with fines and ultrafines) are funded by EPA, NYSERDA and via other mechanisms. It would be feasible to design the studies such that respiratory and cardiovascular response attributed to ultrafine (or fine PM) could be compared in the highly populated urban area of NYC with the less densely populated Upstate cities with populations in close proximity to line sources (including populations of Rochester, Buffalo, Syracuse, Albany, etc.).

Relation to Other Research in the Region and Nation: Research currently supported by EPA is examining the geographic variability of gaseous and PM concentrations in the South Bronx.

**Topic B3.3 Better understand the patterns of, and factors influencing, dose and human exposures to pollutants of ambient origin.**

Description and Rationale: To date, air quality monitoring research supported by NYSERDA has focused largely on measurements of outdoor concentrations at fixed sites. However, the link between ambient concentrations and human health effects is mediated by a variety of factors which modify individual human exposures to particles of ambient origin, including local concentrations, indoor/outdoor activity patterns, penetration efficiencies from outdoors to indoors, indoor decay rates, and other factors. Recent studies have demonstrated high correlations over time between indoor and outdoor PM<sub>2.5</sub> concentrations, and have illuminated some of the factors influencing these relationships. However, little is known about the dose and human exposures to particle sub-classes defined on the basis of size and/or composition. Thus, to better understand the links between ambient concentrations and human health effects for particle sub-classes, New York State studies are needed on patterns of, and factors influencing, dose and human exposures to particles of ambient origin.

New York State Relevance: New York State is home to one of the largest and most diverse populations in the Nation. Findings regarding human particle exposures specific to New York State populations are urgently needed to better understand the true impacts of emissions control programs in the State. In addition, findings from New York State will have relevance to federal air quality control efforts.

Relation to Other Research in the Region and Nation: Funding for human exposure research has to date originated largely from U.S. EPA. However, large PM-related funding programs at EPA, such as the PM Centers, have focused mainly on epidemiology and clinical studies (like NYSERDA), leaving important exposure-related questions under-studied.

#### **Topic B3.4 Support critical research to identify causal components in PM.**

Description and Rationale: All past and current National Ambient Air Quality Standards (NAAQS) for airborne particulate matter (PM) (TSP, PM10, PM2.5) have been based on gravimetric concentration measurements in a predetermined aerodynamic particle size range. Until recently, little attention has been paid to the particle number or surface area (e.g., ultrafines) as potential contributors to toxicity. However, there is strong suggestive, but not conclusive, evidence that some components of the complex PM mixture in ambient air contribute disproportionately to the overall health effects. Identification of the more causal components of PM would provide a basis for more efficient and effective NAAQS and for the implementation of source controls.

Despite the strong association between particulate matter and health effects that may be found in the epidemiological studies, epidemiology is rarely able to establish causality. Toxicologic studies are needed to define the underlying mechanisms. Furthermore, the significance of results will be greatly enhanced if results obtained in controlled clinical studies can contribute plausible explanations of underlying biological mechanisms for ambient particulate-matter-associated health effects as occurred with ozone.

New York State Relevance: (See relevance statement for Topic B3.1a)

Relation to Other Research in the Region and Nation: (See relation statement on Topic B3.1a)

#### **Topic B3.5 Develop long-term data for black carbon as a surrogate for diesel engine exhaust exposures/Develop exposure data for diesel PM urban environments.**

Description and Rationale: Diesel engine exhaust is generally the major source of elemental (black) carbon (EC) in community air, as well as a significant source of organic carbon (OC), and there is suggestive evidence that diesel exhaust particles are a contributory factor for the prevalence and exacerbation of pediatric asthma in urban settings. The opacity of air sampling filters as measured by British (or Black) Smoke (BS) and Coefficient of Haze (CoH) has provided an approximation of black carbon in ambient air in historic air quality networks, but reliable and consistent calibration data are scarce or sometimes nonexistent. Both retrospective and prospective studies of the role of black carbon in ambient air in relation to asthma impacts and other cardiopulmonary diseases could yield useful new insights if it is possible to reliably relate filter opacity to black carbon concentrations and indices of cardiopulmonary diseases.

New York State Relevance: Urban centers in New York State and the adjacent region have historically been exposed to relatively high concentrations of black carbon, and until recent years, there was a long record of data collected in terms of CoH readings. This could create unique opportunities to further the understanding of the relationship between black carbon and health effects. Furthermore, continuous measurements of EC and OC using current state-of-the-art instrumentation are underway in various locations in New York State.

Relationship to Other Research in the Region and Nation: In addition to current EC/OC measurement programs in New York State, comparable measurements are being made in other urban regions throughout the U.S. This provides an opportunity to determine the extent and variation of EC and OC, and the other environmental factors that can influence the readings provided by the continuous monitors.

