ENVIRONMENTAL RESEARCH AND MONITORING NEEDS IN NEW YORK STATE

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

AUGUST 2007

NYSERDA
New York State Energy Research and Development Authority

The New York Academy of Sciences

Questions or comments about this research plan or the **New York Energy $mart**[SM] Environmental Monitoring, Evaluation, and Protection (EMEP) Program should be directed to: Mark Watson, 518-862-1090, ext. 3314, mw1@nyserda.org.

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INTRODUCTION

BACKGROUND

In the fall of 2006, the New York State Energy Research and Development Agency (NYSERDA) and the New York Academy of Sciences (NYAS) 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 energy generation and use. The research plan's potential users include NYSERDA, other New York State/regional/national research funding organizations and agencies, the scientific community, public benefit organizations, and policy makers.

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 and NYAS have identified and prioritized key research areas that are suitable to be addressed through NYSERDA's Environmental Monitoring, Evaluation, and Protection (EMEP) program and other funding organizations.

This plan builds upon the previous EMEP research plan, which was derived through a similar stakeholder process in 2001. Over the past five years, the previous plan was used by NYSERDA as a guide for funding research projects. The plan has also been a useful reference for others—over 1200 copies have been downloaded from NYSERDA's Web site. Since its inception in 1998, EMEP has funded 46 research projects (see Table 1) in the following areas:

- Air quality and related health research associated with particulate matter, ozone, and co-pollutants (18 projects, $9.9 M NYSERDA, $22 M total project cost);
- Ecosystem response to deposition of sulfur, nitrogen, and mercury (21 projects, $9.6 M NYSERDA, $20 M total project cost);
- Crosscutting environmental science, energy, technology, and policy projects (7 projects, $1.1 M NYSERDA, $1.6 M total project cost).

In 2006, the EMEP Program underwent an external evaluation to determine the program's effectiveness in sponsoring and managing research, disseminating results, and affecting environmental policy. As part of this review, EMEP staff put together an overview of the program and major findings from more than 40 different research projects funded by EMEP. The evaluation, which was extremely favorable, may be found on the EMEP Web site at: www.nyserda.org/programs/Environment/EMEP/ProgramEvaluation.asp.

EMEP OVERVIEW

The primary mission of EMEP is to *"increase understanding and awareness of the environmental impacts of energy choices and emerging energy options and provide a scientific, technical foundation for formulating effective, equitable, energy-related environmental policies and resources management practices*." [1] The program is funded through a system benefits charge (SBC) under the **New York Energy $mart**℠ program and is guided by a Program Advisory Group and a Science Advisory Committee.

The EMEP research agenda has developed to integrate an evolving energy–environmental landscape that presents new information gaps and research needs. For example, the program takes into consideration how the following evolving issues relate to the identified research needs:

- changes in industry market structure/deregulation, fuels, and pollution control technologies
- emerging energy technologies

[1] As stated in the March 2006 System Benefits Charge Plan, pp 7.18, http://www.dps.state.ny.us/SBCIII_Amended_Plan_3-2-06.pdf

- volatile energy prices
- concern for the long-term security of energy supplies and meeting peak energy demands
- recognition that greenhouse gases and other climate-forcing agents will need to be addressed along with conventional combustion-related pollutants.

NYSERDA also considers the broader evolving environmental policy context, including:

- increased reliance on market-based environmental protection strategies
- increased need to evaluate real-world effectiveness of environmental policies, i.e., "environmental accountability"
- increased sensitivity to pollution-hot-spot concerns and environmental justice
- scarcity of resources for adequate long-term monitoring programs
- recognition of the need for coherent multi-pollutant policies and programs.

This context is considered in formulating the next phase of the EMEP research program.
In evaluating potential research to address these policy-relevant questions, NYSERDA will take into account:

- the relevance and importance to New York State
- support of the EMEP program goals and overarching strategic objectives
- extent to which the research is being, or will be, addressed by other entities
- feasibility of being able to design and execute a scientifically credible project, given the limited resources in the EMEP program.

OVERARCHING EMEP STRATEGIC OBJECTIVES

The EMEP program has identified five strategic objectives:

1. Support environmental accountability through analysis of long-term-monitoring records and modeling:

- Provide the necessary research to assess changes in the environment, specifically in relation to changes in emissions and energy technology.
- Support research that will help evaluate the effectiveness of air quality management strategies for acid deposition, mercury, ozone and co-pollutants, particulate matter, and climate-forcing agents. Provide insight on how environmental-protection policies may need to be changed in the future to better protect environmental and public health in New York State.
- Where strategic opportunities exist, support efforts to augment basic compliance monitoring to provide scientifically robust information to advance understanding of the fate and transport of energy-related pollution in New York and the region.

2. Support research that will enhance understanding of the source types, source regions, and specific pollution components contributing to major environmental problems in New York State:

- Support research that will provide insight on the relative contribution of the combustion of fossil fuel in the various sectors (e.g., electricity production, heating, transportation) to major environmental problems in New York State.
- Such research should help prioritize opportunities for mitigation and pave the way for cross-sector, potentially market-based pollution control strategies.

3. Enhance the understanding of the multi-media/multi-pollutant environmental impacts of emerging energy technologies, energy systems, and energy-related pollution control technology.

4. Encourage the joint consideration of greenhouse gas impacts and direct health and ecologic impacts of pollution sources in New York State. Support efforts to examine the co-benefits of alternative energy and technology solutions.

5. Build an environmental research capability in New York State to better address the critical problems facing the State and the region and to create opportunities for innovation:

- Help foster collaborative, inter-disciplinary research to make better use of limited resources available for research.
- Provide seed funding to help attract other resources to further develop research capability in New York that can be sustained and grow beyond resources available to NYSERDA.

RESEARCH PLANNING, CONSULTATION PROCESS, AND SCOPING SESSIONS

NYSERDA and the New York Academy of Sciences convened working groups of science and policy experts to help identify critical gaps and research needs in New York State. The identified research needs were organized into three focus areas, representing the major issues related to pollution associated with energy generation and use:

A. Atmospheric Deposition of Sulfur (S), Nitrogen (N), and Mercury (Hg), and Ecosystem Response (Section A)
B. Air Quality and Related Health Research: Particulates (PM), Ozone, and Co-Pollutants (Section B)
C. Climate Change in New York State (Section C)

NYSERDA and the New York State Department of Environmental Conservation (NYS DEC), with the assistance of RESOLVE, Inc., also hosted a Technical Workshop on Wind/Wildlife Issues held in Albany, New York, on August 2-3, 2006. The purpose of the workshop was to bring together experts from across the country to explore the state of the knowledge on wind power=s impacts on wildlife and how that knowledge can be applied in New York. An additional goal of the workshop was to identify research needs on the interaction of birds and bats with wind power sites, as well as potential impact mitigation strategies. Research needs identified through this effort, as well as other alternative energy research needs, may be found in Section D.

NEXT STEPS—IMPLEMENTING THE RESEARCH PLAN

Approximately $17.5 million is available to support the above research objectives through 2011. Program Opportunity Notices (PONs) will be issued periodically to seek proposals that address targeted research areas. Proposals are reviewed and selected through a competitive process. Information about ongoing EMEP projects and funding opportunities may be found on the EMEP Web site (www.nyserda.org/programs/Environment/EMEP/).

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.

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

A. Ecological Effects of Deposition of Sulfur, Nitrogen, and Mercury

Activity	Importance for NYS	Timing		EMEP Priority and Role
		Urgency	Duration to results (years)	
1.0 Monitoring/Surveys/Synthesis				
Monitoring and Trend Analysis for Sulfur, Nitrogen and Mercury	1	1	3-5	High, especially given EMEP's prior investment.
Multimedia Mercury Monitoring Pilot	1	2	3-5	Medium-High. Reactive gaseous mercury is an elusive and expensive target. Seek leveraging
Mercury Biota Monitoring	2	2	3-5	Medium-High. New work should build on past initiatives.
Synthesis to Evaluate Acid Deposition and Mercury Policies	2	2	1-2	Medium-High. EMEP is well positioned to take a proactive role here.
2.0 Biogeochemical Processes and Ecosystem Response				
Soil Processes and Recovery from Acidification	1	1	3-5	Medium-High. Build on recent research efforts.
Acid Deposition Critical Loads Assessments	2	2	2-3	Medium-High. Important near-term connection to other efforts (e.g. federal).
Mercury Biogeochemical Processes	2	2	2-4	Medium-High. Focus on neglected areas of research, e.g. NY estuarine/coastal waters.
Effect of Multiple Stressors on Aquatic and Terrestrial Ecosystems and Biota	2	2	3-5	Low-Medium. Extraordinarily challenging, with high uncertainties of success.
3.0 Ecosystem Management, Economic Assessments and Technology Transfer				
Accelerated Recovery	3	3	2-5	Low EMEP priority and minor role.
Ecosystem Economic Valuation	3	2	2-3	Low, but room for a limited EMEP role in this area which requires complex analyses and consensus of acceptable criteria.

B. Air Quality and Health Effects

Activity	Importance for NYS	Timing		EMEP Priority and Role
		Urgency	Duration to results (years)	
1.0 Air Quality Trends, Including Monitoring and Modeling				
Combustion Products—Improve Monitoring, Characterization, and Understanding of Processes Involving Organic Species	1	1	3-5	High, strong focus on secondary organic aerosols (SOA)
Atmospheric Species—Improve Monitoring, Characterization, and Understanding of Processes	1	1	3-5	High, coordinate with federal efforts.
Trends Analysis—Tool Development and Accountability Analysis	2	2	3- 5	Medium-high, need well defined issues with long-term information.
Integrated Air Quality Observations for Improved Air Quality Forecasting	2	2	2-4	Medium-high, leverage on national initiative from NOAA
Multi-Pollutant Air Quality Management Strategies	2	3	> 5	Medium, build on NARSTO assessment with focus on NYS
2.0 Source Characterization, Pollution Control Technologies, and Emissions Inventory				
Inventory—Identification of Poorly Characterized Sources	1	1	3-5	High
Emissions Inventory—Micro-Inventory	1	1	2-3	High
Emissions Inventory—Improved Estimation of Seasonal Emissions	2	2	2-3	Medium-high. Could require significant financial resources.
Source Characterization—Improved Emission Factors and Activity Patterns	2	2	3-5	Medium-high. Could require significant financial resources.
Source Characterization—Improved Emission Measurement Method Development	2	2	> 5	Medium. National issue; partnership with EPA should be sought
Improved Energy and Environmental Modeling Including Multi-Pollutant Control Strategies	2	2	3-5	Medium-high
3.0 Exposure and Health Effects				
Improved PM Component Exposure Characterization	1	1	3-5	High
Localized Ambient PM and Co-pollutant Exposure Characterization	1	1	3-5	High
Accountability Studies for Programs Aimed at Reducing Exposure and Improving Public Health	2	2	> 5	Medium
Exposure Model Development for Urban and Regional Assessment	2	2	> 5	Low. Could require significant financial resources.
Development and Demonstration of Real-time Personal Speciation Monitors	2	2	3-5	Low. Could require significant financial resources.

C. Climate Change in New York State

Activity	Importance for NYS	Timing		EMEP Priority and Role
		Urgency	Duration to results (years)	
1.0 Reducing Emissions of Greenhouse Gases and Aerosols & Mitigating Climate Change Impacts				
Develop Greenhouse Gas Reduction Curves for NYS	1	1	1	Highest priority EMEP climate change area.
Evaluate the Potential of Energy Efficiency and Renewable Energy to Reduce CO_2 Emissions in NYS	1	2	1+	Efforts are underway to synthesize available. Assess analytical needs after synthesis is complete.
Climate Change Policy Research and Analysis	1	2	1	RGGI auction design research is a high EMEP priority. Other analyses (e.g., offset analysis/protocols) will likely be addressed by RGGI Regional Organization. Additional areas warranting EMEP research may be developed in the future (e.g. non-CO2 agents).
Characterize Opportunities for Geological CO_2 Sequestration in NYS	2	2	5	Look for opportunities to leverage federal funding.
Characterize Opportunities for Terrestrial CO_2 Sequestration in NYS	2	2	2-3	Look for opportunities to identify terrestrial sequestration strategies that provide other co-benefits for NYS (e.g., the agricultural sector) – related to item C2c.
Monitor Performance and Evaluate Benefits and Co-Benefits of Heat Island Mitigation Strategies	2	2	2	Coordinate with other NYSERDA R&D activities in green buildings and look for opportunities for demonstration and evaluation.
2.0 Understanding and Monitoring Impacts, Managing Risks, and Identifying Adaptation Strategies				
Integrated Impact Assessment and Identification of Adaptation Strategies	1	1	1	Highest priority EMEP climate change area. Consider regional approach.
Infrastructure and Land Use	2	3	TBD	More sector-specific analysis may be pursued after the initial impact assessment is completed.
Agriculture	2	3	TBD	More sector-specific analysis may be pursued after the initial impact assessment is completed.
Air Quality and Human Health	2	3	TBD	More sector-specific analysis may be pursued after the initial impact assessment is completed. Leverage ongoing EPA initiatives.
Natural Resources (including shorelines, tidal wetlands, wildlife species, forests, hydrological resources and the ecological cycling of carbon and nutrients)	2	3	TBD	More sector-specific analysis may be pursued after the initial impact assessment is completed.
3.0 Climate Change Outreach and Education				
Outreach and Education Initiatives - to promote government and community awareness of climate change, and assist in identifying potential adaptation and mitigation measures, and opportunities created by a changing climate.	1	2	<1	Increasing public awareness critical to improve opportunities to address the issue. Coordinate with DEC's climate office to produce a "toolkit" to promote local awareness and action.
Importance: 1 = critical/extremely important; 2 = important; 3 = moderately important. Timing/Urgency: 1 = immediate need; 2 = intermediate term need; 3 = deferred need				

DESCRIPTION OF PRIORITY RESEARCH AREAS

A. ECOLOGICAL EFFECTS OF DEPOSITION OF SULFUR, NITROGEN, AND MERCURY

This EMEP program area will support research to improve the scientific and technical foundation for the following key policy-relevant questions:

- Are lakes, streams, and ecosystems in New York recovering from adverse effects of acidification and mercury pollution?
- How will current and anticipated national and regional strategies to reduce emissions of SOx, NOx, and Hg from the electricity sector affect New York State ecosystems?
- For New York and the region, how can the concept of critical deposition loads (e.g., acidity) be incorporated into environmental-protection strategies?
- How will responses to acid deposition be influenced by other concurrent environmental changes such as invasive species and climate change?

A.1. MONITORING / SURVEYS / SYNTHESIS

Topic A.1.a: Monitoring and Trend Analysis for Sulfur, Nitrogen, and Mercury

Problem Statement

The processes of acidification and recovery take place over long time scales and involve various ecosystem compartments. Presently, the data required to evaluate landscape-scale or whole-ecosystem changes ensuing from decreased levels of acid deposition and mercury are either incomplete or lacking. For example, there is available information on lake chemistry, but more information is needed in order to integrate lake chemistry results with other ecosystem components, including both terrestrial and aquatic biota. Furthermore, there is very limited information available to evaluate how streams, terrestrial systems, forests, soils, and biota are responding to decreased deposition.

Research Focus

- Continue to support ongoing long-term-monitoring efforts to facilitate robust trend analyses. Lake water chemistry surveys provide valuable information and data to determine watershed response to decreased deposition.
- Review existing monitoring networks and evaluate whether sites could be combined, expanded, or downsized. Evaluate and integrate data from existing long-term-monitoring sites with that from intensive sites, and link across these scales.
- Support strategic atmospheric deposition networks, which are essential to assessing the relative contribution of regional, national, and global sources of N, S, and Hg. Evaluate for gaps or opportunities.
- Support efforts to provide better information on watershed processes and characterization to support the long-term monitoring of watersheds.
- Evaluate specific needs with respect to information needed (one site, 10 sites, year round, etc.) based on identified gaps in the following areas: streams and terrestrial ecosystem resources, such as soils and forest ecosystems, as well as biota.
- Consider expanding the monitoring effort to evaluate the full extent of the impacts, focusing on sensitive ecosystems, such as alpine areas.

- Establish a standardized monitoring network based on abiotic and biotic compartments of critical ecosystems.
- Given the diverse nature of the datasets for different ecosystems, these data may not be easily integrated across scales. Apply an integrated multi-dimensional monitoring approach, including some multi-scale study approaches, modeling, remote-sensing indicators—ground-truthed with surveys and intensive site data, which can help define some of the characteristics needed for models.
- Continue to test and improve watershed models using Adirondack Long-Term Monitoring (ALTM) data and other comparable datasets in the Catskills.
- Support efforts for linking and standardizing data collected at long-term forest ecosystem monitoring sites across the state.

The data resulting from this expanded monitoring effort can be applied broadly. For example, stream data will help to understand the extent of stream acidification and the factors controlling the spatial and temporal responses of stream aluminum and nitrate (NO_3) export. All monitoring data can assist in the development of a baseline of current conditions, which is needed to assess recovery rates and trends. Monitoring is the foundation for scientific understanding as well as regulatory and policy issues. The actual cost of monitoring is relatively small compared to other research activities, especially considering the key environmental and policy questions that monitoring enables researchers to answer.

New York State Relevance

Important ecosystems in New York State (e.g., Adirondacks, Catskills) continue to be affected by acid and mercury deposition. Despite continued effects, federal funding for research and monitoring in this area has decreased markedly. Data and information compiled through monitoring are required to assess the comprehensive impacts of deposition as well as response and recovery rates ensuing from efforts to reduce emissions.

Relation to Other Research in the Region and the Nation

Long-term biological monitoring efforts in 32 Adirondack lakes may be discontinued; if this happens, there will be a significant data-collection gap that needs to be addressed. The Adirondack Lakes Survey Corporation (ALSC) is planning to conduct a review of the available biological markers for the ALTM waters and is examining past data to determine the best assessment methods. The ALTM has conducted fisheries resurveys in its 52 lakes, sampled fish for mercury in some waters as part of the NYS Mercury in Fish Study, and conducts limited episodic sampling during high-flow events. The ALTM also conducts annual sampling in 43 lakes in cooperation with EPA's Temporally Integrated Monitoring of Ecosystems (TIME) Program.

The Western Adirondack Stream Survey was an experimental design and test of a stream survey strategy in a large (400,000 ha) landscape. During 2003-2005, 200 streams were successfully surveyed during five hydrologically sensitive time periods. The survey design was efficient, providing the first large-scale stream assessment linking terrestrial (soils), stream, and lake chemistry signals.