### **SECTION B4.0 - SOURCE EMISSIONS, TECHNOLOGY AND POLICY**

This section addresses five subject areas where additional effort is needed to provide valuable policy-relevant information to the State of New York in assessing control strategies and energy production options to minimize air pollution impacts. These areas suffer from lack of national attention, and additional

effort will not only provide valuable technical input to the State's energy/environmental policy, but also provide regional and national leadership in a critical gap area.

**Topic B4.1 Support method development and characterization of sources of primary and secondary PM emissions impacting New York State.**

Description and Rationale: In July 1997 the EPA proposed new NAAQS for fine particles (PM<sub>2.5</sub>) and for fine plus coarse particles (PM<sub>10</sub>). These standards were developed, in part, based on the NMAPS, which related adverse health effects to particle size and mass concentrations (see relevance statement in Topic B3.1). Airborne particles arise from direct emissions for a great variety of natural and anthropogenic sources, and indirectly through the formation of particles secondarily from gaseous compounds (such as ozone, sulfur dioxide, oxides of nitrogen, ammonia, and volatile organic compounds) via chemical and physical processes in the atmosphere.

Methods are needed to determine the size distribution, the chemical composition and the mass-emission rates of primary particles and the reactive gases that lead to secondary particle formation through atmospheric chemical reactions. These methods and the source characterizations are needed to support atmospheric modeling of primary and secondary particulate matter through transport and transformation, to determine the sources of biologically important characteristics of airborne particles once identified by health researchers (see description and rationale in 3.3), and to support development of emissions control strategies. Traditional source testing methods do not provide information on size distribution and chemical composition for these purposes. The approach thought to address source characterization is one that attempts to simulate the physical phenomena of cooling and dilution that occurs in a plume using a dilution sampling scheme.

New York State Relevance: The development of standard methods for characterizing the contribution of stationary and mobile combustion sources, dispersed area-wide sources and industrial processes with respect to PM<sub>2.5</sub> will be helpful in gathering source strength information that can be used in designing emission control strategies for the State to meet the 1997 NAAQS.

Relation to Other Research in the Region and Nation: Currently, NYSERDA is co-sponsoring a methods development/source characterization program for fine and ultrafine particles from stationary combustion sources fired by oil and gas with the Gas Technology Institute (GTI), the California Energy Commission (CEC), the U.S. Department of Energy's National Petroleum Technology Office (DOE NPTO), the American Petroleum Institute (API), and with cooperation from the U.S. Environmental Protection Agency (EPA). These technologies and methodologies will provide information to assess the source contributions of combustion sources with respect to ambient fine (smaller than 2.5 microns) and ultrafine (smaller than 0.1 microns) particulate matter. This three-year program began in January 2001 and will characterize up to ten sources with a test of a large-scale boiler in New York City during 2002. Additional source types including wood combustion and coal-fired power plants should be added to the test program.

**Topic B4.2 Synthesize available information on PM in New York State and produce an integrated assessment to provide scientific foundation for SIP development (include Supersite data, other field sites, health/exposure studies)**

Description and Rationale: There are several major PM research and monitoring initiatives going on in New York State and the region. These include the Supersite program, several EMEP field studies in the New York City metropolitan area and upstate New York, emission source characterization efforts, PM health research and exposure studies, as well as regulatory monitoring initiatives. The proposed Integrated Assessment would synthesize available data and put it in a form that will be most useful to policy makers. All too often, environmental research dollars are expended on costly field campaigns and data collection efforts, with too little resources devoted to data analysis and synthesis. The proposed

effort would attempt to avoid this problem in the PM area and would provide timely and geographically relevant information to policy makers in New York. The Assessment would:

- Evaluate and synthesize data coming from all NYS PM sites,
- Evaluate regional PM issues, drawing on northeast PM Supersites program,
- Apply receptor modeling/chemical transport modeling to assess source-receptor relations, where needed,
- Begin to lay out framework for assessing economics of control options,
- Focus on policy implications.

New York State Relevance: In the 2005-2008 timeframe, New York State will need to develop a State Implementation Plan (SIP) to comply with ambient PM<sub>2.5</sub> air quality standards. Preliminary data indicate that several areas in New York State will be out of compliance with the annual standard. The proposed assessment could provide useful information for the development of the SIP.

Relation to Other Research in the Region and Nation: NARSTO has recently completed a PM assessment focusing on the tri-national areas of Canada, the U.S., and Mexico. The effort would build on the efforts on the Northeast Supersites program, focusing on data analysis and synthesis. The effort would need to be timed properly to maximize value of ongoing studies, i.e., possibly starting in 2004.

#### **Topic B4.3      Develop standard test method for particle size distribution for mobile sector emissions: test stand and in-use.**

Description and Rationale: Comparative assessments of stationary and mobile emission sources currently lack standardized test methods such that “source strength” terms for fine-PM emissions from various combustion types could be provided to the atmospheric chemistry and health communities. Contributions from internal combustion engines to atmospheric fine-PM levels are presently based on PM mass emissions whereas size-specific PM contributions from all categories of combustion sources will be necessary to guide policy decisions in the face of PM<sub>2.5</sub> non-attainment. While PM mass data for real-world vehicles is itself sparse, the inference of fine-PM contribution from total mass is at best tenuous.

The objective to be realized is to demonstrate mini-diluter sampling concepts that would condition a real-time slipstream exhaust sample to standard conditions for subsequent particle number, size, and chemistry characterization. The dilution and sample handling conditions would be sufficiently defined to yield a test method that could give matched results in different laboratories applied to diverse stationary or mobile combustion fuel and technology types. Transient combustion events are known to be major contributors of fine-PM in the mobile sources case. Dilution methods and attendant instrumentation for particle mass and number characterization must accurately account for transients on the time scales typical of engines, control systems, and vehicle dynamics.

A source-strength metric for PM number, size, and chemistry that includes transient events must include not only the slip-stream characterization of exhaust mentioned above, but also the variable exhaust flow rate from the combustion source. The data reduction steps necessary to combine exhaust mass flow rate and the particle number/size/chemistry information form a critical step in the objective to yield a true “source strength” integrated metric that can distinguish among the various sizes of sources impacting the atmospheric chemistry or health professional. Further reactions and atmospheric processes will change the direct emissions, but it will be useful and necessary to develop standard test methods that can be applied across a wide range of sources that affect atmospheric fine-PM in order to sort out best policy options to reduce the combined impacts from many sources.

New York State Relevance: New York State will certainly face the need for reductions in PM<sub>2.5</sub> in order to bring ambient levels under the NAAQS. Exactly what options are available are at present only speculative, and are based on insufficient data. These options can point in vastly different directions and impact dramatically different sectors. It may be that diesel engines both on and off-road will need to have



strict controls placed on them such as California is presently implementing. However, old cars that burn excess lubricating oil may be found to be a significant part of the PM2.5 problem, as has been documented in Denver. Far better data than what presently exists will be needed to insure that policies are scientifically well-grounded as New York enters the PM2.5 control era. The fact that we lack a standardized method of characterizing even different sources within a single category [i.e. diesels vs. oil-burning gasoline] indicates the uncertain policy choices that soon will face New York.

Relation to Other Research in the Region and Nation: Development of standard methods for evaluating both stationary and mobile sources for especially PM2.5, but also for toxic and ozone precursors, will have value to several other New York research efforts. The health research initiatives would greatly benefit by access to sector-specific source estimates of ozone, PM2.5, and toxic emissions, which are now lacking. The Super Sites atmospheric characterization efforts, and ozone atmospheric modeling research presently underway in New York, present an even more direct link. The advent of standard test methods can open the door to providing input data to atmospheric chemistry sector that has not been available.

Considerable work to document how direct diesel emissions are transformed in the immediate plume of a moving vehicle is becoming available, and the results of these studies will provide the foundation for setting the fixed conditions that will be used in defining standard dynamometer test methods as proposed here. European researchers and policy makers have recognized this need and are proceeding to set test methods according to their base of information and instruments. EPA has thus far not entered the world of testing emissions for particle number and size with a view toward a standard test method. As total mass of PM emissions from advanced technology diesel engines becomes virtually a non-detectable level using conventional mass testing methods, the possibility and value of documenting a more refined metric that hinges on particle numbers and sizes may emerge as a companion to mass. This is certainly true for the health and atmospheric process communities, less so from a pure regulatory view. The long-term opportunities for collaborative leveraging of research resources are multi-faceted in this case.

## **C. Research Needs Crosscutting the Topics of Air Quality, Health and Ecological Response**

**Topic C1      Assess adequacy of existing monitoring networks as they relate to (i) source attribution, (ii) determining transport, (iii) evaluating health/environmental effects, and (iv) verifying the impacts of changes to pollution controls strategies on air quality (accountability).**

Description and Rationale: A review of current air quality monitoring networks and related research activities in New York State is needed to identify monitoring redundancy and gaps from the perspective of geographic distribution of sites and parameters measured. A related assessment of the state of instrumentation/monitoring technology and development needs would help identify future technology investment priorities.

There are multiple needs for the monitoring of air and environmental quality including estimation of human exposure, identification and apportionment of pollutant sources including understanding of transport and fate of the atmospheric constituents, provision of a data base to develop and test models, and measurement of the changes in concentrations resulting from active intervention (regulatory or related actions). These various needs often require different approaches to the design of the monitoring network, the selection of species to be measured, and the instruments to be deployed. Given limited resources for monitoring and increasingly challenging air quality objectives, it is essential that an efficient and effective, interconnected monitoring program be developed for New York State in order to provide the required variety of policy-relevant information.

New York State Relevance: New York State spends considerable resources on the monitoring of air and environmental quality. [Several key networks and research sites are shown in Figure 1] Despite a number of air quality improvements over the years, acid deposition, ozone, and ambient particulate matter still remain a paramount concern in New York. Tackling these pollution problems in the future will require *better* information on transport, better understanding of source-receptor relations and total deposition, and better monitoring of environmental/health endpoints to assess effectiveness of intervention strategies.