The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) started in 1978 with 22 sites and now operates 250 sites, including 11 sites in NYS. Three of the sites are in the Adirondacks: Huntington Forest (1978), Whiteface Mountain (1984), and Moss Lake (2003). Biscuit Brook (1983) is operated in the Catskills. The NADP also operates the Mercury Deposition Network, started in 1995 and consisting of more than 85 sites across the US, including three sites in NY at Biscuit Brook, West Point, and Huntington Forest.

The New York State Department of Environmental Conservation (NYS DEC) Division of Air Resources (DAR) has been operating an acidic-deposition-monitoring network in 20 locations across NYS since 1985. The DAR supports weekly collection and analysis of wet-deposition chemistry as well as a number of air quality parameters. One site (Whiteface Mountain) is co-located with NADP. The DAR also supports mountain cloud chemistry monitoring at the summit of

Whiteface Mountain during June-September. (See: http://www.dec.state.ny.us/website/dar/baqs/acidrain/network.html).

In the Catskill Mountains, the Collaborative Environmental Monitoring and Research Initiative (CEMRI) is implementing a prototype environmental monitoring strategy that is linking air quality, hydrological, and forestry information across the landscape of the Delaware River Basin.

Many individual research sites routinely measure soil and forest characteristics, but there is little coordination of measurements or synthesis of data.

Topic A.1.b: Multimedia Mercury Monitoring

Problem Statement

Given the lack of consistent monitoring for the various species of Hg in ambient air and the lack of information on how other pollutants affect the dry deposition of mercury, the fate of total annual atmospheric emissions of mercury is difficult to determine, as is the variation of dry and wet deposition of mercury. Speciation of the ambient concentrations of mercury and dry-deposition measurements are important for source attribution and assessment purposes, as well as improvements in model development. However, there are no standardized protocols for measuring speciated ambient concentrations of mercury, nor are there easily deployable methods available at this time to directly measure dry deposition. Improvements are needed in the current technology used to measure mercury dry deposition and ambient air concentrations, to help verify model predictions and improve their accuracy. Addressing the data needs described above, together with atmospheric modeling, will help to better link Hg transport in the atmosphere, deposition, and ecosystem effects.

Research Focus

- Routinely and consistently measure ambient air concentrations of elemental Hg gas, reactive gaseous Hg, and particulate Hg so that atmospheric Hg processes can be better understood and atmospheric Hg models can be tested against these observations.
- Obtain deposition data needed to estimate total mercury deposition, and determine the significance of the dry-deposition flux relative to that of wet deposition and their total impact on biota and ecosystems.
- Determine the impact of total wet and dry mercury deposition on biota and ecosystems.
- Conduct better monitoring and research measurements needed to characterize and understand sources, sinks, and transformation processes of Hg. (See *Environmental Science and Technology* article, “Monitoring the Response to Changing Mercury; 2005; 39(1): 14A-22A). This monitoring would be targeted to evaluate the effectiveness of mercury reduction programs.
- Operate atmospheric-deposition monitoring sites necessary to characterize the spatial pattern of Hg deposition across the state, including dry-deposition measurements. This must be coordinated with ongoing and planned New York State and federal efforts.
- Measure spatial patterns of mercury deposition in mountainous areas such as the Adirondacks and Catskills to evaluate exposure of high-elevation ecosystems.
- Improve current methods to measure mercury dry deposition and fluxes. Effective ways to measure gas fluxes are through eddy flux correlation methods (rapid measurements that are correlated to determine whether the air is going up or down at a particular instant) or through gradient methods. These are difficult for reactive gaseous mercury (RGM) because concentrations are so small and for elemental mercury gas because gradients are so small..
- Evaluate and compare different methodologies that can be used as the basis for more accurate Hg monitoring in New York State and to improve models of mercury transport in the region.
- Establish clear protocols and standards for methods used to measure mercury ambient air concentrations and to collect dry-deposition measurements that can be extrapolated across various ecosystems.

- Evaluate methods that may be easily deployable over large areas that would serve as a proxy for dry-deposition measurements.

New York State Relevance

Measures to reduce mercury emissions are scheduled to be implemented over the next decade in New York State and nationally. To understand the ecosystem response to reduction in Hg deposition, it is important to know how much is being deposited, how much is being re-emitted, and whether the accumulated mercury in soils and watersheds is going to slowly bleed out and have long-term effects. Current deposition networks emphasize measurements of wet deposition. However, preliminary data indicate that, at high altitudes, RGM is prominent, gradients in atmospheric mercury species may exist, and that dry deposition may be two or even three times higher than Hg deposited during rain events. Furthermore, ongoing research in New York and elsewhere about mercury deposition and retention as evidenced by high fluxes in litterfall and throughfall, as well as its remobilization during rain events, indicates that dry deposition is a major source of mercury to ecosystems in New York.

Some studies suggest that long-range transport of elemental mercury and atmospheric conversion to RGM is extremely important in understanding how mercury is deposited in terrestrial and aquatic ecosystems. However, some modeling studies suggest that for near-source regions, elemental mercury rather than reactive mercury is deposited. Improving the measurements of speciated mercury in the ambient air, analyzing the impact of other pollutants on mercury species by season, and improving the accuracy of air deposition and concentration measurements can help clarify the range of RGM transport and dry deposition of various mercury species. This information will be useful in improving current models for assessing mercury transport and deposition in New York State.

Relation to Other Research in the Region and the Nation

Currently there are three wet-precipitation monitoring stations for Hg in New York State. Primary funding for two of these is provided through NYSERDA's EMEP program. The sites are at Huntington Forest (since 1999) in the Adirondacks, Biscuit Brook (2004) in the Catskills, and West Point, NY (2006). Regional studies of mercury deposition and retention on litterfall and throughfall indicate that dry deposition affects ecosystems and that dry deposition might be very high in ecosystems such as the Adirondacks and Catskills.

NYS DEC is working on taking concurrent wet- and dry-deposition measurements (using Tekran analyzers) in order to better characterize the relationship between dry and wet deposition based on mercury species. A comparison of manual measurements of gaseous mercury is being performed with an automated Tekran 2537A in the laboratory and at a field site in Potsdam, NY.

In addition, various federal agencies, including the US EPA and the NADP, are working to establish a collaborative, national dry-deposition network and speciated-mercury ambient-air monitoring network. There is a serious effort currently underway to establish these networks using standardized procedures that will increase our understanding of mercury cycling in the atmosphere and the environment. Various federal agencies, including the U.S. EPA, are engaged in an effort to standardize the methods for speciated monitoring (e.g., for Tekran). These federal agencies are working to establish protocols on data collection and to standardize measurement procedures so that the same methodology can be used across the network, to facilitate data sharing and comparisons.

Topic A.1.c: Mercury Biota Monitoring

Problem Statement

Current available information and data are not sufficient to determine whether biota—fish and wildlife in particular—are recovering, or how they are responding to changes in the deposition rates of mercury, N, and S. Biotic monitoring efforts are needed to address data gaps that prevent the determination of biological recovery linked to depositional changes. The establishment of consistent bio-indicators of mercury exposure will assist scientists in developing a consistent benchmark. This will allow the tracking of changes in mercury concentrations in selected biota in a consistent manner over time.

Research Focus

- Evaluate which biological and physical parameters are best for detecting year-to-year changes in mercury deposition.
- Evaluate the spatial and temporal variation in potential metrics (e.g., young-of-year yellow perch, sediment, plankton) to document mercury changes over time.
- Gather additional information on selenium in New York State, since it is reported to counteract and mitigate mercury impacts. Provide information on background levels, sources, and concentrations in fish and wildlife.
- Investigate the interaction of Hg in acidic environments with base cation depletion to determine biota recovery rates.
- Monitor biota to provide better information to consumers (e.g., fish-consumption advisories) and help determine recovery rates (trends in changing mercury levels). Information regarding mercury levels in biota in coastal areas is limited, and biota-monitoring efforts should include the estuarine and marine environments.

New York State Relevance

Fish and water samples have been collected from 130 lakes across New York State over the past three years. Given the findings about mercury concentrations in fish, the NYS Department of Health has recently added numerous water bodies, including all water bodies in the Adirondacks and Catskills, to their fish-consumption advisories. However, present fish-monitoring efforts in NYS are limited, and there are many NYS lakes and parks for which there are no mercury data. New York State's many lakes provide breeding areas for the common loon and other fish-eating birds, which are susceptible to mercury contamination.

Relation to Other Research in the Region and Nation

The NYS DEC has conducted a recent survey of mercury concentrations in fish including yellow perch, largemouth bass, smallmouth bass, and walleye. These data could help determine if fish-tissue Hg concentrations are decreasing over time, provided that this monitoring continues. Planned monitoring efforts are limited, and consideration should be given to continued monitoring of yellow perch to ensure future trend analyses. The Adirondack Cooperative Loon Program, in cooperation with the BioDiversity Institute and the Wildlife Conservation Society, conducts research on the effects of mercury in loons and their food web.

Topic A.1.d: Synthesis to Evaluate Acid Deposition and Mercury Policies

Several baseline (synoptic and temporal, ongoing) studies and many intensive studies have been conducted (sponsored by EMEP), especially in the Adirondacks and Catskills, to understand the processes of acidification (S, N, and Hg). Several major data gaps have been identified. While individual studies often include policy implications in their findings, there could be more collective synthesis with long-term monitoring results, to inform specific policy strategies.

Problem Statement

Without a baseline synthesis of current conditions, it is difficult to:

1. Evaluate ecosystem trends and recovery rates from acid deposition.
2. Assess whether adequate monitoring is in place to determine whether ecosystem improvements occur as a result of new policy developments. For example, the federal Clean Air Interstate Rule (CAIR), aimed at reducing N and S atmospheric emissions, will start in 2010, and although there are data on lake chemistry improvements, other necessary information to assess progress is not integrated across studies.
3. Answer key questions on ecosystem response mechanisms, including: why is nitrogen decreasing in some lakes; why is dissolved organic carbon increasing, and how does this trend affect acid-base chemistry; are acid neutralizing capacity (ANC) and aluminum levels declining; are biota responding/improving?

4. Identify important data gaps. Dry-deposition estimates continue to be inadequate. There is a need to identify what specific datasets are key for assessing specific policy issues. The only site in the Adirondacks with continuous monitoring of dry deposition in the EPA network (CASTNET) is located at the Huntington Forest. Two other CASTNET sites are located in NYS (Connecticut Hill and Claryville). For more details see: http://www.epa.gov/castnet/. For existing and proposed monitoring elements (datasets), determine to what baseline condition ecosystems need to be restored. Devote study to vulnerable ecosystems or sensitive species. Consider charismatic species as indicators that can be more easily explained to the public.
5. Address the gaps between ecological and social sciences research and inform policy-making processes.

Research Focus

- Conduct a comprehensive synthesis of current and past conditions, including all available data on deposition, water chemistry, soil conditions, forests, and biota. Evaluate data gaps in each of these areas with respect to monitoring, intensive process studies, and modeling. Address questions such as:
    1. What data sets are best for examining what specific issues?
    2. Are all the necessary ecosystem components currently being monitored?
    3. What methods can be used to scale up from these data sets/ecosystems to a broader region?
- Integrate available data on water chemistry at lake-watershed sites by linking these to data on terrestrial systems and biota. Assess lake and stream aquatic biota response in key food-web trophic levels. Evaluate fish community response in lakes with long-term chemistry.
- Link both temporal (long-term) and spatial datasets (e.g., for forest songbirds surveys, surveys of reproductive success) to changes in acid deposition. This effort may uncover a set of environmental impacts on large groups of species that have not yet been recognized.

New York State Relevance

There are long-term programs for lake water chemistry and biota (ALTM, AEAP) in New York State, and information from these are not well integrated. A synthesis of research findings and datasets can improve the understanding of biota effects. There is currently a partial assessment of stream chemistry conditions in the Adirondack region. The Western Adirondack Stream Survey was a successful design in assessing 20% of the region. A further assessment of streams, in the remaining 80% if the Adirondacks, provides an opportunity to integrate with existing watershed data (e.g., Adirondack Park Agency GIS coverage) across more diverse landscapes (e.g., High Peaks, Champlain Valley) of soils, hydrology, and vegetation.

Relation to other Research in the Region and Nation

Ongoing initiatives include: the New England Governor's Eastern Canadian Premiers Acid Rain Efforts; the EPA Review of Secondary Standards for Air Quality; and the North American Research Strategy on Tropospheric Ozone (NARSTO) synthesis acid rain effort. A useful compendium on the Adirondacks can be found in "Acid Rain and the Adirondacks: A Research Summary" by Jenkins et al., a synthesis of historic Adirondack Park acidification research (www.adirondacklakessurvey.org/).

There are many datasets on soils and forests that can be integrated as part of the synthesis work. For example, the USDA Forest Service supports the Forest Inventory and Analysis (FIA) and Forest Health Monitoring (FHM) programs. About 80-100 plots have been established in the Adirondacks. The Direct Delayed Response Project (DDRP) established plots in the mid-1980s, which were revisited recently (Driscoll, Church, et al.).

An EMEP project extrapolated results from research, monitoring, and modeling efforts from a few intensively studied lakes to the larger regional Adirondack population of lakes and developed a statistically representative database for Adirondack soils. This project also characterized

watersheds according to their responsiveness to ongoing and future changes in sulfur and nitrogen deposition. EMEP is also supporting an ongoing study at SUNY ESF assessing the sensitivity of New York soils to cation depletion. The EMEP-supported Western Adirondack Stream Survey is improving the characterization of the acidification status of Adirondack streams and soils and is advancing the use of aluminum as an ecological indicator. Large, long-term, spatiotemporal datasets on bird presence and reproductive success are available for linking with landscape-level environmental stressors.

The existing datasets need to be evaluated before determining whether they can be integrated, as there may be inconsistencies with methods and scale.

A.2. Biogeochemical Processes and Ecosystem Response

Topic A.2.a: Soil Processes and Recovery from Acidification

Problem Statement

It appears that soil base conditions have been deteriorating over recent years in some acid-sensitive Adirondack lake watersheds, while the lake water chemistry has generally been improving. It is expected that the availability of base cations in the soil will continue to decline. This is important because the extent to which acid-sensitive lakes will continue to recover is highly associated with soil processes. Moreover, further deterioration of soil conditions could contribute to adverse impacts on vegetation. Recent research and sampling efforts have begun to bridge important data gaps regarding the relationship between soil conditions and surface water chemistry. However, some critical questions remain to be addressed, particularly in relation to forest responses to changes over time in soil base status. There is also limited information about what is controlling the observed increased retention of nitrogen, the increasing supply of dissolved organic carbon (DOC), or the mechanisms influencing these processes. Further research is needed to ascertain how changes in soil conditions over extended periods impact lakes, streams, forests, and other ecosystem components. More information is needed on forest response to the offsetting effects of varying degrees of declining acidic inputs and continuing base cation depletion.

Research Focus

- Develop databases to address the above information gaps.
- Link soil information more directly to stream chemistry and forest health.
- Use multiple approaches such as monitoring, modeling, tracers, and/or experiments to better understand the mechanisms of N cycling, retention, and leaching.
- Develop stream chemistry indicators of soil and forest health conditions.
- Strengthen modeling capabilities regarding terrestrial responses to changing levels of acidic deposition and base cation depletion.

New York State Relevance

A comparison of current New York State soil data with EPA soil results from the mid-1980s suggests that the soil base conditions have been deteriorating over recent years while the water chemistry in many lakes has improved. Two different models (PnET-BGC and MAGIC) also suggest that soils will continue to get worse in the future under levels of emission control expected as of 2004. Hence, conducting terrestrial research and linking it to aquatic systems can provide important data that can be applied to improve resource management in New York State.

Relation to Other Research in the Region and Nation

The need for terrestrial research focused on collection of field data to link soil acid-base chemistry with aquatic and forest response indicators is becoming more widely recognized. Recent and ongoing soil studies for the National Park Service and Forest Service in Shenandoah National

Park, Virginia, and on Forest Service lands in West Virginia, North Carolina, Tennessee, and South Carolina are supporting model-based assessments of ecosystem response to changing levels of S and N deposition.

An EMEP project results from research, monitoring, and modeling efforts from a few intensively studied lakes to the larger regional Adirondack population of lakes, and developed a statistically representative database for Adirondack soils. EMEP is also supporting an ongoing study assessing the sensitivity of New York soils to cation depletion. Through the Forest Inventory Analysis and other efforts, the U.S. Geological Survey (USGS) in Troy has archived soils datasets for much of the Catskill region, including the New York City watersheds. The USGS Western Adirondack Stream Survey has also produced an archived soils dataset.

Topic A.2.b: Acid Deposition Critical Loads Assessments

Problem Statement

Research aimed at evaluating the effectiveness of emissions reductions often stop short of determining whether the targeted reductions allow ecosystems to recover. This type of research aims to determine whether and over what time scale ecosystems are recovering, and whether further emission reductions may be needed to promote full recovery. Ecosystem recovery can be broadly defined as a return of key ecosystem processes and variables to pre-acidification conditions. Important parameters to assess may include acid-neutralizing capacity of surface waters, base saturation of soils, and the degree of re-establishment of key biotic components and their respective functions. Chemical measures serve as indices that reflect the suitability of habitat for sensitive biota. Biogeochemical models such as MAGIC and PnET-BGC are available to predict and evaluate ecosystem responses to historical changes and future scenarios of atmospheric deposition. However, there is limited information on whether currently observable trends in some of these variables are likely to persist and whether and at what chemical condition biological components will likely respond. A critical loads assessment can help set a chemical limit that is sufficiently protective of sensitive biological indicators in sensitive ecosystems.

Research Focus

- Conduct critical loads studies. Establish critical loads of sulfur and nitrogen deposition that are necessary to promote the continuation of ongoing ecosystem recovery. Determine whether threshold or critical deposition loads exist below which harmful effects on key parts of aquatic and terrestrial ecosystems will be diminished.
- Obtain data on deposition at finer spatial resolution than available with current state and national networks to assess the connection between inputs and response of particular communities. Obtain information at shorter time intervals, such as on an event basis, to improve the understanding of how episodic acidification and other events may affect recovery. Monitoring data for deposition and ecosystem variables are essential for determining how emissions reductions are manifested across the landscape. These results are needed to establish a better connection between deposition and the direction and rates of ecosystem responses.
- Determine the rates of key biogeochemical cycling processes and transport rates within ecosystems such as the role of soil processes in accumulating or releasing N and S. Better quantify the role of these processes in terms of ecosystem recovery and the response of terrestrial and aquatic biota.
- Better define the spatial extent of impacted ecosystems. Care should be taken to properly scale up from a small number of plots or watersheds to entire regions and to integrate different studies to develop an assessment of an entire region.
- Map impacted areas across the state according to an ecosystem sensitivity index that is based on some combination of existing data, any required new information, and modeled projections. The spatial extent of these sensitive areas might vary depending on which ecosystem components are considered.