Relation to Other Research in the Region and Nation: The U.S. EPA is launching an evaluation of air quality monitoring networks nationwide. The effort proposed here could build on the national analysis as a regional pilot focusing on the augmentation of regulatory networks with long-term study sites.

NYSDEC maintains several networks for the monitoring criteria air pollutants (SO<sub>2</sub>, CO, NO<sub>x</sub>, O<sub>3</sub> and PM<sub>2.5</sub>), acid deposition network, the federal reference method (FRM) network for PM<sub>2.5</sub> mass, speciated PM<sub>2.5</sub> network, an air toxics network, as well as sites in New York State associated with the Interagency Monitoring of Protected Visual Environments (IMPROVE) and the Photochemical Aerosol Monitoring Station (PAMS). These networks are supplemented by a number of programs supported by NYSERDA and other entities. NYSDEC, as part of the EPA speciation network, is establishing sites at Downtown Rochester, Pinnacle State Park, Whiteface Mountain, and several NYC sites (e.g., Bronx Botanical Gardens, Queens College, and IS52). Other speciation network sites exist in Burlington, VT, Additional sites in Buffalo and Manhattan will be established in the future. There are IMPROVE sites at Pinnacle, Lye Brook and Proctor Maple, VT, Chicopee, MA and Cornwall, CT. Currently, NYSERDA is supporting supplementary monitoring at Whiteface Mountain and Pinnacle, in Tuxedo and at Hunter College in Manhattan, and in Potsdam and Stockton. NYSDOH supports the station at Mayville, Chautauqua County.

The National Atmospheric Deposition Program (NADP), Clean Air Status and Trends Network (CASTNet), Atmospheric Integrated Air Monitoring Network (AIRMon) and Mountain Acid Deposition Program (MADPro) networks exist to estimate wet, dry and cloud deposition, respectively. In addition, there is at least one independent monitoring station that estimates wet and dry deposition (Institute of Ecosystem Studies' Environmental Monitoring Program, Millbrook, NY). One-half dozen dry deposition monitoring sites exist in New York State. There are no current efforts to increase the density of dry deposition monitoring networks in New York, and the cloud deposition monitoring network may be facing elimination. The Adirondack Lakes Survey Corporation, in collaboration with DEC, NYSERDA, and U.S. EPA is supporting a 52 lake water quality monitoring program to evaluate the effects of acid deposition in the Adirondacks.

## **Topic C2. Evaluate Environmental Effects and Strategies for Mitigation of Electricity Generation**

Description and Rationale: The siting of electricity generation is often a contentious process, with much discussion, analysis and concern about the local and regional impact on land-use, habitat, air quality, public health, and impact on aquatic systems associated with water used for power production or cooling. Research is needed to address ways to assess, monitor, and reduce these adverse impacts including the evaluation of new and emerging cooling technologies and their impacts. The development of tools that can facilitate the siting process are also needed.

New York State Relevance: As a result of increased demand for electricity and the restructuring of the electric industry, New York State is in the midst of siting numerous power plants, primarily within the Hudson Valley, New York City and Long Island. Although these power plants are extremely clean compared to the current stock of power plants, siting is often hindered and delayed by questions about the impact on aquatic resources, land-use, habitat, air quality and public health in New York. In addition to meet future power demands in downstate load pockets, distributed generation, combined heat and power sources, and emergency generators will play a greater role in meeting base and peak power demand.

Research and monitoring activities in the region and nationally are not adequate to assess local effects associated with this development.

Relation to Other Research in the Region and Nation: This work should be coordinated with the assessment of distributed generation “Topic C3.” The selection of any new monitoring sites would be informed by the assessment of monitoring networks and needs under Topic C1. Technology development initiatives should be coordinated with related public-benefit efforts in other states and nationally.

**Topic C3. Evaluate the environmental implications of the distributed generation of electricity in New York State.**

Description and Rationale: New York utilities and government organizations, as well as utilities in New England, are currently trying to sign up owners of large existing backup generators (typically diesel) to produce electricity for situations when “capacity deficiency” occurs. Many of these engines were permitted to run only in case of emergency. These sources are high NOx emitters and a source of primary fine particles and air toxics. They are also expected to come on line (or produce power off line to relieve load on the grid under contract agreements with the serving utility) when air pollution levels are very high (summer ozone episodes). The environmental implications of the emerging use of distributed generation technology, in particular the use of large diesel engines, needs to be better understood. A variety of alternative policies and pollution control strategies should be evaluated including after treatment technology, fuel switching (e.g., biodiesel), and combined heat and power applications.

New York State Relevance: Increased use of fossil fueled distributed generation is anticipated in New York State and elsewhere in the region given the changes in the energy industry, the demand for power, and regional transmission constraints. In addition, backup generators (or emergency generators) may play an increased role in the supply of energy in critical areas in New York State in times of high demand.

Relation to Other Research in the Region and Nation: California is evaluating alternative control options for these high-emitting engines. An EPA/regional study is underway to do case studies of retrofitted engines to evaluate achievable reductions in NOx and toxics emissions (including particulates).

**Topic C4. Maintain and initiate, where necessary, measurements of fine particulates and precursors, wet and dry deposition of Sulfur and Nitrogen, and base cations at specific long-term study sites, building on assessments described in C1 above.**

Description and Rationale: Although data from long-term monitoring programs are critical to answering research, management and policy questions, funding for monitoring programs is hard to find, and once found, difficult to maintain. This effort, as well as the identification of potential funding organizations, will be based on the findings of Topic C1.

New York State Relevance: (See relevance statement in Topic C1.)

Relation to Other Research in the Region and Nation: (See relation statement in Topic C1.)

**Topic C5. Identify multiple sources and relative contributions of fixed nitrogen, including ammonia, to New York State ecosystems; examine watershed retention of nitrogen to assist in source reduction initiatives; improve understanding of the sources of ammonia and its role in aerosol formation in New York State - including inventory development and exploration of mitigation options.**

Description and Rationale: The fixed nitrogen that contributes to atmospheric deposition originates from at least three major emission sources: (1) stationary sources, (2) vehicles, and (3) agronomic systems.

There may also be substantial inputs of nitrogen through biological fixation in some ecosystems. In devising strategies for source reductions of nitrogen emissions, data are needed on the relative contributions of atmospheric nitrogen inputs to ecosystems from these various sources. Additionally, nitrogen arriving from the atmosphere from different sources and in different forms (e.g., nitrate, ammonium, organic N, NO<sub>x</sub>) may have different ecosystem retention capacities. Current published studies show widely varying proportions of ecosystem retention of nitrogen from the atmosphere.

Ammonia appears to be a critical component in the formation of PM in the Northeast after organic carbon. Currently, there is little information on the sources and levels of ammonia emissions impacting New York State. An initial assessment of what is known about area and point sources, including the agricultural sector, that also explores measures to control emissions and thereby reduce secondary PM formation will be helpful in control of ambient PM levels.

New York State Relevance: New York State has required electricity generators to reduce NO<sub>x</sub> emissions to reduce acidic deposition and summer ozone levels. Sites located in New York that are part of the NADP indicate that about one-third of atmospheric nitrogen deposition is ammonium, which primarily originates from agricultural activities. The relative contributions of stationary vs. mobile sources of nitrogen in atmospheric deposition across the State are unknown. Data are needed to define source apportionment for atmospheric nitrogen deposition in New York to maximize effectiveness of nitrogen-related control programs.

Relation to Research in other Regions and Nation: Mid-Atlantic Regional Air Management Association (MARAMA) is currently developing an ammonia inventory. Hubbard Brook Research Foundation, with NYSERDA support, is currently conducting a synthesis study on the status and effects of nitrogen pollution in the northeastern U.S. In addition, the New York Supersite program is evaluating the ammonium portion of PM and is investigating whether ammonium is the limiting reactant in PM formation in the region.

#### **Topic C6. Develop evaluation protocols to verify the impacts of pollution control strategies.**

Description and Rationale: Billions of dollars have been spent on reducing emissions in an attempt to improve air quality and environmental health in the nation. This effort would attempt to develop better evaluation protocols to draw scientifically defensible associations between changes in pollution control and emissions, ambient air concentrations, and health/environmental endpoints (i.e., verification/accountability). The effort may include the use of statistical approaches, analytical methodologies, models, and the synthesis of monitoring data and research findings to strengthen the cause and effect relationship.

New York State Relevance: Because New York State is impacted more adversely by the pollutants of concern than many other areas of the country, the state would benefit from better information on the relationships between pollution control strategies and health/environmental response. For example, many strategies have been employed in New York State in an attempt to reduce ozone levels, however uncertainties exist regarding the effect of the measures. The intent of this research topic is to ultimately generate more effective decision-making and policy development, and more focused and efficient research efforts.

Relation to Other Research in the Region and Nation: This activity has been identified as a priority by the U.S. EPA and NARSTO, and limited research is underway.

#### **Topic C7. Assess the feasibility and cost effectiveness of multipollutant control strategies for existing generation infrastructure in New York State.**

Description and Rationale: New York produces about half of its electricity through the use of fossil fuels (natural gas, 25%; coal, 16%; petroleum, 10%). With the continued need for improvement of the quality of

the environment, it is very important to investigate the feasibility and cost effectiveness of various control technologies (including multi pollutant control technologies) and strategies (including fuel switching) to further reduce emissions of NO<sub>x</sub>, SO<sub>2</sub>, particulate matter, mercury, other toxic pollutants, and potentially CO<sub>2</sub>. The analysis should be done for both the near-term (3 to 5 years) and long-term (10 years and beyond), along with sensitivity studies, since there is a wide range in level of feasible controls for the four pollutants. Additionally, the effort should evaluate outstanding issues and barriers for technology (as well as fuels and processes) penetration and use. The emphasis of this effort should be on power plants that contribute to pollution in New York and should take into account size, age, type of boilers, fuels, sulfur content, existing federal and state requirements for NO<sub>x</sub> and SO<sub>2</sub>, etc., including market-based cap and trade approaches.