New York State Relevance
With respect to the current state of the science, there is clear evidence of the following:

1. Acid deposition has declined significantly over New York State since the mid-1970s, mostly as a result of reduced sulfur emissions upwind of New York State.
2. Many surface waters in acid-sensitive regions of the state have shown signs of improvement in water chemistry such as increases in ANC and decreases in SO_4^{2-}. Recovery to pre-acidification levels, however, has not been widespread, and, in general, the improvements have been less than expected given the decreases in deposition of strong acids. Studies by the USGS in the Catskill region have shown that past levels of nitrogen deposition affect the changes in water quality associated with various forest harvesting practices.
3. Only a small amount of information exists about the current state of New York's soil chemistry relative to pre-acid precipitation conditions, but recent limited evidence suggests that soil base status continues to decline, which may be limiting the recovery of sensitive surface waters and decreasing the likelihood that some current recovery trends will continue.
4. Limited data suggest that certain biotic components are showing signs of improvement. The recovery and impacts on terrestrial biological components such as red spruce and sugar maple are even more difficult to document due to limited temporal data and the complex mix of stressors that affect tree species.

Some fragile ecosystems in New York State have associated critical loads that are likely very low, and careful gathering of information and modeling efforts are needed to document the variation across the state.

Relation to other Research in the Region and Nation
A number of federal agencies (including the U.S. Forest Service, National Park Service) are exploring the use of a critical-loads approach to examine the likely response of ecosystems to changes in atmospheric deposition on lands they manage. Recently, the US EPA joined with the Forest and Park Services and the USGS to explore critical-loads approaches within a multi-agency perspective. These agencies are interested in supporting critical-loads pilot projects, over the next two to three years, that will focus on incorporating as much research and monitoring data as are available in given areas (e.g., the Adirondacks, high-elevation systems in the western US) to support several critical-loads projects. The pilot projects will serve to demonstrate how to apply a critical-loads approach to assessments of various ecosystems in the future. Any project funded through the EMEP program should seek to build upon and/or coordinate with any ongoing critical-load studies in the region. There are also ongoing efforts to conduct total maximum daily load (TMDL) analyses for specific New York water bodies. Critical-load studies may benefit from coordination with these ongoing efforts.

Topic A.2.c: Mercury Biogeochemical Processes

Problem Statement
There is high uncertainty about how mercury methylation processes in aquatic environments will be affected by changing levels of organic matter, DOC, or N inputs. In general, it is understood that sediments with hypoxic and sulfidic conditions depress methylation processes. Given current efforts to reduce eutrophication, it is important to investigate whether these efforts will result in unintended effects, such as enhanced methylation rates in sediments.

Research Focus

- Conduct research to understand mercury methylation processes and their relationship to organic matter/DOC availability in different environments, including lakes, streams, estuaries, and coastal areas. Methylation processes may vary at diverse locations, given different profiles in organic matter availability. Investigate the role of dissolved organic carbon (DOC) in mediating ecosystem response to acid and Hg deposition.

- Provide a better source characterization to understand the proportional contributions of N to coastal environments and its relationship with mercury methylation processes.
- Collect high-quality scientific information designed to improve understanding of Hg and MeHg biogeochemistry and bioaccumulation in the coastal marine environment.
- For example, systematic studies could be conducted of the distribution of MeHg in selected marine organisms, such as fish in the NY/NJ Harbor and the NY Bight. These could include migratory piscivorous species (e.g., bluefish, striped bass) and non-migratory site-specific finfish and shellfish (e.g., cunner, quahog).
- Develop a predictive model that generally can be used to predict methylation in lakes and reservoirs.

New York State Relevance

Efforts to reduce loadings of nutrients (e.g., N, P) to the NY estuarine and coastal areas are likely to lead to decreased eutrophication and increased oxygen levels in sediments. Hypoxic and sulfidic conditions tend to diminish methylation—the more available organic matter in the system, the less methylation that occurs. As the sediments become healthier, one hypothesis is that there may be more in-faunal activity, and a possible unintended result of decreases in nitrogen could be an enhancement in methylation rates due to increased activity by sulfate-reducing bacteria. Under this hypothesis, improving conditions could lead to a period of enhanced methylation and increased Hg in fish. Preliminary data indicate that in certain coastal environments (e.g., Long Island Sound), the relationship between organic matter and the availability of mercury is quite strong. More data collection efforts and studies are needed to test this hypothesis. Substantial decreases in NOx emissions to the atmosphere are expected in the next three to five years, with associated reduced deposition. In addition, the Adirondacks lakes and Catskills streams are showing increasing levels of DOC concentrations, which are persisting, and it is not clear how changing DOC impacts MeHg processes.

Relation to Other Research in the Region and Nation

These process-level research recommendations represent an important step in advancing knowledge concerning (1) the biogeochemical cycling of Hg and MeHg in coastal waters, (2) the linkages to nutrient inputs and eutrophication, (3) the connections to atmospheric Hg deposition, especially indirect contributions via watershed runoff, and (4) the bioaccumulation of MeHg in marine biota, including those destined for human consumption. Such mechanistically focused studies and the monitoring efforts will not only benefit, as noted, NYS, but will add and complement efforts currently underway in selected coastal regions of the United States. These include Long Island Sound, San Francisco Bay, and the Gulf of Mexico, as well as some recent though limited studies in NY/NJ Harbor (e.g., Contaminant Assessment and Reduction Project (CARP), monitoring by the NYS DEC and NJ DEP). This information will be especially useful in developing/improving models for the behavior and fate of Hg in the coastal zone, as well as in assessing the impact associated with pollutant-derived Hg and its potential influence in affecting the production and bioaccumulation of MeHg in the marine environment. This information is also of significant value to local and federal public health and environmental agencies specifically concerned with marine resources.

Topic A.2.d: Effect of Multiple Stressors on Aquatic and Terrestrial Ecosystems and Biota

Problem Statement

Changes in deposition are occurring simultaneously with other large-scale influences on ecosystem structure and function. Climate change will undoubtedly cause changes in key processes as well as shifts in biological communities. Analyses of the interaction between climate change and the influences of atmospheric deposition will be critical for making long-term predictions of ecosystem health in the region. Other factors, including changes in land use, species invasions/introductions, and extinctions, will alter biological communities and their effects on rates of key processes such as decomposition and nutrient cycling. There is also a lack of specific ecological endpoints (chemical and biological) for the array of aquatic and terrestrial

ecosystems/communities in the NYS Forest Preserve, which are necessary in determining the "standards" being sought.

Research findings from the ALTM study and available data on surface-water chemistry show that surface waters in a large number of New York lakes are slowly improving as a result of decreased acid-deposition rates. However, recent time-series analyses of water chemistry suggest that the rates of improvement exhibited at these lakes have slowed. A USGS survey of western Adirondack streams has shown that over half of the streams have lethal aluminum levels for fish during high-flow events.

Various biological communities have decreased in extent, persistence, and composition over the past few decades. There have been changes in wildlife populations, such as declines in migrating songbirds and amphibians, yet the major causes of these changes are not well established. There are open questions about how much fish recovery is occurring and how widespread this might be. While there is evidence that fish species richness is no longer widely declining, it does not show widespread recovery. Ecologically important and charismatic species such as loons have shown signs of reproductive impairment. Several forest communities such as high-elevation red spruce, hemlock, American beech, and sugar maple have shown declines in vigor and, in some cases, replacement by other species. Additionally, organisms such as smallmouth bass and yellow perch have shown widespread contamination by atmospheric mercury deposition that is sufficient to warrant consumption advisories. Air pollutants can alter community characteristics such as species richness and biodiversity, which affect ecological processes as well as the sustainability and persistence of those communities.

It is widely recognized that mercury has an effect on aquatic food webs. Recent assessments have shown elevated mercury levels in terrestrial food webs as well, which have the potential to biomagnify methylmercury at higher rates than fish webs. Once mercury is deposited on ecosystems, there is very limited information to assess how it may be transformed by various processes. Songbirds (e.g., gleaners, red-winged blackbirds, tree sparrows) and other insectivore species are likely to be affected.

Research Focus

- Assess the effects of various factors, in addition to N and S deposition, on surface water chemistry in the Adirondack and Catskill Mountains, including the influences of mineral weathering and climate. Conduct research to address the following critical questions:
    1. Will ongoing improvements in DOC, pH, and ANC of surface waters continue, stabilize, or reverse? What levels of change in these parameters lead to biological recovery?
    2. Why are lake water DOC concentrations going up, and how does this influence lake water acid-base chemistry?
    3. Are some New York lakes and streams failing to recover in spite of reductions in SO_4 concentrations? If so, why?
    4. How do the interactions between sulfur, nitrogen, mercury, and carbon synergistically affect aquatic ecosystems?
- Determine how changes in multiple environmental stressors such as acid deposition, climate change, and invasive species interact to influence biotic and abiotic characteristics of forest ecosystems.
- Investigate how variation in geology, soils, and topography affect ecosystem response to acid and Hg deposition.
- Quantify the relative contribution of various stressors on biota. Determine species susceptibility to the synergistic effects of acid and mercury deposition as well as changing soil conditions, and establish the deposition-related risks for existing biological communities and their chances for re-establishment.

- Evaluate effects on organisms at different trophic levels, including species responsible for important processes (e.g., zooplankton control of phytoplankton production). Research should consider species diversity effects on ecological processes, e.g., how particular mixes of species or community richness alter nutrient cycling and retention.
- Determine if current and likely future trends in water quality allow biological recovery without human intervention (stocking, etc.).

Assessments should build upon work by previous intensive studies and by others in New York State, such as the Adirondack Effects Assessment Program, fisheries work by the ALSC, and breeding bird surveys. They may be coordinated with ongoing research efforts, such as at the Biodiversity Research Institute (research on terrestrial food webs) and at the Adirondack Cooperative Loon Program/Wildlife Conservation Society.

New York State Relevance

Although some recovery is evident, the lakes and streams in the Adirondack and Catskill regions continue to be at high risk from acidic deposition. Model projections suggest that continued Adirondack lake-water chemical recovery will require further reductions in acidic deposition. The limited data available on mercury impacts on biota in New York has indicated impairment to fish-eating birds, such as loons, and identified potential biological "hot spots." Such findings will affect public policy in New York and elsewhere.

Multi-stressor approaches are particularly needed to understand declines in species such as the wood thrush; recent evidence suggests that deposition-driven factors such as soil calcium availability and mercury in food sources may play a role in such declines. Field measurements in New York, where the synergistic effects of acid rain and mercury deposition may be especially great, would serve as a valuable template for nearby states and Canadian provinces. If compelling evidence of negative impacts is clear, the contribution of such scientific findings to conservation biologists and others will be significant in their efforts to better understand long-term and widespread declines of breeding songbirds and other biota.

Relation to other Research in the Region and Nation

The ALSC has substantial lake data available for over 20 chemical parameters. The Adirondack Effects Assessment Program has accumulated a long-term dataset of biological indictors. The Northeast Forests 2100 project has assessed the impact of climate change on a number of ecosystem components, many of which are related to deposition issues. A number of mercury-related studies have data on aquatic systems in New York, including the Adirondack Cooperative Loon Program and the Syracuse University/Tetra Tech Sunday Lake Assessment. The USGS has substantial data from the Catskill region.

Research in New York State has shown the role of calcium availability in affecting the relative abundance of sugar maple in the forest community and the effect of key species on nutrient cycling, especially N dynamics. Research in Pennsylvania by the U.S. Forest Service has documented declines in sugar maple that are exacerbated by acid deposition and its role in depleting calcium and magnesium from forest soils. Widespread effects of acid deposition on aquatic communities such as fish, zooplankton, and invertebrates are well documented in New York, and recovery of these communities is an unmet goal. Atmospheric acid and mercury deposition also affect forest management strategies, as demonstrated by USGS studies in the Catskills that indicate that historical nitrogen deposition affects water quality and aquatic ecosystem response after forest harvests. Mercury contamination of predator fish is a leading cause of fish-consumption advisories in New York.

A.3. ECOSYSTEM MANAGEMENT, ECONOMIC ASSESSMENTS, AND TECHNOLOGY TRANSFER

Topic A.3.a: Accelerated Recovery

Problem Statement

As acid deposition decreases, it may be possible to accelerate ecological recovery by use of several ecosystem management options. However, if the goal is to return to pre-acidification levels, part of the problem is that essential base cations, especially calcium, are not at, or may not return to, adequate levels for some time. A relevant question is: Do the existing Adirondack and Catskill soil databases constitute an adequate baseline (density, elevation, types of data) for terrestrial and aquatic resource recovery tracking? Also, limited information is available to guide managers of ecological resources as to which restoration projects work best in terms of promoting the recovery of biota. Several major liming/mitigation studies over the last 20-30 years have been conducted. Many acid sensitive and responding lakes in the Adirondack region occur within designated Wilderness areas where Forest Preserve rules and guidelines preclude certain project activities.

Research Focus

- Assess past research on lake and watershed liming projects, and interpret results relative to recent chemistry findings. Evaluate past assessments of benefits and constraints to base additions in the New York State Forest Preserve, including the NYS Final Environmental Impact Statement (FIES) on Liming Acidified Waters and NYS FEIS on SO_2 Control.
- Conduct experiments and demonstrations for accelerated recovery of terrestrial and aquatic ecosystems and organisms. Do not limit projects to soil restoration; expand restoration efforts to other ecosystem compartments, including forests and fish.
- Evaluate the success of past efforts to re-introduce fish at certain lakes in the Adirondacks.
- Evaluate the definition and metrics of what a restored fish community looks like in Adirondack and Catskill lakes and streams, as well as other sensitive areas of New York State.
- Evaluate various metrics that can be used to assess forest/tree health in terms of calcium. Identify key (sensitive, changing) terrestrial species.
- Investigate whether it is possible to restore ecosystems by adding calcium to soils. Establish a forest soil condition baseline, including the establishment of standardized metrics for forest soils.

New York State Relevance

Acid deposition has had detrimental effects on both aquatic and terrestrial systems in New York State, including loss of calcium concentrations in watersheds. Liming/calcium additions, fish restoration, and forest management tools can provide improved opportunities for recreational fishing and early recovery of ecological resources. It is important to evaluate whether these and similar restoration projects can be an effective resource management tool in New York State and whether results may be sustained over time.

Relation to Other Research in the Region and Nation

Some liming projects have taken place in the northeast region over the past 20-30 years, including the Adirondack Lake Acidification Mitigation Project, Living Lakes Project, Woods Lake investigations, and NYS DEC lake liming program. A number of ALTM lakes were part of these intensive investigations, either as limed lakes or control lakes (i.e., Woods Lake, Little Simon Pond, Darts Lake, Sagamore Lake, Barnes Lake, and Little Clear Pond). The research findings are helpful to evaluate whether the use of resources in these projects results in significant changes.

Topic A.3.b: Ecosystem Economic Valuation

Problem Statement

The links between the natural and social sciences are weak in some areas, which undermine efforts to perform economic valuation of ecosystems or evaluate changes in benefit-cost analysis. A particular weakness for social science valuation is the lack of information and modeling (analogous to MAGIC or PnET) about how terrestrial ecosystems respond. Integrated scientific assessments can help build a crucial bridge between scientific findings and the social science community, especially in reference to valuation of resources. It also provides a method for identifying the value of additional information that can help inform research priorities over the chain of effects linking human activities and ecological impacts. All meaningful economic analysis considers changes in ecological resources from a baseline to a changed condition. To help with economic valuations, it is important to relate scientific findings to endpoints and measures that people can understand, such as human health, recreation, and wildlife.

Research Focus

- Conduct assessments leading toward the development of baseline information needed for risk assessments and benefit-cost analysis. In order to improve on the knowledge that informs the valuation of ecosystems, the integrated baseline needs to be comprehensive with respect to pathways linking human activities and effects. The effort needs to elaborate on assessments of lake water chemistry and also include additional ecosystem components, such as terrestrial and biota (forests, soils, invertebrates, fish, birds, and other wildlife), and their respective functions.
- Collect more information about the different human uses and non-uses of ecosystems, their current magnitudes and value, and how such uses and their values respond to changes in ecosystem quality.

New York State Relevance

New York State has large areas set aside as parks and wild areas. For 20 years a central issue in the debate about clean air regulation has been acid rain, and one focus of that issue has been New York State's Adirondack Park. However, during most of this debate, no estimates have been available for valuing in monetary terms the ecological changes that would be likely to occur as a result of reduced air pollution.

Relation to other Research in the Region and Nation

A valuation project by Resources for the Future, focusing on New York State’s Adirondack Park, provides monetary values of the ecological changes that would be likely to occur as a result of reduced air pollution. This study quantifies the total economic value of expected ecological improvements in the Park from likely policies such as Clear Skies, the Clean Air Interstate Rule, and other legislative alternatives that would lead to roughly a 70% reduction in emissions of sulfur dioxide and nitrogen oxides from power plants. A new project will provide estimates of willingness to pay (WTP) for ecological changes resulting from reduced acidification in the Adirondack Park and Southern Appalachian region on a geographic and temporal scale that would be expected to result from current legislative or regulatory proposals.

B. AIR QUALITY AND HEALTH EFFECTS

This EMEP program area will support research to improve the scientific and technical foundation for the following key policy-relevant questions:

- What are the weaknesses in the energy-related emissions estimates for New York, which, if addressed, would improve the assessment of emissions reductions strategies for ozone precursors and particulate matter ($PM_{2.5}$)?
- What is the optimal mix of local and regional emission-control measures for $PM_{2.5}$ constituents that will represent a cost-effective means of achieving the annual and daily $PM_{2.5}$ standards in New York?
- What are the links between emission sources and ambient concentrations of, and exposures to, the health-related components of particulate matter, specifically in New York urban environments?
- Are there mitigation options that can help reduce the specific components of the combustion-related fine particle/oxidant complex that are causing adverse health effects? What are the impacts of these alternative mitigation options on emissions of climate-forcing agents?
- What are the local and regional implications for energy production and use from potential composition-specific $PM_{2.5}$-standard proposals in the next decade?
- What are the local and regional implications for energy production and use from a decrease in the 8-hr ozone and daily $PM_{2.5}$ National Ambient Air Quality Standards in the next decade?