New York State Relevance: One of the stated objectives of the EMEP program is to “help develop approaches to mitigate impacts of electricity generation and improve environmental quality.” A key input to meet this objective is information on the technical feasibility and cost effectiveness of pollution controls for power plants contributing to pollution in the State. The emphasis of this effort should be on power plants that contribute to pollution in New York and should take into account size, age, type of boilers, fuels, sulfur content, existing federal and state requirements for NO<sub>x</sub> and SO<sub>2</sub>, etc., including regional and national market-based cap and trade approaches.

Relation to Other Research in the Region and Nation: There are currently a number of alternatives, serious proposals and bills under discussion in the U.S. Senate and the House dealing with substantial reductions in emissions from electricity sector. Many of these bills involve multi-pollutant strategies to control various emissions from the electricity generation sector, especially from coal-fired boilers. These coal-fired boilers are a significant fraction of emissions from this sector (in the U.S. and in the New York state) of SO<sub>2</sub> (almost 100%), NO<sub>x</sub> (more than 90 %), mercury (almost 100%), and CO<sub>2</sub> (estimated to be above 70 to 80 percent).

The technology and strategy evaluation at the national and regional level is, by necessity, general in nature since the population of such units is quite large. Such a national evaluation is just starting, but it will not meet the specific needs of the New York State. The emphasis of this effort therefore should be specific to the power plants in New York by taking into account size, age, type of boilers, fuels, sulfur content, existing federal and state requirements for NO<sub>x</sub> and SO<sub>2</sub>, etc., including regional and national market-based cap and trade approaches.

**Topic C8. Evaluate the potential effects of emissions trading (e.g. mercury, fine particulate precursors, etc.) at local and regional level.**

Description and Rationale: Several northeast states have raised questions about potential adverse local impacts of pollution control programs that incorporate national/regional emissions trading. Additional research is needed to understand the local risks in the context of regional/national trading programs. SO<sub>2</sub> and NO<sub>x</sub> should be considered - both are precursors to PM<sub>2.5</sub>; NO<sub>x</sub> is also a major precursor to ozone; both PM<sub>2.5</sub> and ozone have federal ambient air quality standards to protect public health. Additionally, mercury emissions from coal-fired boilers are becoming the focus of rapidly emerging national, regional, and state policies. There are serious questions being raised about the feasibility of trading-based mechanisms for mercury mitigation since they may not provide protection against adverse local impacts if not designed with care. This project should evaluate the local emissions impacts in the context of existing national and regional strategies to control SO<sub>2</sub> and NO<sub>x</sub>. It should also evaluate the feasibility of and constraints on any market-based approaches to control mercury emissions in New York State.

Market-based approaches, when designed properly (for example, establishing an adequately stringent cap in the “cap and trade” program, and defining limits on trading to mitigate local impacts) have the potential to result in significant cost savings as well in significant emission reductions. It is important that any strategies to reduce SO<sub>2</sub>, NO<sub>x</sub>, and mercury emissions from power plants take advantage of market mechanisms to reduce cost and at the same time provide protection against local adverse health impacts.

New York State Relevance: The evaluation of mercury and primary and secondary PM trading is necessary to support development of appropriate State Implementation Plans.

Relation to Other Research in the Region and Nation: A recent university study has evaluated additional health risks from local emissions in the context of regional strategies in Massachusetts. A regional group is evaluating the scientific knowledge of mercury speciation in the power plant flue gases and how that may affect the design of a market-based approach for mercury emission reductions that are cost effective and also protective of ecological and public health. Several environmental economists have evaluated the local impacts of the Title IV trading program.

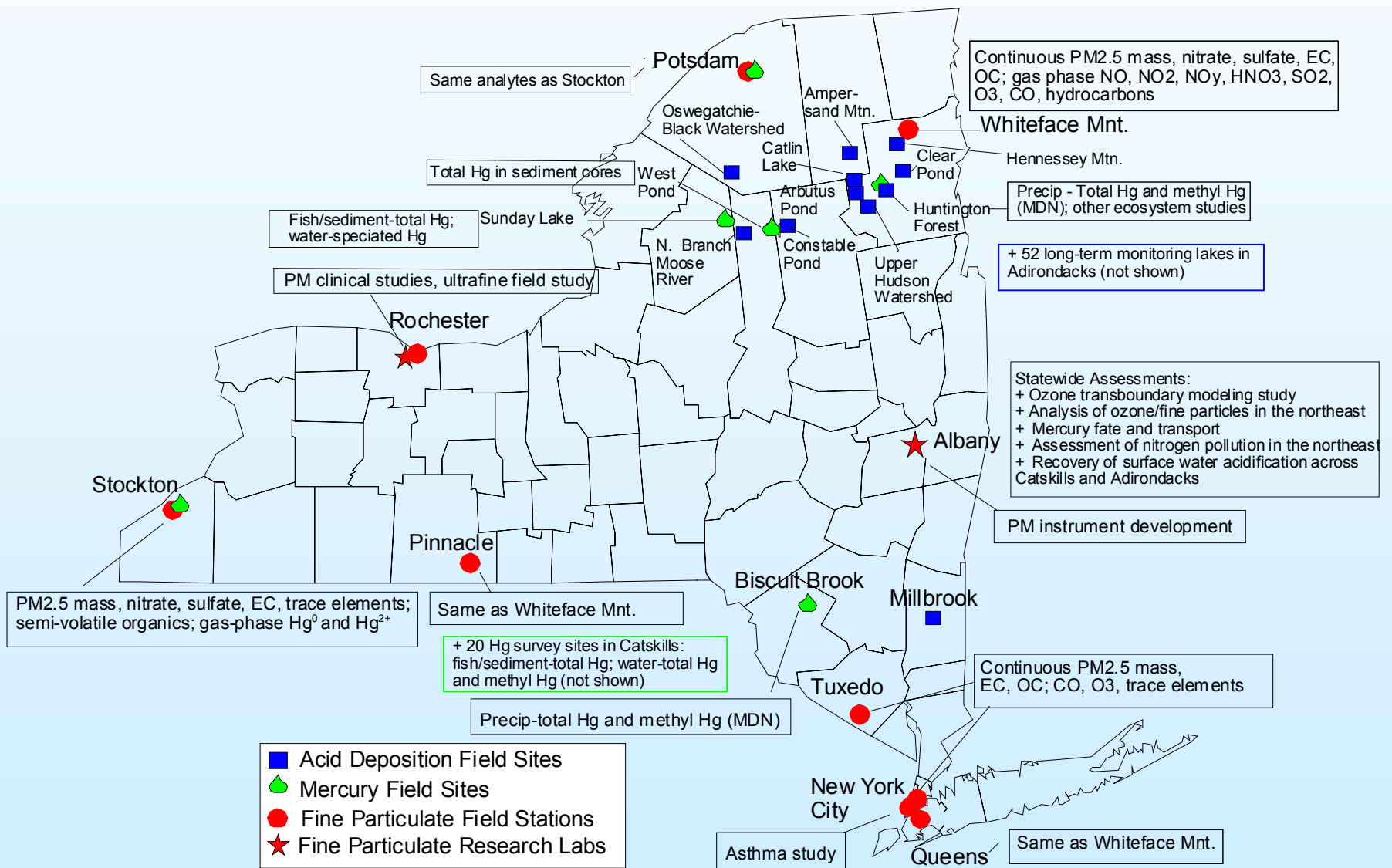
#### **Topic C9. Evaluate the environmental impacts of biodiesel in New York State**

Description and Rationale: This initiative will include an assessment of the environmental impact of biodiesel, focusing on the potential for biodiesel to improve air quality in New York State. In addition, to being a “home-grown” renewable fuel, an attractive attribute of biodiesel has been the *potential* environmental benefit compared to conventional diesel fuel, including reduced primary particulates and reduced NOx emissions.

New York State Relevance: Unlike most other energy resources, New York State has the potential to be a supplier of biodiesel and other biofuels. Use of biodiesel in New York State in stationary (e.g., distributed generation, home heating) and mobile sector applications could possibly provide a more cost-effective means of improving air quality than alternative pollution controls; however we currently lack necessary field data to fully evaluate the potential impacts in New York.

Relation to Other Research in the Region and Nation: The U.S. EPA and DOE are supporting some emissions tests for a variety of biofuels. This initiative should be coordinated with Topic C.3 (Distributed Generation).

# NYSERDA Environmental Monitoring, Evaluation, & Protection Program Field Stations and Research Sites



**Appendix 2: NYSERDA - New York Energy \$mart<sup>sm</sup>  
Environmental Monitoring, Evaluation, and Protection Program Project Portfolio**