B.1. AIR QUALITY TRENDS, INCLUDING MONITORING AND MODELING

In order to address the above questions, it is necessary to characterize ambient $PM_{2.5}$ and precursor gases due to combustion processes. There is great interest in organic species due to their large contribution to $PM_{2.5}$ mass and a need for greater understanding of semivolatile species and the atmospheric processes controlling them. Due to the importance of organic species, Topic B.1.a focuses entirely on improving the monitoring, characterization, and understanding of atmospheric processing of organic $PM_{2.5}$ and precursor species. However, there is still a need to characterize other trace species resulting from combustion processes (Topic B.1.b).

Improved modeling tools for trends analysis (Topic B.1.c) as well as accountability studies (Topic B.1.d) will be necessary to determine whether emission-control measures are having a positive impact on air quality.

Finally, this section of the research plan will also focus on opportunities for multi-pollutant air quality management strategies (Topic B.1.e) and integrating air quality observation systems with chemical transport models for improved air quality forecasting.

Topic B.1.a: Combustion Products—Improve Monitoring, Characterization, and Understanding of Processes Involving Organic Species

Problem Statement

Energy production and use involves multiple fuels that, when combusted, emit gaseous and particulate carbon compounds (organic carbon [OC] and elemental carbon [EC]). These carbonaceous species affect the formation of secondary aerosol particles and ozone. The chemistry and nature of the OC aerosols are the least well characterized of all air pollutants, yet carbon comprises more than 40 percent of the particulate matter (PM) mass in New York City on

an annual basis. Understanding the sources and processes by which carbon compounds form $PM_{2.5}$ is critical for developing effective control strategies.

Advancing our knowledge about the carbon in air pollution depends on combined measurements of speciated volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and secondary organic aerosols (SOAs). Only with combined measurements can a complete description of the organic fraction in air be determined.

Research Focus

PM: Improved spatial and temporal measurements of speciated organic aerosols are needed to assist in identifying the sources and concentration gradients of organic aerosols in New York State. In addition, highly time-resolved data of organic PM species may assist in identifying diurnal patterns of secondary aerosol production and the processes involved. The interpretation of this ambient data will need to be supplemented with ambient VOC measurements and emissions inventory data (Topic B.2).

VOCs: Improved information is needed with respect to VOC sources, role in aerosol formation, role in ozone formation, control technology options, and data gaps. In addition, highly time-resolved measurements of speciated ambient VOCs are needed for both anthropogenic and biogenic species, to estimate the significance of their impact on photochemical oxidant cycles leading to ozone and secondary organic aerosol, regionally and locally. This may also require measuring other oxidant species. Data interpretation needs to consider not only the spatial and temporal (especially seasonal) distributions of VOCs and secondary organic aerosols, but also the potential for end-product formation during atmospheric processing (e.g., formaldehyde, acetaldehyde, acrolein, organic nitrates).

New York State Relevance

New York is susceptible to elevated O_3 and fine particle concentrations from local and regional sources. Perhaps least well characterized is the chemistry of organic carbon. To make progress in reduction of O_3 and fine particle levels in the state, especially around New York City, improved knowledge of the organic components is needed. This need is accompanied by an additional need to characterize both organic reactants and products in relation to human exposure within the state. Relatively little is known about human exposure to these species (Topic B.3.a).

Relation to Other Research in the Region and the Nation

There is currently ongoing research into secondary organic aerosols, both regionally and nationally. However, there is only a minimal attempt to obtain simultaneous data on VOCs, SVOCs, and SOAs that can be used for chemical analysis and human-exposure scenarios.

Organic species measured in projects under this topic may be measured concurrently with other chemical species (Topic B.2.a) to maximize research value.

Topic B.1.b: Atmospheric Species—Improve Monitoring, Characterization, and Understanding of Processes

Problem Statement

The production and use of energy results in emissions of many gaseous and condensed-phase chemical species. These emissions may be involved in numerous complicated atmospheric processes, including ozone production or aerosol formation. In addition to Topic B.1.1, which focused on organic species, much information is needed to characterize atmospheric species, including trace gas concentrations, particle size distributions, and chemical composition of aerosols. The species of interest in the atmosphere include not only those species that are directly emitted or that are formed through atmospheric chemistry, but also intermediate species that can provide insights into the chemistry. Beyond ground-based measurements, the vertical profile and synoptic-scale spatial distributions of aerosols and gases are needed for improved understanding of atmospheric processing and air quality management. (Note: Mercury measurements are addressed in Topic A.1.)

Research Focus

- Perform highly time-resolved measurements of NOy, NOx, HNO_3, HONO, PAN, NH_3, H_2O_2, organic peroxides, and VOCs in urban and regional atmospheres in New York State to improve the quantitative understanding of atmospheric oxidation cycle and ozone production. Explore possibilities for monitoring on a routine basis.
- Characterize particle-size distributions in New York State on a highly time-resolved basis to identify source types and dynamics in particle production and growth. These measurements should be performed alongside detailed measurements of gaseous compounds and speciated aerosols in the ultrafine, accumulation mode, and coarse thoracic size ranges.
- Develop innovative methods for interpreting remote-sensing data for New York State and the region. Research is needed into multi-sensor data analysis from different instruments, which can potentially improve the spatial and temporal resolution and quality of aerosol optical data, for estimating coarse/fine-mode fractions, and separating absorbing and non-absorbing aerosols.
- Develop methodologies for interpreting satellite data in terms of air quality parameters of interest (surface quantities). For example, aerosol optical depth has been used as a proxy for surface $PM_{2.5}$, but the correlation between these two measurements is complex and needs to be better understood.
- Measure $PM_{2.5}$ species using a high temporal resolution for better source apportionment, process studies, support of health studies, and trend analysis. Samples for analysis may include archived samples from previous studies, to maximize research value.

New York State Relevance

New York State has made considerable progress in characterizing PM composition, measuring diurnal and seasonal patterns of trace gases and PM, and apportioning pollutants to source regions and source types. Additional details concerning these categories and others are needed to advance understanding of the atmospheric processes forming ozone and secondary particles in New York's atmosphere. This information will help advance a multi-pollutant approach to achieving the National Ambient Air Quality Standards (NAAQS).

Relation to Other Research in the Region and the Nation

Detailed studies of ozone and particle precursors and chemical processes have proven to be essential for air quality planning in other locations, such as Houston, TX.

Topic B.1.c: Trends Analysis—Tool Development and Accountability Analysis

Problem Statement

Trends analyses are needed to assess whether regulatory programs aimed at reducing pollution are having a positive impact on air quality. Determination of trends in air quality measures has been difficult because insufficient data are available to verify emission reductions, and ambient data collections are limited by spatial and temporal coverage of observations. The determination of trends is further complicated by the complexities of atmospheric chemistry, which often creates non-linear relationships between emissions and ambient observations. Innovative techniques are needed to establish credible trends.

Research Focus

- Develop approaches for dynamic and probabilistic evaluation of models for air quality management to determine:
    - how well models simulate changes in air quality induced by changes in weather versus emissions
    - the ability of air quality models to accurately estimate the emissions reductions needed to comply with standards

- Analyze changes in $PM_{2.5}$, PM components, NOx, NOy, VOCs, ozone, and other trace gases to determine trends resulting from regulatory programs (e.g., NOx SIP call, New York State Acid Deposition Reduction Act, changes in fuel use). Approaches may include trends analysis of data from ground-based measurements and emerging remote-sensing techniques, including satellite measurements. Analysis should have sufficient temporal and spatial scope to capture the possible impacts of the regulatory implementation on ambient concentrations and exposure levels for New York State residents.

New York State Relevance

Accountability (Topic B.3.c) and credible estimates of the changes in regional and local pollutants will become increasingly important to New York as it develops new strategies for emission controls to meet more stringent ozone and PM standards and evaluates reductions in acid and mercury deposition (Topic A). This is especially relevant because local and upwind emissions combined with local and regional meteorological effects must be taken into account when estimating change over the long term in New York. Being downwind of many important source regions, including across the northern border, may pose challenges for New York State in demonstrating accountability.

The New York State Department of Health, Centers for Disease Control, and U.S. EPA, are developing a New York State Environmental Public Health Tracking Network. Included in the objectives are evaluations of the effects of the NOx SIP Call on respiratory health and of meteorological conditions on health in New York State.

Relation to Other Research in the Region and Nation

Increased regional and national emphasis will be placed on developing means to track progress in reducing O_3 and PM concentrations to meet ambient air quality standards. Research programs, including improved emissions inventories for precursors, and model evaluations are continuing. Observational studies are essential for advancing models and credible trend analyses. Both the Health Effects Institute (HEI) and the U.S. EPA have begun accountability research projects.

Topic B. 1.d: Integrated Air Quality Observations for Improved Air Quality Forecasting

Problem Statement

Because regulations now require spatial prediction, there is a need for an integrated air quality observation system that coherently brings together air monitoring measurements and 3-D chemical transport models for better air quality forecasts. The ultimate system will be able to make air quality predictions with multiple observations from different platforms. Of particular energy relevance are those times of high electricity usage coinciding with stagnant meteorological conditions.

Research Focus

Research is needed on the development of a regional, integrated air-quality monitoring system in and around New York State to meet NYS air quality regulatory and policy needs. This would require the creation of partnerships to pull together ongoing research and development in surface sampling and speciation, remote sensing of aerosol and trace gases (including satellite measurements), and chemical transport modeling. This research topic also relates to Topic B.2.c and Topic B.2.d, which focus on improved emissions estimates.

New York State Relevance

The air quality forecast system described above could be used to assess SIP models and assumptions. This modeling capability would be very helpful for forecasting air quality on high-electrical-demand days.

Relevance to other research in the Region and the Nation

There is ongoing and planned federally supported research in creating a test bed for implementation of an air quality decision support system in other regions. For example, U.S. EPA and NOAA have signed a Memorandum of Understanding (MOU) to collaboratively develop a

national air quality forecasting tool for use by state and local forecasters to provide air quality reports.

Topic B.1.e: Multi-Pollutant Air Quality Management Strategies

Problem Statement

There are a number of cases where full accounting of scientific knowledge would have guided decision makers to different strategies for air quality management. One example is the early choice for VOC reductions to control O_3, which did not achieve expected O_3 reductions, rather than combined NOx and VOC control. Currently, state implementation plans are designed around individual pollutants. However, air quality management appears to be more effective and efficient if plans are designed on a multi-pollutant basis, including criteria pollutants, hazardous air pollutants (HAPs), and climate-forcing agents (Topic C.2.d). This approach would apply to development of emission controls for energy production and use, including emerging technologies and mobile sources. The technical basis of such an approach needs to be evaluated in a New York State context.

Research Focus

- Examine potential opportunities for optimizing emission controls for interrelated pollutants (O_3, PM, and their precursors, mercury, greenhouse gases, etc.) in New York State and the region while minimizing potential adverse side effects (e.g., local vs. regional emission reductions).
- Explore reactivity-based control strategies and potential effects on regional ozone and secondary PM formation. This should include strategies for optimizing control measures for specific source types (with consideration of new energy technologies and fuel changes) on NOx, NOy, VOCs, O_3, SO_2, and other photochemically active trace gases.

New York State Relevance

A multi-pollutant approach for New York would mean a major change in developing the state implementation plans and state-level air quality management. An early exploration of this alternative approach will provide some technical guidance for state response to this change of direction. Consideration of HAPs levels is likely to be required in the future, and the implications of such a requirement need to be examined.

Relation to Other Research in the Region and Nation

Technical support for multi-pollutant air quality management is in the very early stages of development. There is little specific research being planned for this area, except within the U.S. EPA. Even so, there are or have been efforts to identify scientific issues associated with multi-pollutant air quality management, such as the NRC report (“Air Quality Management in the United States”) and an ongoing assessment of science needs for multi-pollutant air quality management being developed by NARSTO.

B.2. SOURCE CHARACTERIZATION, POLLUTION CONTROL TECHNOLOGIES, AND EMISSIONS INVENTORY

Recent work by NARSTO has pointed to the need for improved emissions inventories throughout North America to improve overall air quality management. In New York State, there is also a need to improve the quality of emissions inventories that are widely used for multiple applications, including air quality planning (through modeling), air quality forecasting, trends analyses, source attribution studies, human exposure studies, and accountability-type studies. Electric generating units are well characterized due to continuous emission monitoring. Efforts here should emphasize those source types related to energy production and energy use that are currently not adequately characterized, including back-up generators, distributed generation technology, commercial use of residual oil, mobile sources, and residential wood combustion. Emissions

estimates need to be made on finer spatial and shorter temporal scales and to establish chemical speciation of emissions (with focus on speciation of emissions for both primary fine PM and VOCs).

Topic B.2.a: Emissions Inventory—Better Characterization of Currently Poorly Characterized Sources

Problem Statement

Much of the current emissions inventory is based on emission factors that in some cases are 20 years old. Due to changes in technology, activity patterns, and emissions of interest, there is a need to evaluate the current inventory to identify those sources that are poorly characterized and to improve the inventory by improving emissions factors and activity data. A recent assessment by NARSTO, "Improving Emission Inventories for Effective Air Quality Management Across North America," identified many areas in need of improvement. Due to regional variations in air quality and source types, and the cost of measuring emission factors, efforts to improve the emissions inventory should have a regional focus and involve U.S. EPA and adjacent states and provinces. A Regional Emissions Inventory Workshop sponsored by NYSERDA and others is planned for 2008 to address this objective.

Research Focus

Research should focus on identifying and evaluating those emissions inventories and activity patterns with greatest uncertainties. Examples of energy-related sources in need of improved inventories are: stationary diesel engines; mobile sources, including non-road equipment; marine vessels; locomotives; residential wood combustion; stationary commercial and residential boilers and furnaces; and electrical generating peaking units. Emissions of primary particle size, speciated PM emissions, PM precursors, hazardous air pollutants, and ammonia were identified as high priorities for improvement in the NARSTO Assessment (www.narsto.org). Information from this evaluation should inform source characterization research priorities where possible. This characterization includes understanding emissions outside the average operation such as upsets, start-ups, and shut-downs. Satellites and other remote-sensing techniques may provide improved measurements of temporal variability in emissions.

New York State Relevance

Better and more accurate estimates of emissions of species that are precursors to ozone and fine PM are needed for improved air quality planning. The need for finer resolution in space and time for emission estimates will be increasingly important as air quality standards are tightened and energy-use patterns change.

Relation to other Research in the Region and Nation

The U.S. EPA has begun addressing the major recommendations resulting from the NARSTO Emissions Inventory Assessment. A recently released Emission Factor Uncertainty Assessment by EPA assesses the uncertainty of the best-rated emission factors and develops uncertainty ratios for a range of probability levels (see http://www.epa.gov/ttn/chief/efpac/uncertainty.html). The proposed studies above build on the work being undertaken by the U.S. EPA. There is potential that the EPA would make its future fine-PM standard more stringent and include a sub-daily standard (potentially over a 4- to 6-hour period, compared to the current 24-hour standard). The proposed emphasis on finer-scale inventory would provide much needed information for meeting future standards.

Topic B.2.b: Emissions Inventory—Micro-Inventory

Problem Statement

Emissions inventories tend to represent broad geographical areas and relatively long time intervals. As a result, the data are of more limited value to air quality modeling and exposure studies on shorter time intervals. There are localized geographical areas of high emissions density where concentrations cannot be predicted by the inventory. These hotspots often are located in densely populated areas. Exposure to residents is a result of many individual sources,

such as commercial buildings burning residual oil for domestic hot water and space heating, highly congested roadways, construction equipment, and industrial facilities. Changing energy-use patterns, emerging technologies such as combined heat and power, condensing boilers, and increased use of low-sulfur fuels or bio-fuels will change source profiles from buildings. Improvement in the inventory of emissions sources, fuel types, and activity patterns is essential for improved pollution-mitigation planning, air quality forecasting, and exposure assessments.

Research Focus

Develop "micro-inventories" through pilot-scale studies (including method development) with the goal of improving or ground-truthing the current inventory (e.g., boiler size, commercial activities, back-up generators) and supporting concurrent or subsequent exposure studies at the community-level scale. These studies must resolve and/or estimate the emissions at much finer spatial (a few hundred meters) and temporal (an hour or less) scales than traditional inventories, which are generally at the county level and are based on annual or seasonal averages.

New York State Relevance

The residents of New York City experience an asthma rate four times higher than the national average. EMEP-supported research has shown hospital admissions for asthma to be associated with ozone, SO_2, and maximum one-hour $PM_{2.5}$. The $PM_{2.5}$ finding suggests that a future sub-daily $PM_{2.5}$ NAAQS could help reduce exposure in this city. Detailed evaluation of the emissions sources in a small area will be needed for careful exposure studies and future air quality planning and energy planning, including additional use of coal-fired boilers, oil-fired boilers, natural gas turbines, and back-up generators during high-electricity-demand days.

Relation to other Research in the Region and Nation

Other regions also have uncertainty in their emissions inventory. There are five Regional Planning Organizations (RPOs) that coordinate air planning and management among states. New York is in the Mid-Atlantic/Northeast Visibility Union (MANE-VU). The RPOs have begun to address emissions inventories for criteria pollutants and their precursors for the year 2002. New York City has also expressed an interest in improving the emissions inventory as part of their recent sustainability initiative, PlaNYC (www.nyc.gov/html/planyc2030/html).

Topic B.2.c: Emissions Inventory—Improved Estimation of Seasonal Emissions

Problem Statement

Energy-related emissions vary seasonally depending on fuel use, fuel availability, home heating needs, electrical demand, and meteorological conditions. Improved emissions inventories and activity patterns are needed to adequately describe these changes and improve emissions estimates. One special case is high-electricity-demand days (HEDD). These days occur during the summer when conditions are very hot, air conditioning use increases, and the demand for electricity is very high. This leads to emissions of PM and ozone precursors at levels higher than modeled by air quality planners, due to increased generation at some plants and the start-up of "peaking" plants (often combustion turbines or diesel engines) to meet the increased load. To add to the situation, back-up generators in highly populated areas that have much higher emissions rates than central station plants are used to curtail load on the electrical grid. The meteorological conditions are generally stagnant for a few to several days, preventing emissions from dispersing quickly. This results in high ozone and PM in the ozone transport region, often close to or exceeding the NAAQS. Improved emission estimates are needed for these days in order to develop emissions-reduction strategies, including increased energy efficiency and renewable energy, and to improve air quality forecasting.

Research Focus

Substantial improvements in systematic estimation of emissions by season using innovative methods are needed, with high spatial and temporal resolution.