Contract #	Title	Principal Investigator and Research Organizations	Site	Total Project Cost	NYSERDA Cost
<b><i>Fine Particle and Ozone Research Projects</i></b>					
4913	*Clinical Studies of Exposure to Ultrafine Particles	Dr. Mark Utell, Univ. of Rochester Medical Center	Rochester (clinical)	\$817,141	\$480,851
6084	Source Apportionment of Fine Particles in New York City	Dr. George Thurston, NYU Medical Center	New York City, Tuxedo	\$801,432	\$489,358
6083	Impact of In-and Out-of-State Power Plants on Semivolatile Pollutants in New York	Dr. Philip Hopke, Clarkson University	Stockton, Brockport (NYS northwest border)	\$769,196	\$563,121
4914	*Analysis of Ozone and Fine Particles in the Northeast	Dr. S.T. Rao, SUNY-Albany	Statewide (modeling)	\$537,652	\$537,652
6085	Assessing the Effects of Transboundary Pollution on New York's Air Quality	Dr. S.T. Rao, NYS Dept. of Environmental Conservation	Canadian-NYS border, statewide (modeling)	\$660,569	\$387,919
4918	*Enhanced Measurements of Oxidants, Fine Particles and their Precursors	Dr. Kenneth Demerjian, SUNY-Albany	Whiteface Mountain, Pinnacle State Park, NYC/Queens	\$8,176,143**	\$2,737,689
5060	Development and Demonstration of Continuous Ambient Particulate Monitor (R&P 6400 series)	Dr. Harvey Patashnick, Rupprecht & Patashnick Co., Inc.	Albany (lab work), field site (TBD)	\$122,078	\$49,880
6183	Development and Demonstration of Innovative Instrument for Ambient Particulate Matter Mass Measurement Standard	Dr. Harvey Patashnick, Rupprecht & Patashnick Co., Inc.	Albany (lab work), field site (TBD)	\$1,328,580	\$450,000
6484	Fine Particle Constituents and Acute Asthma in Urban Areas	Dr. Daniel Luttinger, Health Research Inc./NYSDOH	New York City	\$293,511	\$184,966
6820	Monitoring Particle Size Distribution in Rochester	Dr. Philip Hopke, Clarkson University	Rochester, NY	\$246,555	\$165,783
6230***	Fine/Ultrafine Particulate Emissions Profiles	Mr. James McCarthy, Gas Technology Institute; Dr. Glen England, GE-EER	New York State (TBD), California, others	\$2,020,000	\$165,000
				<b>\$15,772,857</b>	<b>\$6,212,219</b>



**Appendix 2: NYSERDA - New York Energy Smart<sup>sm</sup>  
Environmental Monitoring, Evaluation, and Protection Program Project Portfolio**

Contract #	Title	Principal Investigator and Research Organizations	Site	Total Project Cost	NYSERDA Cost
<b><i>Acid Deposition and Mercury Research Projects</i></b>					
4915	*Long-Term Monitoring Program for Evaluating Changes in Water Quality in Adirondack Lakes	Karen Roy, Adirondack Lakes Survey Corporation (ALSC)	52 Lakes in Adirondacks	\$9,112,942	\$3,845,443
4917	*Evaluation of the Recovery from Acidification of Surface Waters in the Adirondacks	Dr. Myron Mitchell, SUNY College of Environmental Science and Forestry - Syracuse	Arbutus Pond, Huntington Wildlife Forest, & Statewide modeling	\$989,538	\$802,861
4916/68 18	*Mercury in Adirondack/Catskills Wetlands, Lakes and Terrestrial Systems	Dr. Ronald Munson, Tetra Tech, Dr. Charles Driscoll, Syracuse University, Dr. Mike McHale, U.S. Geological Survey	Sunday Lake (Adirondacks) & various sites in the Catskills	\$904,830	\$741,960
6086	Effects of Atmospheric Deposition of S, N, Hg on Adirondack Ecosystems	Dr. Dudley Raynal, SUNY College of Environmental Science and Forestry	Huntington Forest; Oswegatchie-Black Watershed; Constable, West, Clear Ponds; Upper Hudson Watershed, Moose R.	\$413,400	\$282,613
6485	Critical Gaps in Research on Mercury in New York State	Dr. Christian Seigneur, Atmospheric & Environmental Research, Inc.	Statewide (modeling)	\$107,098	\$96,805
6486/ 6490	An Integrated Assessment of the Recovery of Surface Waters from Reduced Levels of Acid Deposition in the Catskills and Adirondacks	Dr. Douglas Burns, US Geological Survey, Dr. Gary Lovett, Institute of Ecosystem Studies	Adirondacks and Catskills (modeling and assessments)	\$277,199	\$245,519
6487	Status and Effects of Nitrogen Pollution in North Eastern United States	Kathy Fallon Lambert, Hubbard Brook Research Foundation	Statewide	\$399,320	\$169,320
6488	Atmospheric Transport and Fate of Mercury in New York State	Dr. Chris Walcek, Research Foundation of SUNY	Statewide (modeling)	\$139,271	\$103,000
6819	Monitoring Deposition and Effects of Air Pollution in the Hudson Valley	Dr. Gary Lovett, Institute of Ecosystems Studies	Millbrook, NY	\$133,333	\$100,000
				<b>\$12,476,931</b>	<b>\$6,387,521</b>
<b>Total Funds Committed</b>				<b>\$28,249,788</b>	<b>\$12,599,740</b>

\*Projects identified in the New York Public Service Commission 1998 System Benefits Charge Order

\*\*Includes \$3.449 million of EPA support for PM2.5 supersite.

\*\*\*Non-SBC Statutory funds