Research should build upon the recent work done by the northeastern states on the quantification of emissions on high-electricity-demand days. In addition to emissions from single-cycle gas/oil

turbines, speciated emissions from oil- and gas-fired boilers and stationary diesel engines should be quantified. Where practical, these efforts should be coordinated with the micro-inventory effort. Research is also needed to identify the meteorological and other conditions that result in the operation of these peaking units, as well as emissions from start-up and shut-down operations. Understanding these conditions can provide the basis for more accurately predicting emissions from these units.

New York State Relevance
New York has a varying fuel mix due to energy-related activities and electricity demand. Knowledge of seasonal and daily emissions will help in air quality planning and forecasting.

Relation to other Research in the Region and Nation
In the ozone transport region, some states such as New Jersey may use electricity-demand forecasting to trigger NOx control use.

Topic B.2.d: Source Characterization—Improved Emission Factors and Activity Patterns

Problem Statement
Current emissions inventories are lacking detailed source-emissions profiles (including chemical speciation of emissions, primary particle size distributions, VOCs, and HAPs) and activity patterns with adequate time resolution.

Research Focus
Studies are needed to improve the quality of emissions profiles and activity data for those point, area, and mobile (on-road and off-road) sources for which current data are missing or inadequate, and to examine emerging technologies. More-sophisticated emissions profiles need to be developed with other stakeholders using dilution sampling for both VOCs and fine PM. Examples of energy-related sources include back-up generators, distributed generation technologies, industrial boilers, construction equipment, residential fuel use (including wood), outdoor wood boilers, and commercial/institutional sources of combustion. The effort to improve emission factors should be driven by regional needs and should take into account changes in combustion technologies, control technologies, fuels, and technologies to facilitate future emissions-trading opportunities.

Where possible, in-use emissions should be measured to compare with tabulated emission factors (e.g., AP-42 values). This will improve the emissions profiles, the inventory, and air quality management. In-use mobile-source emissions characterization studies are examples of the types of studies that are essential because they provide data about rapidly transforming emissions (particle formation and chemical reactions) in air pollution hot-spots. Such hot-spots are not well characterized by regional monitors and are of limited use in identifying the need for pollution mitigation strategies (such as diesel-emission reduction technologies) and exposure studies. This type of study will also support accountability assessments.

New York State Relevance
Improved emission factors and activity patterns could be used to improve New York's emissions inventory, resulting in improved air quality planning.

Relation to other Research in the Region and Nation
The U.S. EPA has recently produced a draft *Emissions Factor Uncertainty Assessment* in which they develop uncertainty ratios for emission factors. This is a national problem, and partnerships will be needed to address emissions inventory improvements.

Topic B.2.e: Source Characterization—Improved Emission Measurement Method Development

Problem Statement

Improved sampling instrumentation and chemical measurement technologies are needed to better quantify primary PM and gaseous emissions from stationary stacks, mobile tailpipes, and area sources. In addition, improved chemical speciation is needed. For example, characterization of individual hydrocarbon emissions rather than total VOCs is needed for more source types. Instrumentation for speciated organic PM would also be an improvement over OC measurements and would serve to advance air quality planning.

Beyond improved instrumentation, measurements are needed for sources under varying operational conditions such as start-up and variable loads. Measurements should also be developed under different (seasonal) ambient conditions.

Additional technologies are evolving that could help measure emissions from area sources under actual conditions. Improvements in remote-sensing technologies, whether ground-based, air-based, or satellite based, may provide verification of existing inventories, improved measurement of area or fugitive sources under actual ambient conditions, and identification of new point sources.

Research Focus

Innovative methods are needed to characterize PM emissions with respect to composition and size for both local and regional conditions in the Northeast. Source emissions should be characterized under varying operating conditions (start-up, steady-state, shut-down, idle, cruise, partial loads, full load, etc.). Measurements should include:

- S and C emissions from petroleum sources and bio-fuels blended with petroleum products in applications including back-up electricity generators; distributed generation technologies; on-road, non-road, and marine diesel engines; and residential, commercial, and utility oil combustion;
- wood smoke from residential or small commercial operations in rural and suburban areas;
- speciated organic SVOC emissions from commercial food operations; and
- biogenic sources of gases and particles, especially wildfires and VOCs.

New methods are also needed to measure mercury (Topic A.1) and air toxics.

Demonstrations of remote-sensing and data-analysis tools are needed to assess their usefulness in:

- quantifying primary PM, precursors of secondary PM and ozone, and their subsequent transformation in short time intervals in complex urban environments;
- quantifying non-urban emissions such as biogenic emissions from area sources;
- quantifying anthropogenic (sulfate and nitrate) and biogenic (forest fire) emissions transported into New York State; and
- developing datasets appropriate for use with air quality models for planning and forecasting.

New York State Relevance

NYSERDA has supported emissions-testing research of fine-particle emission factors and speciation profiles using dilution sampling on oil- and gas-fired combustion systems. The condensable emissions measured with the dilution sampling system had poor agreement with AP-42 emission factors. As a result, the AP-42 factors, which were considered too high for the condensable fraction of PM, were adjusted in the 2002 National Emission Inventory. Other sources need improved emissions measurements as well.

Relation to other Research in the Region and Nation
This is a national problem, and partnerships will be needed to address emissions inventory improvements.

Topic B.2.f: Improved Energy and Environmental Modeling, Including Multi-Pollutant Control Strategies

Problem Statement
Enhancement of New York's electricity-sector modeling capability is necessary to more fully evaluate the impacts of existing and proposed environmental regulations and policies on the electricity-generation sector. Critical issues include emissions, system operation, markets, wholesale prices for energy and capacity, allowance prices, fuel use and diversity, imports and exports, new capacity needs, new technologies, plant retirements, and system reliability. It is important to further develop and refine the capability and tools to analyze both generation and transmission systems. This capability will enable the comprehensive analysis of New York policies as well as policies developed at the regional and national levels, informing decision-makers in developing sound environmental policies.

Research Focus
The following are needed improvements to specific modeling capabilities:

- Enhance the model representation of overall operation of electric-generation units and their associated emissions. This may include improvements in the capability to model the operation of oil-gas steam-generation units and their associated air emissions. Factors to consider and quantify include reliability rules, local operation requirements due to load pockets, fuel availability/supply disruptions, fuel-storage capability, start-up and ramp-up times, short-term environmental limitations, short-term price and supply expectations, extreme weather, forced outages, transmission constraints, unplanned transmission outages, and monthly, weekly, daily, and hourly load shapes.
- Improve the capability to model operation of gas-turbine peaking units and the associated air emissions that impact air quality at critical times.
- Improve the capability to model imports and exports to and from the region. Imports are largely dependent on appropriate representation of the transmission system.
- Improve the representation of new generation and transmission technologies, renewable sources and markets, end-use energy-efficiency technologies, combined heat and power, and emission-control technologies.
- Improve the capability to incorporate as model inputs the changes in power flows that may occur as a result of system changes.
- Improve the capability to develop links between various models, whereby output from one model becomes critical input for another model with a different function. For example, yearly new-generation requirements estimated by the multi-year Integrated Planning Model (IPM) can be used as input data for the detailed, single-year Multi-Area Production Simulation (MAPS) model. Another critical link is the capability to use hourly point-source emission output data from MAPS as input to the multi-dimensional episodic air quality model.

The following are examples of specific modeling analyses that are needed:

- Model high-electricity-demand days by evaluating the hourly emissions impacts on a single design peak day to estimate impacts of controls on specific generation units, demand-response programs that temporarily reduce electricity load, and permanent demand reductions due to energy-efficiency programs.
- Model the impacts of achieving proposed energy-efficiency and renewable targets and proposed appliance and equipment standards.

- Model the impacts of various national and regional environmental policy proposals on New York.
- Model multi-pollutant strategies to evaluate the degree to which various programs interact with each other in achieving environmental goals.
- Model improvements in the transmission system, including new lines and new technologies.

New York State Relevance
Environmental policies have a direct impact on New York, whether developed at the state, regional, or national level. It is necessary to fully evaluate the impacts of proposed policies and strategies in order to appropriately balance the benefits and costs to New York.

Relation to other Research in the Region and Nation
Coordinate input data and model results with ongoing modeling performed by the New York Independent System Operator, as well as other regional ISOs, including New England and PJM Interconnection. Also coordinate with modeling performed by the U.S. EPA, DOE, NESCAUM, and other states and regions.

B.3. EXPOSURE AND HEALTH EFFECTS

NYSERDA has recently contracted with the Johns Hopkins University Bloomberg School of Public Health to identify and summarize recently completed and ongoing research projects involving New York State air pollution exposures and health effects. In addition, the study will identify critical gaps in the current understanding of the relationships of exposure to energy-related air pollution in New York State and identify research needs. NYSERDA anticipates refining the following research topics once the summary and needs assessment is completed and prior to focusing a solicitation on these topics.

Topic B.3.a: Improved PM Component Exposure Characterization

Problem Statement
While it is now well established that exposure to $PM_{2.5}$ causes adverse health effects, what remains unclear is which components of $PM_{2.5}$ and associated co-pollutants are responsible for the observed effects. Atmospheric PM is a complex mixture of chemical compounds resulting from the mixed composition of numerous sources. Studies are needed to improve understanding of the relationships between exposure and health effects and specific components of PM and co-pollutants.

Research Focus

- Support efforts to augment the available ambient PM speciation data in New York for use in health exposure studies. The focus should be on size and chemical components of $PM_{2.5}$ and associated gas-phase organic precursors.
- Projects of interest might include, but are not limited to, expansion of analytical capabilities of ongoing studies, analyses of archived samples using multi-element/chemical analysis techniques, or intensive but short-duration monitoring campaigns focused around hot-spots of particular concern.
- Projects might address relationships between personal and ambient exposure, augment and strengthen ongoing epidemiologic studies, or support source-apportionment analyses, particularly where epidemiological studies are being considered. To the extent possible, projects should use state-of-the-art analytical methods and capabilities.

New York Relevance
New York State is responsible for, and is the recipient of, a complex array of ambient particle types and associated co-pollutants. Efforts to better understand the relative importance of specific $PM_{2.5}$ components will help us prioritize technological and regulatory enhancements to reduce human health risks. Numerous studies focused on air quality conducted over the past several years have rich databases with detailed chemical speciation for $PM_{2.5}$ components and co-pollutants in New York State. Archived samples could be analyzed for additional PM components. These data could be used in exposure or health studies.

Relation to Other Research in the Region and Nation
The U.S. EPA funds five particulate matter health effects research centers to understand how people are exposed to PM and what the health effects are (http://www.epa.gov/pmresearch/). The Health Effects Institute (HEI) recently launched a national initiative, the National Particle Component Toxicity Initiative (NPACT). This initiative will combine comprehensive air quality data with toxicologic and epidemiologic studies to examine how PM and gases affect health (http://www.healtheffects.org/).

Topic B.3.b: Localized Ambient PM and Co-Pollutant Exposure Characterization

Problem Statement
While general air quality has improved over the past 30 years as a result of regulatory control programs, geographic areas exist where high-emitting or highly concentrated sources may cause consistently higher concentrations of air pollution than other areas. For example, recent health studies in New York City have shown adverse health effects associated with PM components or co-pollutants. Detailed spatial and temporal characterization of concentrations of PM components and co-pollutants is needed to aid exposure studies in areas of major sources such as residual oil-fired power plants, back-up generators, distributed generation technologies, major express highways, warehouse staging areas with high numbers of diesel vehicles, residential communities impacted by wood smoke, or other locations heavily impacted by energy-related sources. Spatially-intensive air monitoring is needed to assess concentration gradients, contributions from important source types, exposure assessments, and potential health effects. Activities in these areas could be coordinated with or extend research conducted as part of a micro-inventory (Topic B.2.2).

Research Focus

- Assess the potential health relevance of pollution exposure hot-spots in New York State. There should be a defined residential population nearby that is potentially impacted by the hot-spot. These might include, but would not be limited to, areas in and around the port of New York, particular neighborhoods impacted by high-volume road traffic, or areas affected by a high density of diesel generators or power production.
- Characterize the spatial and temporal patterns of concentrations in the vicinity of the hot-spot, e.g., through receptor modeling efforts or by spatially intensive air monitoring, to characterize personal exposures and to assess human health risks.

New York State Relevance
New York is home to high levels of economic activity as well as high and diverse population densities, often in close proximity to one another. On high-electricity-demand days, diesel back-up generators are used to meet the electricity demand. These typically occur during periods of meteorological stagnation in densely populated areas. Nearly all of the urban population is in close proximity to major roadways, as are major portions of the suburban and rural populations. In addition, in suburban and rural areas, wood combustion presents a problem due to high PM emissions and often unfavorable meteorological conditions for dispersion. By emphasizing studies to understand hot-spots of concern, we will be better able to address the impact that hot-spots may have in relation to overall levels of $PM_{2.5}$.

Relation to Other Research in the Region and Nation
The U.S. EPA funds five particulate matter health effects research centers to understand how people are exposed to PM and what the health effects are (http://www.epa.gov/pmresearch/). The Health Effects Institute (HEI) recently launched a national initiative, the National Particle Component Toxicity Initiative (NPACT). This initiative will combine comprehensive air quality data with toxicologic and epidemiologic studies to examine how PM and gases affect health (http://www.healtheffects.org/). The HEI strategic plan (2005-2010) focuses on 1) PM and gaseous pollutants, 2) diesel exhaust, and 3) air toxics.

Topic B.3.c: Accountability Studies for Programs Aimed at Reducing Exposure and Improving Public Health

Problem Statement
Studies are needed to perform an analysis of whether efforts to reduce air pollution concentrations have yielded measurable improvements in exposure and human health. Regulatory programs are focused on reducing source emissions. Full accountability will link emission reductions to reductions in ambient concentrations, personal exposures, and health and ecosystem effects to determine the effectiveness of the regulatory actions.

Research Focus

- Undertake studies to analyze and/or model exposure and health changes in response to regulatory programs impacting air quality in New York State.
- Proposals should clearly define the regulatory program of interest and have a plan with sufficient temporal and spatial scope to capture the possible impacts of regulations on ambient concentrations, human exposures, and health risks for New York State residents.

New York State Relevance
Accountability is relevant in all areas of the U.S. New York's location downwind from a major source region may pose challenges in demonstrating accountability. Currently, a joint project by the New York State Department of Health, New York State Department of Environmental Conservation, Centers for Disease Control, and U.S. EPA. is developing a New York State Environmental Public Health Tracking Network.

Relation to Other Research in the Region and Nation
Both the Health Effects Institute and the U.S. EPA have embarked on accountability research projects. Partnering and leveraging these ongoing efforts will be advantageous.

Topic B.3.d: Exposure Model Development for Urban and Regional Assessment

Problem Statement
New experimental designs are needed to conduct studies that will lead to improved exposure models that can be linked with air quality models, especially for population centers. Advancements in human health studies will depend on an improved ability to estimate population exposure, taking into account activity patterns and varied exposure conditions. Two such examples of where exposure model development is needed are mobile emissions exposure in locations that are close to major roadways and long-range transport of ozone and PM.

Research Focus
Significant areas of New York State are in non-attainment for current ozone and $PM_{2.5}$ NAAQS. Large proportions of the state's population reside or work in current non-attainment areas. The NAAQS are expected to tighten in the future, reducing the 8-hour ozone standard to between 64 and 74 ppb, and reducing the daily $PM_{2.5}$ to 35ug/m3. An improved ability to model exposure linked with air quality models is needed. Model verification with pilot studies will also be needed.

New York State Relevance
Considerable ambiguity exists in attempting to estimate exposure and health impacts in New York City, with its complex high-density, local industrial, commercial, and residential conditions, with regional contributions to pollution.

Relation to other Research in the Region and Nation
The national programs are limited, and added investigation in the Northeast's urban conditions would enhance other programs already in the design and execution phases.

Topic B.3.e: Development and Demonstration of Real-Time Personal Speciation Monitors

Problem Statement
Personal exposure is a function of an individual's proximity to many sources and time spent in daily activities. The air quality of geographical regions near important local sources is not well represented by the network of monitors developed for characterizing air quality for a broader region. Recent advances in sensors and nanotechnology have revolutionized our ability to detect a wide range of materials in near real-time. However, currently available personal monitors are based on technologies that are 30 or more years old. A need exists for the development of personal monitors to measure PM components and co-pollutants over short time intervals using miniature, light-weight monitors.

Research Focus
EMEP is currently supporting a review of available and emerging personal monitoring technology by Johns Hopkins University. This review will serve to direct future efforts.

New York Relevance
Significant advances in personal monitoring would add substantial value to large-scale exposure and health studies being carried out by New York State research teams and would be an important contribution nationally.

Relation to Other Research in the Region and Nation
The National Institute of Environmental Health Sciences (NIEHS) is currently making funding decisions on a first round of personal-sensor development projects. Once funded, these studies would help leverage the EMEP effort.

C. CLIMATE CHANGE IN NEW YORK STATE

This EMEP program area will support research to improve the scientific and technical foundation to address the following key policy-relevant questions:

- What are the potential ecological, public health, infrastructure, and economic impacts of climate change in New York State, and how can integrated risks associated with climate change be managed and minimized?
- What are the key parameters that need to be monitored to establish baselines and assess climate change impacts in New York?
- What are the cost-effective climate change mitigation/adaptation strategies for New York to pursue?
- What are the optimum air quality management strategies for New York State that can foster the joint goals of attaining National Ambient Air Quality Standards and reducing greenhouse pollutant emissions?

C.1. REDUCING GREENHOUSE GASES AND OTHER CLIMATE-FORCING AGENTS

Topic C.1.a: Develop Greenhouse Gas Reduction Curves for New York State

Problem Statement

Climate stabilization will likely require reduction of greenhouse gas emissions in many sectors, not just in the production of electricity. Current estimates of total greenhouse gas (GHG) emissions in New York State have been developed, including the relative atmospheric contributions by different emission sources. However, the set of strategies that may be adopted to achieve the required reductions will depend on their costs, the availability of technologies, and on policy decisions. Research is needed to assess cost and availability of different emission reduction strategies that can lower emissions in all sectors and for the full range of greenhouse agents (CO_2, methane, N_2O, SF_6, tropospheric ozone, black carbon aerosols, etc.).[2]

Research Focus

Research focusing on emission reduction opportunities ("supply") should be comprehensive (multi-sector), aim to set economic ground rules, be sector specific, and take into account new technologies, which have the potential to affect policy development. Specific research may include:

- Develop distinct supply curves for several sectors, including the power industry, transportation, buildings, agriculture, landfill gas (LFG), and afforestation. (A supply curve for greenhouse gases graphs the possible emission-reduction opportunities on the x-axis versus the cost per ton of CO_2-equivalent emissions avoided on the y-axis.) For each strategy, estimate current and projected costs (e.g., to account for the learning effect). Prioritize the strategies, based on lowest cost potential.
- The analysis could start as a scoping study and could be revised and enhanced with more detailed analysis done under items C.1.b (Energy Efficiency and Renewable Energy Potential), C.1.d (Geological Sequestration Potential), and C.1.e (Terrestrial Sequestration Potential).

2. For more information see the most recent report by the Intergovernmental Panel on Climate Change (IPCC). *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. http://ipcc-wg1.ucar.edu/wg1/wg1-report.html.

- Estimates should be developed under different reduction scenarios (aggressive, moderate, etc.) and take into account likely changes in fuel cost.
- Attempts should be made to monetize the co-benefits of various strategies for New York State, including enhanced economic activity, increased jobs, lower public health costs, and other policies that the State may pursue. In this context, it is important to look at the beneficial effects of combining traditional control measures for ozone and fine particulate matter ($PM_{2.5}$) with measures that could reduce emissions of CO_2 and other greenhouse agents.

New York State Relevance

The development of a supply curve for greenhouse gas emission reduction options in New York State could help identify cost-effective emission-reduction strategies to inform policy decisions and the subsequent evaluation of adopted policies.

Relation to Other Research in the Region and Nation

This type of analysis should capitalize on previous research, including a 2003 report on reduction of greenhouse gas emissions in New York;[3] the NYSERDA 2003 report on energy efficiency and renewable resource potential in New York State;[4] *U.S. Climate Change Supply Curves,* developed by the U.S. Environmental Protection Agency; and the recent McKinsey & Company assessment of "A Cost Curve for Greenhouse Gas Reduction."[5] ICLEI's Harmonized Emissions Analysis Tool[6] supports local planning for greenhouse gas emissions reduction and facilitates quantifying emissions reduction activities and their co-benefits.

Topic C.1.b: Evaluate the Potential of Energy-Efficiency Measures and Renewable Energy to Reduce Greenhouse Gas Emissions in NYS

Problem Statement

Experts predict that to stabilize the concentration of greenhouse gases in the atmosphere, reduction of greenhouse gas emissions is needed within the next few years, followed by a reduction to a level of one-third or one-quarter of current emissions by 2100.[7] However, the U.S. Department of Energy expects that per capita energy consumption will grow by 0.3% annually in the next 25 years. Therefore, achieving such challenging emission reduction targets would likely require substantial increases in deployment of energy-efficient and renewable energy technologies and continued development of these technologies, among other strategies.

Research Focus

The assessment of the costs and benefits of a range of policies and programs to achieve a real-world marked increase in penetration of energy-efficiency (EE) measures and renewable energy (RE) technologies in New York State could be conducted under a variety of scenarios. Research could include an assessment of EE and RE potential in the electricity and end-use fuels sectors and aim to:

- Evaluate the technical and economic potential of different RE and EE strategies and determine which technologies represent large opportunities for reducing greenhouse gas

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[3]. Center for Clean Air Policy in collaboration with the NY Greenhouse Gas Task Force (2003) "*Recommendations to Governor Pataki for Reducing New York State Greenhouse Gas Emissions,*" April 2003; http://www.ccap.org/pdf/2003-Apr-NYGHG-Chapt7-Trans.pdf

[4]. "Energy Efficiency and Renewable Energy Resource Development Potential in New York State," Prepared for NYSERDA by Optimal Energy et al., August 2003

[5]. McKinsey & Company, "A Cost Curve for Greenhouse Gas Reduction," *The McKinsey Quarterly*, 2007 No.1; http://www.epa.gov/air/caaac/coaltech/2007_05_mckinsey.pdf

[6]. Further information is available at http://heat.iclei.org/ICLEIHEAT/portal/main.jsp

[7]. See for example a February 2007 report *"Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable,"* written by the United Nations and Sigma Xi and prepared for the U.N. Commission on Sustainable Development; http://www.unfoundation.org/SEG/

emissions. Consider alternative approaches to assessing the economic potential (e.g., rate of return analysis) of strategies

- Evaluate the achievable potential and identify options for policies, regulatory approaches, incentives, and other programs that could be implemented to accelerate the market penetration of EE and RE technologies and to consider public acceptance in bridging the gap between technology potential and actual implementation.
- Identify opportunities for local RE generation instead of importing power via the interstate grid.
- Analyze greenhouse gas reduction strategies for the transportation sector by considering the entire transportation system, including infrastructure, mass transit, congestion pricing, and an evaluation of land-use practices and improved design for urban/suburban centers and road networks leading to decreased vehicle miles traveled in New York State.
- Provide guidance on EE standards for new appliances, including electronic devices currently entering the market.
- Investigate what type of energy generation is being displaced by EE and RE technologies to better understand the real environmental impacts of EE and RE.

Relevance to NYS

New York State has a long-term commitment to energy efficiency and renewable energy, given the many benefits of these technologies in terms of emissions benefits, economic opportunities, and improved system reliability. More recently, Governor Spitzer has announced a goal of reducing consumption of electricity by 15% in New York State by 2015.

Relation to Other Research in the Region and Nation

Several assessments relevant to New York should be considered, most notably the 2003 *Energy Efficiency and Renewable Energy Resource Development Potential in New York State;*[8] NYSERDA's 2003 analysis on the feasibility of establishing a statewide renewable portfolio standard (RPS) for electricity generation;[9] and/or the NRC report "*Alternatives to the Indian Point Energy Center for Meeting New York Electric Power Needs."*[10] This 2006 report reviews both demand and supply options for replacing 2000 MW capacity at the facility, using simulation models to analyze different scenarios for implementing the different options. It also examines how institutional constraints will affect the adoption of such options and their potential impacts. In addition, the research should consider the proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings, such as *"The Technical Economic and Achievable of Energy Efficiency in the U.S.,"* and in particular the associated *"Meta Analysis of Recent Studies,"*[11] which provides a good review of eleven studies of the achievable potential for EE in several regions across the nation, including in New York State.

The EPRI report "*Electricity Technology in a Carbon-Constrained Future"* [12] found that emissions from the U.S. electric sector could be significantly reduced through aggressive development, demonstration, and deployment of a broad portfolio of technologies such as energy efficiency,

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[8]. This report was prepared by Optimal Energy Inc. in the course of performing work for and sponsored by NYSERDA; August 2003; http://www.nyserda.org/sep/EE&ERpotentialVolume1.pdf

[9]. Available online at: http://www.nyserda.org/Energy_Information/renewableportfolio.pdf

[10] .National Research Council, Committee on Alternatives to Indian Point for Meeting Energy Needs. 2006. *Alternatives to the Indian Point Energy Center for Meeting New York Electric Power Needs.* The National Academies Press. Available online at http://www.nap.edu/catalog.php?record_id=11666#description.

[11]. Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings; *The Technical, Economic and Achievable Potential for Energy-Efficiency in the U.S. – A Meta-Analysis of Recent Studies*. Written by Steven Nadel, Anna Shipley and R. Neal Elliott, American Council for an Energy-Efficient Economy; available online at: http://www.aceee.org/conf/04ss/rnemeta.pdf

[12]. Available online from EPRI's Energy Technology Assessment Center. http://my.epri.com/portal/server.pt

plug-in hybrid electric vehicles, renewable energy, and other measures. Studies done in other states may also provide insight.

Topic C.1.c: Climate Change Policy Research and Analysis

Problem Statement
New York State and several other states are in the process of developing and implementing the first major CO_2 cap-and-trade program for the electricity sector in the U.S. Many design and implementation questions remain to be addressed. Policies to reduce emissions from other sectors also need to be explored.

Research Focus
Climate change research in New York State should support the effective implementation of the Regional Greenhouse Gas Initiative (RGGI). This seminal research should be conducted to complement future policy developments at the national scale. Furthermore, since the RGGI program represents only ~25% of GHG emissions in the region, climate change policy research and analysis should also consider other sectors, not necessarily involving cap-and-trade schemes. An integrated policy analysis is needed, including:

- Conducting research and analysis to support effective RGGI implementation that includes CO_2 offsets, analysis of CO_2 leakage, analysis of auction/trading options, and assessments of multi-pollutant issues.
- Consider other potential climate change policy options (e.g., low-carbon-fuel policies) and assess costs and benefits for New York State. Also consider potential constraints (e.g., transmission constraints/load pockets, local/regional air quality concerns) in assessing/evaluating climate policy, as well as the interplay of multiple policies affecting this issue (e.g., RPS, RGGI).
- Develop protocols to verify emission reduction estimates of different offsets measures. Guidelines and such protocols could be used in RGGI to develop new carbon-offset projects or under new policy initiatives.
- Support the development of a comparable baseline in CO_2-equivalent units in order to compare relative benefits of different strategies, policy options, and projects. The research products and analysis should use a common language in terms of units and metrics.

NYS Relevance
New York has recently created the Office of Climate Change, under the NYS DEC. In addition, several bills have been proposed in the New York State legislature. These initiatives highlight the ongoing interest in New York State to address climate change. Major policies and programs already in place include the **New York Energy $mart**[SM] program and the Renewable Portfolio Standards, among others.

Relation to Other Research in the Region and Nation
Analysis in this area could potentially be coordinated with other RGGI states and could build on the RGGI modeling and auction design work done to date. Some of this policy analysis will likely be done by the new NYS DEC Office of Climate Change. Analysis of CO_2 offsets and development of protocols may be done by the RGGI Regional Organization (RGGI, Inc.).

Topic C.1.d: Characterize Opportunities for Geological CO_2 Sequestration in New York

Problem Statement
Capturing CO_2 emissions and storing the gas in underground geological formations could significantly reduce the amount of CO_2 released to the atmosphere. Before this can be implemented, however, site-specific geological research needs to be conducted to determine which formations are capable of storing CO_2. Other opportunities for sequestration may exist but

are currently in the very early stages of development (e.g., mineralization, ocean sediment storage).

Research Focus

In geological sequestration, CO_2 that has been captured at the source is transported to a location where it is injected into a suitable geological formation deep underground. Research should focus on assessing the technical potential of on-shore and off-shore geological sequestration in NYS, assessing the deliverability of CO_2, scoping out the needed infrastructure, and designing regulatory rules to ensure the success of such operations. Because geology varies widely throughout the state, detailed characterization of geological formations (including collection and analysis of geological samples, as well as field testing) and associated estimated storage capacities are critical knowledge gaps. Wherever possible, strategic technical capability should be developed in New York State to address long-term needs.

Dissemination of research results is very important. As a member of the Midwest Regional Carbon Sequestration Partnership (MRCSP), any geological characterization in New York State should be integrated into the Partnership's existing data. Education and outreach to policy makers and the general public is critical in the area of geological sequestration.

At this time, NYSERDA funding is not sufficient to finance long-term, multi-year demonstrations; significant public and/or private funding would be needed to support a large-scale demonstration.

To the extent that the New York State Advanced Clean Coal Power Plant Initiative moves forward, NYSERDA's sequestration research should be integrated with this project. Such efforts could provide the necessary leverage to support a large-scale demonstration.

New York State Relevance

New York State sources emit approximately 250 million tons of CO_2 each year, roughly 3.5% of the total annual CO_2 emissions in the U.S. New York is in an unusual position of spanning the distance from the Illinois Basin to the Atlantic coast, perhaps providing several options for sequestering CO_2. There may be co-benefits associated with geological sequestration activities in New York State (e.g., economic benefits of enhanced gas recovery), which should be explored, quantified, and demonstrated. Off-shore sequestration may offer unique opportunities to NYS (e.g., geology, location, site ownership).

Relation to Other Research in the Region and Nation

Research should complement the current work in other areas of the country through the U.S. DOE National Energy Technology Laboratory's regional sequestration partnerships. To this end, NYSERDA and the New York State Museum have joined the MRCSP and have initiated some preliminary characterization work. Given the large federal resources dedicated to geological sequestration, NYSERDA should leverage its funds to team up with other research partners whenever possible. Care must be taken not to duplicate other research but to instead build upon previous work.

Topic C.1.e: Characterize Opportunities for Terrestrial CO_2 Sequestration in New York

Problem Statement

Terrestrial sequestration may provide a near-term strategy for reducing CO_2. Terrestrial sequestration, such as changing agricultural practices to increase the carbon uptake by plants and soils, can reduce the amount of carbon in the atmosphere. Opportunities for terrestrial sequestration in NYS are not well characterized.

Research Focus

Successful terrestrial sequestration can be achieved by manipulating natural processes to maximize CO_2 uptake and by protecting areas that naturally have high uptake of CO_2, such as forests. This could involve, for example, changing management of agricultural lands to low- or no-till farming methods, which decreases the decomposition of organic material, keeping carbon in the soil; or reforestation, choosing tree species that are fast growing and long lived and would

therefore use a large amount of CO_2 over their lifespan. Agriculture and forestry are areas where some of the low-cost/high-benefit opportunities exist. Accurate assessment of the extent of terrestrial sequestration options in New York State, including estimated costs and benefits for each option; determination of the best options for NYS in terms of net amounts sequestered and time scales; and links to carbon supply curves for NYS are critical information needs.

Soil management is an important agricultural issue, one that is specific to a region's soils. Studies should be undertaken to determine carbon sequestration rates specific to the predominate soils in NYS, building on previous work such as that done by Cornell University and the Nature Conservancy. Expansion of work on carbon sequestration rates versus N_2O emissions on cropland converted from conventional tillage to no-till/reduced till, with and without nitrogen management, should also be considered.

Dissemination of research results is very important. As a member of the Midwest Regional Carbon Sequestration Partnership (MRCSP), any terrestrial characterization should be integrated into the Partnership's existing data. Education and outreach to policy makers and the general public is critical in the area of terrestrial sequestration.

New York State Relevance

As with other northeastern U.S. states, NY has extensive areas of native and managed forests, as well as abandoned agricultural lands returning to forest. Large opportunities also exist for sequestration on agricultural lands throughout the state. In addition, it will be important to explore, quantify, and demonstrate the co-benefits that may be associated with terrestrial sequestration activities in NYS (e.g., increased soil organic matter).

Relation to Other Research in the Region and Nation

In addition to the regional sequestration partnerships, collaborations could be developed with other states (e.g., in the RGGI region) to further terrestrial sequestration investigations and better develop new offset categories involving forest management practices. Care must be taken not to duplicate other research but instead to build upon previous work.

Topic C.1.f: Monitor Performance and Evaluate Benefits and Co-Benefits of Heat Island Mitigation Strategies

Problem Statement

Heat islands have regional-scale impacts on energy demand, air quality, and public health. Related mitigation strategies, such as urban forestry, living walls, green roofs, buildings with cross-ventilation, and light-colored surfaces, may be effective. However, there are no comprehensive assessments on the effectiveness of these strategies to cool off cities because it is extremely difficult to simulate complex urban structures. Improved performance data and measures to optimize the design of the different options will provide a baseline to evaluate their likely mitigation potential. Efforts to combat the heat island effect will both mitigate greenhouse gases and act as adaptations to climate change.

Research Focus

Various options have been considered to address heat island effects. The following will improve the collective understanding of what measures work best and which fail to meet their mitigation potential:

- Analyses and demonstrations to determine the cost and value of mitigation strategies, as well as their deployment potential, and establish which strategies offer the best benefit/cost ratios
- Research should include appropriate energy and non-energy benefits of strategies to better inform policy options. These assessments should address co-benefits such as related improvements of public health, reduced (and improved quality of) storm water run-off, or decreased electricity demand given decreased need for air conditioning of residential and commercial spaces (as well as associated cost reductions, improved air quality, and reduced GHG emissions).

- Assessments and monitoring of ongoing mitigation strategies (e.g., urban forestry projects, green roofs, light-colored surfaces and pavement materials, and temperature/humidity trade-offs from urban forestry efforts in New York City) to help improve calibration and evaluation of regional climate models
- Pilot projects should gather and then analyze sufficient site-specific information on local conditions, to improve our understanding of which measures are better adapted to, or work best in, particular environments
- Research to provide a better understanding of anthropogenic contributions to summertime urban heat islands

New York State Relevance

New York City is the major urban center in NY State, and like many other metropolitan areas, it is exposed to summertime temperatures that are several degrees higher than surrounding suburban and urban areas (i.e., ~4ºC higher, on average). These summertime conditions, referred to as the heat island effect, require particular mitigation measures.

Other Research in the Region and Nation

Several initiatives and assessments are underway and should be considered to prevent duplication of research and to optimize upcoming policy and programs addressing heat island effects in the New York City metropolitan area. A 2006 NYSERDA-sponsored report, "New York City Regional Heat Island Initiative,"[13] sheds light on appropriate mitigation strategies for the city. Further related information on appropriate mitigation strategies is emerging from "The Cool City Project," an ongoing collaboration between Columbia University's Institute for Social and Economic Research and Policy and community-based organizations and residents. The Urban Heat Island Pilot Project[14] conducted assessments to evaluate existing surface characteristics of metropolitan areas to help inform meteorological and air quality modeling analyses that evaluated the impacts of heat island mitigation strategies. In 1997, EPA launched the Heat Island Reduction Initiative (HIRI) to work with local officials and other community stakeholders to reduce the impacts of summertime heat islands. Through HIRI, EPA promotes strategies that provide economic, environmental, and quality-of-life benefits—beyond reducing surface and air temperatures.[15] Arizona State University recently launched a National Center of Excellence on SMART Innovations for Urban Climate and Energy, which focuses on developing the next generation of sustainable materials and renewable technology (SMART) innovations that can help reduce urban temperatures and the resulting effect on energy consumption in U.S. cities. (See: www.asusmart.com). On the west coast, the Heat Island Group at Lawrence Berkeley National Laboratory conducts research to find solutions to the heat island effect.[16]

C.2. Understanding and Monitoring Impacts, Managing Risks, and Identifying Adaptation Strategies

Topic C.2.a: Integrated Impact Assessment, and Identification and Evaluation of Adaptation Strategies

Problem Statement

Climate variability and change are anticipated to impact infrastructure and land use, agriculture, air quality and human health, and a multitude of natural resources. Specific issues related to these impacts are discussed in the following sections. Prior to devoting limited research dollars to

[13] NYSERDA (2006) "Mitigating New York City's Heat Island With Urban Forestry, Living Roofs, and Light Surfaces; prepared by Columbia University Center for Climate Systems Research and NASA/GISS; Hunter College's Department of Geography, and Science Applications International Corp. Further information is available at: http://ccir.ciesin.columbia.edu/nyc/links_impacts_heat.html

[14] http://www.epa.gov/heatisland/pilot/chicago.html

[15] http://www.coolcommunities.org

[16] http://eetd.lbl.gov/HeatIsland/ , http://coolcolors.lbl.gov/

intensive studies, an integrated assessment would be useful in identifying impacts and needs specific to New York State. Based on the findings of this initial assessment, more-focused studies could be pursued.

Research Focus
An integrated assessment should be conducted to:

- Identify and assess potential impacts in New York State under different climate change scenarios,
- Identify the key parameters that need to be monitored to establish baselines and assess climate change impacts in New York,
- Identify and evaluate potential vulnerabilities,
- Assess potential economic impacts, and
- Identify and evaluate potential adaptation/risk-management strategies.

New York State Relevance
There are numerous areas in New York State and the region that are, and will be, experiencing climate-related impacts. These are described in more detail in the following sections.

Relation to Other Research in the Region and Nation
Although not specific to New York State, the recent report by the Union of Concerned Scientists summarizes a range of anticipated climate-related impacts in the Northeast over the next 100 years. The Metropolitan East Coast Assessment, although not a statewide assessment, explored the impacts of climate change and variability on the physical systems and human activities in 31 counties of the New York City metropolitan region. There have been some summaries published, such as the *Environmental Advocates of NY* publication, "Forecast for New York: Projected Global Warming Impacts and Next Steps." The Environmental Impact Statement prepared for the Regional Greenhouse Gas Initiative may also provide some relevant analyses for this assessment.

INFRASTRUCTURE AND LAND USE

Topic C.2.b: Evaluating and Reducing Impacts of Climate Change to New York State Infrastructure and Land Use

Problem Statement
Climate change in the form of higher mean and extreme values of temperature and precipitation, as well as sea-level rise and enhanced storm surge, will create additional demands on the design, operation, and maintenance of New York's lifeline infrastructure systems. These systems, including electricity and transportation infrastructure, sewage collection, and water and wastewater treatment facilities, could experience interruption in normal operations, damage, and, in extreme cases, complete loss of services at vulnerable points. Moreover, land use/landscape decisions are likely to become increasingly important due to the potential impacts on New York State's infrastructure and its built environment.

Research is needed to evaluate the specific impacts and the additional burdens that will be placed on New York State infrastructure and its built environment due to climate change, as well as to provide guidance to policy makers and urban planners on what changes to expect and plan for in the next decades. The anticipated impacts are likely to be wide ranging, including higher peak summer electric demand and grid vulnerabilities, due to increased electricity demand during more frequent cooling-degree days, especially in metropolitan regions subject to the heat island effect. Likewise, precipitation and stream-flow changes could affect hydroelectric generation in New York and the region. These climate-related changes could place additional burdens on New York's electricity supply, transmission infrastructure, and distribution infrastructure. In terms of wastewater treatment facilities and the transportation sector, many infrastructure systems are aging and in need of repair and/or replacement. Some wastewater treatment facilities are unable to handle high-flow events, and

this has the potential to contaminate drinking water supplies. Flooding in coastal and inland areas is likely to increase, although not necessarily simultaneously. The magnitude of floods will depend on the severity of storms and on sea level rise, as well as on land-use practices. If land, particularly forested land, is cleared and hardened for development, terrestrial water storage capacity will decline. Effects will be proportional to the extent of development and the ratio of permeable to impervious surfaces within the flood plain. In urbanized watersheds, both flood potential and water loss will likely increase.

Research Focus

Three key steps will contribute to the effort of evaluating impacts and providing guidance to policy makers: 1) the development of a consensus on what impacts are likely to take place under different climate change scenarios,[17] 2) assessments of the particular impacts that will affect each infrastructure system, and 3) agreement on measures and best management practices that will ameliorate the impacts of climate change and/or help New York State prepare for the associated risks. Research to support this effort would include:

- Analyses to better understand the impact of climate change on New York's electricity system, including the potential impact of increased peak demand in the downstate metropolitan area. Refinement of methods to better forecast peak electricity demand days would be useful. Related to this increase in peak electrical demand, research to develop passive means of cooling in buildings is needed (and related to the heat island mitigation section C.1.f).
- From a climate change mitigation standpoint, research and analysis are needed on the supply side, to ensure that the electricity infrastructure can handle the different electric load and capacity profiles associated with the new emerging technologies (e.g., plug-in hybrids, wind, distributed combined heat and power systems). Also, new regulations that could potentially reduce capacity factors of high-carbon sources such as coal could have an impact on the grid. Efforts to increase the reliability of the electric grid are critical to reducing human health effects during heat events, when air conditioning is the principal adaptation to prevent mortality.
- Studies to better understand the climate-related impacts and vulnerabilities of our water/wastewater treatment and transportation infrastructure, to help provide options and guidance to resource managers and state planners.
- Land-use decisions can be influential in preparing for and mitigating the impacts of climate change. Studies to assist in the planning of local and regional responses to climate change are needed and must address issues related to sea-level rise and more extreme weather events, such as storm water management and water storage issues at the landscape scale. Information is needed to effectively plan for development within watersheds, coastal development, and the protection of forests, permeable landscapes, wetlands, and other natural flood-mitigation and water-retention systems.

New York State Relevance

In recent years, the population of New York State has experienced several emergencies due to failing service and infrastructure vulnerability (e.g., summer 2006 blackout in Astoria, Queens). Similarly, wastewater treatment facilities in districts with combined sewage systems can not reliably manage combined sewage overflows (CSOs) during severe storm events, resulting in unsanitary conditions in some neighborhoods or beach closings during the summer months. Services in New York City's subway system have also been impaired by flooding.

Relation to Other Research in the Region and Nation

Several assessments indicate that a broad range of impacts are expected to occur in the northeastern U.S. The recent report by the Union of Concerned Scientists summarizes a range of anticipated climate-related impacts in the Northeast over the next 100 years. The Metropolitan East Coast Assessment explored the impacts of climate change and variability on the physical systems and human activities in 31 counties of the New York City metropolitan region. Reports

[17] According to the type of mitigation strategies expected to take place at the global level, varying from business as usual (BUA) to moderate to more-aggressive efforts.

such as these are an invaluable foundation to use when attempting to define how the different climatic conditions will affect New York State's infrastructure and the built environment. An ongoing collaboration between New York City's Department of Environmental Protection and various universities seeks to better characterize the specific impacts that will affect local infrastructure services in New York City. This includes an assessment of the risks posed by sea-level rise, increase in the frequency and intensity of storm events and hot summer days, and changing precipitation patterns on the city's water supply and wastewater treatment facilities.

AGRICULTURE

Topic C.2.c: Characterization of Potential Changes to the Agricultural Sector due to Climate Change, Identification of Adaptation Strategies and Opportunities, and Agriculture's Role in Mitigating Impacts

Problem Statement

Climate change may bring new opportunities to New York's agricultural sector but will also pose new risks and challenges for farmers and land managers. Further research is needed to better understand how warmer weather and changes in the water cycle, as well as extreme weather events or violent storms, will likely affect agricultural yields of crops and dairy farms. In the short term, higher CO_2 levels and warmer temperatures may increase the yield of some crops, such as grape crops in the Hudson Valley. However, because higher temperatures will tend to favor aggressive invasive species at the expense of indigenous species that can't adapt to changes in climatic conditions, increased pesticide and herbicide use and loss of biodiversity are expected, while short-term droughts are likely to increase the need for artificial irrigation in the region and increase stressors on farm animals. The agricultural sector also has the potential to help reduce greenhouse gas emissions as well as mitigate emissions from other sources, and the potential strategies remain to be identified and/or better characterized. This assessment relates to work proposed under section C.1.e: Terrestrial Sequestration.

Research Focus

Focused research efforts are necessary to address the new challenges and opportunities for New York's agricultural sector associated with a changing climate, as well as to identify best management practices to reduce emissions. The research effort would include:

- Characterization of the likely impacts of climate change on agriculture, including identification of:
  - impacts of shifting climate zones on biodiversity, and the types of crops and plants that are likely to prosper versus those that would be compromised
  - invasive species expected to flourish in the region, and strategies for their mitigation
  - potential effects of frequent high-temperature days to farm animals and their productivity
  - adaptation strategies and potential opportunities
- Assessments of the economic impacts associated with different climate change scenarios, including the potential benefits (e.g., revenue, jobs created) from the agricultural sector's involvement in the production of renewable fuels (biofuels) or in projects to sequester CO_2
- Studies to help New York's agricultural sector play a role in mitigating climate change (e.g., through production of biofuels, agricultural soil carbon sequestration, reduction of methane emissions, precision feeding to reduce N_2O emissions)
- Syntheses of data on key management practices (e.g., tillage, fertilization, manuring, and grazing) that could assist in the design of policies to maximize the role of agriculture in mitigating climate change
- Establishment of benchmark sites, suitable for measurement of soil carbon and other parameters; integration of remote sensing data and development and application of new technologies for more-rapid, less-expensive measurement of carbon stocks and

greenhouse gas fluxes; and improvements in our ability to forecast future agricultural greenhouse gas emissions and sinks

New York State Relevance

The agricultural sector in New York State, including approximately 36,000 farms that occupied one-quarter of the state's land area, contributes greatly to the regional economy. Climate change can seriously impact this sector's economic outlook (production in 2004 returned over $3.6 billion dollars to the agricultural economy). Additional employment opportunities and revenue could be realized by this sector's involvement in mitigation efforts and the production of renewable fuels (e.g., ethanol).

Relation to Other Research in the Region and Nation

Research efforts should leverage resources from other organizations and/or agencies, including, for example, partnerships with the New York State Department of Agriculture and Markets, which offers funding for research in various areas related to identified impacts, and to the role the agricultural sector can play in mitigating climate change impacts (e.g., a recent RFP for the construction of a cellulosic ethanol pilot production facility[18]). In addition, several documents provide a good basis for further research, including two documents focusing on agricultural (and forestry) contributions to greenhouse mitigation strategies: "*Agriculture's Role in Greenhouse Gas Mitigation*" and "*Agricultural and Forestlands – U.S. Carbon Policy Strategies*" released by the Pew Center on Global Climate Change in 2006.

AIR QUALITY AND HUMAN HEALTH

Topic C.2.d: Research to Improve the Understanding of Direct and Indirect Effects of Climate Change on Air Quality and Human Health in New York State and to Identify Strategies to Address these Impacts

Problem Statement

Several human health impacts have been identified in relation to changes in climatic conditions, and research is needed to better characterize which effects are likely to take place in New York State. Increased summer-season heat-stress morbidity and mortality are expected due to the changing climate, especially in large urban areas because of heat island effects. Respiratory ailments related to poor air quality are likely to increase. From an air quality perspective, the changing climate will affect not only the temperature, which plays a key role in photochemical smog production, but also the frequency and strength of stagnation conditions that lead to pollution events. It is expected that climate change will also result in an increase in ozone levels, even if emissions remain constant. The relationship between climate and air quality is complex and needs to be better understood. The warming climate will increase peak electrical demand on hot summer days, which in turn will exacerbate air quality problems. Furthermore, the number of days above the ozone or short-term PM standards could increase, as well as the length of ozone episodes. Climate change and alterations in the weather patterns are likely to affect the range (both altitude and latitude), intensity, and seasonality of many tropical insect-borne and other infectious diseases. There is also a potential for changes in human health pathogens, some of which are sensitive to moisture conditions in air and soil. Furthermore, increased frequency of flooding events (especially of key water and wastewater systems) can create unsanitary conditions that may result in water-borne diseases.

Research Focus

The research needs to be tailored to assist planning efforts by various public health and other agencies, and natural resource managers. It also needs to determine what indicators must be monitored. The following are needed:

- Assessments to assist in the development of summer heat-stress emergency response plans, using information on risk factors and meteorological data

[18] RFP notice available at: http://www.agmkt.state.ny.us/rfps/cellulosic_ethanol/Cellulosic%20Ethanol%20RFP%203.pdf

- Research and analysis to evaluate how current and near-term air quality management strategies (e.g., CAIR) affect climate change and to develop new air quality management strategies (e.g., for NOx, VOC, ammonia, PM, SO_2, etc.) that also support a climate stabilization policy
- Research to provide a better understanding of atmospheric processes and the relationship between climate and air quality in the region. Research to quantify and understand the relationship between criteria pollutants and meteorological variables is essential, so that projected trends in these meteorological variables can be translated into their air-quality implications. Improved models and forecasting tools are needed.
- Analysis to better understand and mitigate the potential air quality/smog impacts associated with increasingly frequent peak electrical demand days
- Studies to identify populations vulnerable to pathogens and vector-borne diseases in New York State, and how they may vary according to changes in temperature, humidity, and/or flooding. This research should characterize risks from, and attempt to anticipate possible changes in, the distribution of insect-transmitted diseases, as well as identify measures to prevent water-borne diseases.

New York State Relevance

Climate change will exacerbate the heat island effect throughout the New York City metropolitan area, thus increasing the number of summer heat-stress cases. Similarly, air quality (ozone and $PM_{2.5}$) is likely to deteriorate, and this will affect populations in NYC neighborhoods already experiencing one of the highest incidences of respiratory ailments and asthma attacks in the country. Densely populated areas of New York State are likely to be more vulnerable to vector-borne diseases that could thrive in warmer weather, higher humidity, and/or flooding conditions.

Relation to Other Research in the Region and Nation

Future assessments of human health effects associated with climate change should be coordinated with ongoing research projects, such as EPA Office of Research and Development's research effort under the STAR grants, the New York State Department of Health's Climate-Related Morbidity Study, or the Columbia University Health Project.[19] Other programs or assessments to consider include the California Energy Commission's Public Interest Energy Research (PIER) Program, which supports impact and adaptation studies, particularly in relation to ecological and water resources, and human health, as well as the IPCC recent assessment on Climate Change Impacts for Policymakers.

NATURAL RESOURCES

Topic C.2.e: Support Research to Evaluate Climate-Related Changes that can Threaten the Viability of Natural Resources in New York State, Including Shorelines, Tidal Wetlands, Wildlife Species, Forests, Hydrological Resources, and the Ecological Cycling of Carbon and Nutrients. Conduct Research Needed to Develop Adaptation Strategies to Limit Associated Risks

Problem Statement

Climate change and related effects—warmer temperatures and changes in precipitation patterns—are likely to bring about disruptions to hydrological systems and to carbon/nutrient cycling. These changes have the potential for wide crosscutting impacts on natural resources, including shorelines and tidal wetlands, forests, wildlife, pests and pathogens, and agriculture. Further research is needed to better understand the potential magnitude of these changes, the associated risks, and strategies for addressing and adapting to related risks. For example, aquatic resources, such as shorelines and tidal wetlands, which act as a first line of defense against flooding in NY coastal areas, are likely to be threatened by sea-level rise, extreme

[19] A brief description of these two projects is given in the background paper titled, "Climate Change in New York State" (NYSERDA – NYAS, 2007).

weather events, increased precipitation, and disruptive landscape patterns. The ensuing coastal erosion will heighten the vulnerabilities to storm damage and flooding and will facilitate the advancement of saline waters farther up the estuary. Upstream salt water incursion, coastal inundation, and warmer temperatures could displace complex habitats and threaten the abundance, distribution, and productivity of regional wildlife and forests, while altering the prevalence of parasites and diseases, which can exacerbate the impacts. It is expected that a decoupling of plant-animal pollination and dispersal systems, changes in ecosystem water and nutrient relations (e.g., temperature-sensitive reaction rates, redox changes), and interactions with pests, pathogens, and invasive species will threaten the viability of species (forests and wildlife) unable to migrate fast enough to keep up with their respective rapidly changing "climatic envelopes."

Research Focus

Although the effects will vary in accordance with future mitigation measures and corresponding climate change scenarios, there is general agreement that some effects are unavoidable. The research effort in this area needs to improve the understanding of climate-related impacts to critical natural resources, as well as to provide guidance to resource managers and municipal planners in order to facilitate pro-active responses. The following should be considered:

- Research to identify potentially affected areas necessary to inform emergency response and land-use planning. Policy makers need consensus on what impacts are likely to take place under different climate scenarios and the best strategies to manage risks.
- Studies to better understand and prepare for changes in the state's hydrology that may have an impact on the hydroelectric generation capacity and wastewater treatment strategies.
- Monitoring to document trends and predict forest composition changes. Research efforts could also focus on identifying tree species that will be suitable for the anticipated changes in climate, thereby providing valuable information to New York's timber, pulp, and paper industries, as well as to natural resource managers.
- Monitoring to document the impact of a changing climate on New York's diverse wildlife, including the many species listed as endangered, threatened, and of special concern. The information is also critical to estimating the impacts of a changing wildlife mix on other ecosystem components.
- Research on the shifts in habitat structure and food availability, altered susceptibility to and prevalence of parasites and diseases, changes in hibernation patterns and metabolic rates, and responses to extreme hot or cold weather events.
- Regular surveys of invasive species, pests, and pathogens in order for resource managers to prepare for, and potentially avert, significant detrimental impacts to New York's natural resources. Focused research projects will also help identify effective mitigation measures.
- Research focused on the carbon- and nutrient-cycling processes impacted by a changing climate to inform the management of natural resources, and contribute to related research efforts in areas such as acid deposition effects and eutrophication of lakes and coastal areas.

New York State Relevance

The State of New York has already experienced and will continue to experience climate-change-induced alterations that can potentially affect the natural resources of the state. There are potentially significant economic impacts on parks, recreation, and tourism that can significantly affect the regional economy. This extends from closures of certain parks areas in the Catskill Mountains after recent storms created hazardous conditions on certain hiking trails[20], to early snow melt events that threaten the ski and hospitality industry in upstate New York, to damage to property and natural resources from storm surges in the state's estuaries and coastal areas.

[20] http://www.dec.ny.gov/environmentdec/33218.html

Climate change and related effects, including invasive species, could alter the composition and distribution of New York State forests and biodiversity.

Relation to Other Research in the Region and Nation

Several research projects are attempting to understand the complex relationships between climate change impacts and the resilience and vulnerabilities of New York State's natural resources. Further research should consider assessments and projects such as:
1) NOAA and NYS DEC research on the Hudson River National Estuarine Reserve, to explore options for protecting the state's shoreline, tidal wetlands, and vegetated shallows in the Hudson River from the impacts of sea level rise; 2) USGS research on the impacts of land-use patterns on the Hudson Valley's water supplies; 3) University at Albany's research on the impact of climate change and land-use patterns on water storage capacity and storm water management practices in the Hudson Valley; 4) Cornell University's studies to assess a variety of ways in which farmers and land managers can adapt to climate change issues related to invasive insects, disease, weed pests, and pesticide and herbicide use in New York and the region; and 5) a synthesis by a coalition of U.S. and Canadian forest scientists of existing research to better understand the ways climate change may alter northern forests. This coalition, NE Forests 2100, is currently gathering and distilling current science in the areas of forest composition and productivity, hydrology, carbon cycling and sequestration, nutrient cycling, wildlife effects, pests and pathogens, and other forest disturbances.

C.3. Climate Change Outreach and Education

C.3.a: Support Outreach and Education Initiatives in New York State to Promote Government and Community Awareness of Climate Change, and Assist in Identifying Potential Adaptation and Mitigation Measures and Opportunities Created by a Changing Climate

Problem Statement

Despite global initiatives to stabilize the climate, some impacts of climate change are now unavoidable. These impacts are poorly understood by the general public. Outreach and education campaigns are needed to inform the public about likely climate change impacts, adaptation measures, emergency response plans, and other related measures.

Government agencies have the potential to significantly affect GHG emissions through various policy decisions. Many of these policies require implementation at the town or municipal level. Outreach and education campaigns are needed to promote the roles that communities can play in reducing GHG emissions. These types of initiatives should help build local capacity and educate residents and urban planners, businesses, and consumers, as well as current and future constituents (including K -12 students) on the need to engage in climate mitigation activities.

Research Focus

The outreach and education initiatives must be broad-based and should:

- Assist towns and municipalities in their efforts to promote the implementation of a variety of policies to prepare for, adapt to, and help mitigate climate change impacts. This could take the form of a "toolkit" for New York State localities that would: 1) explain the potential impacts of climate change in their region, 2) highlight potential adaptation strategies that they may want to consider, 3) provide case studies on progressive local policies/practices addressing energy/climate, and 4) provide information on the incentives available for investment in energy efficiency and renewable resources, including NYSERDA and other programs.
- Educate consumers, merchants, students, and local governments about the carbon footprint concept, the carbon embedded in different activities, and specific actions to reduce GHG emissions. Successful mitigation activities and/or programs should be highlighted and/or recognized.

- Develop targeted information for particular communities on the role they can play to mitigate climate change (e.g., by providing information on no-till farming targeted at the agricultural sector).
- Include materials that are easily understood by, and accessible to, the general public and various stakeholders and target audiences. This consideration could be taken into account when developing reports and/or summarizing research findings.
- Engage scientists, science educators, teachers, and outreach professionals in the dissemination of the information on climate change impacts and adaptation measures.
- Coordinate with other NYSERDA program outreach activities.

New York State Relevance

Stabilizing the climate at current levels of disruption will require the implementation of a significant number of mitigation activities in the next few decades. Several climate change policies are likely to be promulgated in New York State that will mandate implementation at the municipal level. The outreach and educational efforts can prepare the state population to recognize these impacts and to prepare for them (e.g., understanding evacuation plans, identifying emergency centers), and help reduce contributions to climate change (e.g., through energy-efficiency measures and use of renewable energy).

Relation to Other Research in the Region and Nation

The outreach and education efforts should be coordinated with ongoing initiatives, such as the *Cities for Climate Protection Campaign*[21] launched by ICLEI to support the work of cities, towns, and municipalities on climate change education and planning of mitigation activities. Resources should be leveraged from various programs, including the federal *"State and Local Climate Change Program,"*[22] which awards grants and cooperative agreements for education and outreach programs to increase awareness about climate change and support state action plans and demonstration projects. Available materials on climate change should be considered, for example those by the New England Science Center Collaborative (NESCC)[23]. This organization provides information both to science educators at museums, aquariums, and environmental and other centers visited by families; as well as directly to students. The US EPA "State and Local Climate Change Program" is an important clearinghouse of climate change information and materials[24] that can adapted for use in NYS outreach and educational campaigns. NYSERDA's **New York Energy $mart**[SM] program has an educational component and could include information on climate change impacts in New York State.

[21] Further information is available at: http://www.iclei.org/index.php?id=800

[22] http://www.gcrio.org/edu/ and http://yosemite.epa.gov/oar/globalwarming.nsf/content/VisitorCenterPublicOfficials.html

[23] For more information, contact Mary Lou Krambeer, nescc@chartervt.net, and (603) 444-0949

[24] A Climate Change Outreach Kit is available from: http://test.earthscape.org/r1/epa06/epa06.html

D. Environmental Effects of Alternative Energy and Other Emerging Energy Options

This EMEP program area will support research to improve the scientific and technical foundation to address the following key policy-relevant questions:

- What are the multi-media impacts of emerging alternative energy in New York and across the region, and how do these impacts compare to traditional fossil-fuel resources?
- What are optimal approaches to minimize the potential environmental impacts of alternative energy resources?
- What are the potential environmental impacts and exposure impacts of more localized power production and emerging combined heat and power technologies?

NYSERDA plans to target research projects similar to a number of initiatives currently underway related to the environmental impacts of alternative energy and emerging energy options. These include:

D.1. Impacts of Wind Power Development on Wildlife in New York State

This program area will support research to help improve the scientific and technical foundation to address the following key policy-relevant questions:

- What are the potential impacts of wind power development on wildlife in New York?
- What studies are needed to address impacts of wind power development on wildlife in New York State, and to support the State's role in permitting and siting decisions?
- What methods should be employed to conduct pre- and post-construction wildlife impact studies and risk assessments at wind facilities in New York State?
- What are the best approaches to avoid and mitigate potential impacts of wind power development on wildlife in New York State?
- What research gaps in the wind-wildlife interactions arena should New York State address?
- What is New York State's role in addressing regional and national issues related to impacts of wind power development on wildlife?

Background on Contents

The priority research needs outlined herein originated from an August 2006 stakeholder workshop on wind power and wildlife interactions, sponsored by NYSERDA. At the workshop, participants brainstormed a wide range of research questions relevant to wind power development in the State of New York. Subsequent to the workshop, a consultant carried out a three-step process to add detail and structure to the raw information generated at the workshop.[25]

[25] RESOLVE facilitated the August 2006 workshop and managed the research questions prioritization process. RESOLVE is a non-profit organization specializing in neutral third-party facilitation and/or mediation of complex natural resource, energy, public health, and community-based policy issues involving diverse sets of stakeholders. Founded in California in 1977, RESOLVE is based in Washington, DC (www.resolv.org). Subcontractor Western EcoSystems Technology (WEST), Inc. provided technical editing assistance throughout the research questions prioritization process.

The first step involved categorizing the research questions by topics. The consultants organized the research questions according to either the stage of the development process to which questions applied (i.e. pre-project or permitting; post-construction or monitoring; mitigation), or the different types of more general research needs. The consultant chose these categories rather than resource-focused categories because most of the questions were broad enough that they could pertain to numerous resources (i.e. migration studies).

The consultant then summarized comments and questions from the workshop, eliminating duplication and providing additional clarification. This synthesis and integration step necessarily required the consultant to make some assumptions about and/or interpret the intent of the commenter. In many cases, the comment was quite broad and covered multiple categories/topics. Where appropriate, the list presented below includes specific questions as examples of the type of research that would fall under the broader categories. Research questions that were not included in the original list but have been raised for wind power development are included.

Topic D.1.a: Impact/Risk Prediction Pre-Construction

Problem Statement

There is a need to establish site evaluation and permitting protocols for wind power facilities (i.e. wind turbine construction). Part of this need pertains to determining and validating which pre-construction research methods result in the best predictions of the post-construction impacts of wind power facilities on wildlife. While a number of approaches are used to evaluate sites for risk to wildlife and their habitat, few of the methods have been evaluated. For example, the most common approach to evaluating a site is through a reconnaissance-level site assessment that uses existing published information to assess potential impacts to wildlife from a proposed development. This approach has had limited utility because of the paucity of published studies and because of limits on the transferability of results from one site to another due to site differences. Pre-construction baseline studies result in quantitative data on abundance and use of proposed sites by wildlife, and these studies are much easier to use in comparison with existing data on existing wind facilities. Nevertheless, the small number of published studies and their limited distribution hampers the application of this approach to evaluation of a specific site. There are only 19 studies nationwide that have estimated avian fatalities adequately post-construction, and only two of those were in the northeastern U.S.

No adequate methods appear to exist for estimating the potential risk for bats at a proposed wind energy development site, with the possible exception of bat acoustic surveys. Both approaches (i.e., preliminary site assessment and baseline studies) would be dramatically improved by an increase in regional sites where actual impacts have been compared to pre-construction prediction of impacts from these sites. Validation of these site evaluation methods would provide permitting agencies guidance on predictive tools for evaluating impacts from proposed projects. Developers would also benefit from improved methods for evaluating multiple sites and in the design of specific sites. This type of method validation will only be possible through the application and evaluation of multiple sites representing a range of ecological conditions. The research needs outlined below focus on methods for pre-construction data collection, for the purpose of estimating potential impacts or developing risk assessments.

Research Focus

- Determine the best available field methods and metrics for estimating risk and impacts to birds and bats pre-construction, and evaluating sites proposed for development.
- Develop recommendations for minimizing risk and impacts at proposed wind power facilities.

New York State Relevance

The New York Field Office (NYFO) of the United States Fish and Wildlife Service (USFWS) and the New York State Department of Environmental Conservation (NYSDEC) play an important role in the assessment of risk and impact to wildlife at potential wind energy sites in New York. Concerns identified by these agencies are often related to the need for developers to use the best

available pre-construction site evaluation methods to address potential development impacts to diurnal and nocturnal migrant birds, migrant bats, breeding birds, breeding bats, and federal- and state-listed species. Currently, typical site evaluation protocols combine information from existing local sources (e.g., New York Breeding Bird Atlas, data from raptor watch sites, location of known bat hibernacula) and site-specific field studies. The Pennsylvania Game Commission has developed recommended pre- and post-construction wildlife monitoring methods (PGC 2007) at proposed wind facilities, and the NYSDEC is currently developing voluntary guidelines pertaining to windpower and wildlife impact assessments. Though recommended field studies vary by site and region of the state, several components are often common to pre-construction protocols. These include, but are not limited to, breeding bird surveys, nocturnal avian migrant surveys (marine radar), migratory raptor surveys, wintering raptor/waterfowl surveys, migratory bat surveys (acoustic), breeding bat surveys (acoustic and/or mist-netting), sensitive species searches, and delineation of sensitive habitats. While these methods have been commonly used in New York, the effectiveness for their predictive relevance to post-construction impact has not been thoroughly evaluated. Research relating predictions to actual impact would assist the State of New York as it gives future guidance to industry and local and regional governments regarding studies needed for proposed wind facilities.

Relation to Other Research in the Region and the Nation

Siting and permitting decisions are the best opportunity to avoid impacts from wind energy development, including wildlife fatalities and habitat impacts. NYSERDA held a conference in August 2006 with the purpose of reviewing what is known about the impacts of wind development on birds and bats and to identify the best approaches for integrating this information into permitting of wind energy projects in New York. The same need was identified in The Wildlife Society's review of wind energy development impacts on wildlife (Arnett et al. 2007) and the National Academies of Sciences' review of the environmental impacts of wind energy development in the Mid-Atlantic Highlands (NRC 2007). The U.S. Fish and Wildlife Service published draft voluntary interim guidelines in 2003 for pre-project studies, and the Service is currently convening a Federal Advisory Committee Act (FACA) to modify these guidelines.

Topic D.1.b: Impact Estimation and Risk Validation Post-Construction

Problem Statement

What are the best methods for post-construction monitoring to estimate wind power facility direct (i.e., mortality) and indirect (e.g., altered habitat, displacement) impacts on birds and bats?

Predicting and mitigating impacts resulting from wind energy development requires an understanding of impacts over a wide range of ecological conditions, and it is important that research at the state, regional, and national levels address common problems with similar methods and metrics. Wind energy development is not a random process, and the impacts of wind energy development cannot be studied in the form of an experiment. Rather, impacts and risk must be studied as a series of independent studies that cover a range of development projects in the context of a range of ecological situations. While the types of impacts of wind energy development are consistent throughout the country (i.e., they involve fatalities and habitat impacts), the mechanisms by which these impacts occur and their magnitude vary with ecological characteristics of the developed site. The northeastern U.S. and the nation are characterized by much variability in the ecological setting, and no one study site, state, or region will provide sufficient opportunity to study the range of potential impacts from wind energy development.

An accurate estimation of post-construction impacts is essential in evaluating methods used to predict these impacts. The methods and metrics for estimating impacts have been adequately described in Anderson et al. (1999), and most studies conducted in New York follow these recommendations. However, the protocols by which these methods are implemented vary from site to site, and additional research could assist New York State in developing recommendations for implementation protocols. In addition, replication of the properly conducted studies is necessary to make broader inferences to different ecological settings.

Research Focus

- Estimate impacts at existing and new facilities using scientifically appropriate methods for estimating bird and bat fatalities, displacement, habituation, and use around built wind facilities.
- Conduct comprehensive seasonal studies at multiple sites containing a range of important variables (e.g., land cover types, topography) to estimate impacts, verify predictions of impact and risk, and use the results of this research to evaluate present and/or proposed future site developments for minimizing risk and impacts.

New York State Relevance

The NYSDEC Draft Guidelines for Conducting Bird and Bat Studies at Commercial Wind Energy Projects were made available in January 2008 and can be accessed at http://www.dec.ny.gov/energy/40966.html. Development of field methods for post-construction mortality studies in New York and the eastern U.S. have been based largely on recommendations made by the NYSDEC and USFWS, commenting on environmental impact studies for proposed wind projects. The methods recommended by the agencies are similar to studies conducted in the western U.S. as well as the studies conducted at Myersdale, Pennsylvania, and Mountaineer, West Virginia. Typical components required for estimation of fatality rates include standardized searches of plots beneath turbines for carcasses and an adjustment of the found carcasses based on an estimation of searcher efficiency and carcass removal rate. Notwithstanding, the protocol by which these methods are applied vary greatly among studies, including, but not limited to, search intervals (e.g., daily, weekly), number of turbines searched (e.g., all turbines, proportion of turbines), search effort at each turbine (e.g., pattern, time spent, plot size), search effort for each season, area searched at each turbine, frequency of search efficiency trials, carcass size used in removal trials, and effort/timing of searcher efficiency and carcass removal trials.

As of June 2007, five utility-scale wind facilities (388 MW, 215 turbines) were online in New York. Only one facility, the Maple Ridge Wind Farm (195 1.5 MW turbines), has been studied following construction to assess mortality risk to birds and bats. Initial findings from the first-year pilot study have recently been released (Jain et al. 2007). The pilot data suggest that different search intervals may influence the estimated fatalities. In the absence of guidance on standard protocols to estimate fatality rates, researchers continue to base analyses on agency recommendations and previous studies to inform further design changes to the protocol for additional years of study.

Relation to Other Research in the Region and the Nation

The estimation of fatalities resulting from wind energy development has occurred throughout the country. However, methods adequate for estimating annual fatality rates for birds have been applied at only 19 sites, only two of which were in the northeastern U.S. Adequate studies of bat fatalities are also limited. The majority of the existing studies have occurred in agriculture, Conservation Reserve Program lands, prairies, and a mixture of these ecological settings. Studies are lacking in other landscape types, particularly in the highlands and coastal areas of the Northeast, where the best wind resources exist. Two studies of bat fatalities in the Northeast suggest that facilities on mountain ridge tops in this region may result in far more bat deaths than facilities built in other landscapes. Even less is known regarding habitat impacts from wind energy projects, especially impacts resulting from displacement. While existing studies in Minnesota, North Dakota, Oregon, and Washington suggest that displacement effects on ground-nesting birds in grassland/agriculture landscapes are small scale (i.e., <100m), little data exists for other landscapes.

Topic D.1.c: Mitigation Studies/Research

Problem Statement

There is currently insufficient scientific data about effective measures and activities for mitigating the impacts of wind power facilities on birds, bats, and other wildlife. Thus, there is a need to identify and implement available (or potential) mitigation measures and activities, monitor their

performance over time, and develop objective scientific evaluations of their effectiveness. It is essential that potential measures be evaluated so that time and resources are not wasted in implementing mitigation measures that do not work or that actually increase rather than decrease risk. It is likely that effective mitigation measures could be easily transferred from site to site throughout the country, and some measures could potentially be incorporated into the design of wind energy production technologies.

Research Focus

- Identify potential methods for mitigating impacts to birds, bats, and other wildlife from wind facilities.
- Implement and evaluate potential mitigation methods (e.g., turbine feathering, ultrasonic bat deterrent) at multiple wind facilities.

New York State Relevance

The Renewable Portfolio Standard (RPS) for New York State calls for 25% renewable power by the year 2013. Currently (as of January 2008), NY has six operating wind projects totaling 423 MW of nameplate capacity. To meet the RPS, the number of wind projects in New York is likely to dramatically increase over the next six years. NYSDEC and USFWS, in comments on environmental impact assessments for proposed wind projects, have suggested turbine management as a means of mitigating mortality impacts to birds and bats.

Relation to Other Research in the Region and the Nation

A number of potential mitigation measures have been suggested, some measures have been implemented, but few measures have been evaluated throughout the country. For example, Bat Conservation International (Ed Arnett, personal communication) is currently evaluating measures to repel/deter bats from wind turbines. Young et al. (2003) evaluated the effectiveness of a UV gel coating on turbine rotors and towers in reducing fatalities at Foote Creek Rim. William Hodos (2003) determined that test birds could see selected blade painting patterns better than others in laboratory experiments, but the patterns have not been field tested to determine if better visibility translates into lowered impacts. Arnett et al. (In Press) report that preliminary evidence from a wind project in West Virginia suggest that most bat fatalities occur during evenings of low wind speed, suggesting that operational management of wind plants might reduce risk to bats.

Topic D.1.d: Significance of Impacts

Problem Statement

At the current level of development, impacts to populations of birds and bats have not been confirmed. However, there is interest in determining if the cumulative impacts from wind energy development in New York have the potential to reduce the viability of wildlife populations and of particular rare and common species of both birds and bats. While existing methods do not allow an estimate of the abundance of bats exposed to potential collision mortality at wind energy facilities, the relatively high fatality rates at two wind facilities in the Northeast have raised concerns regarding potential population effects in this region. In addition, impacts to individuals for long-lived low-fecund species (e.g., bats) may have greater implication at the population level. Clearly evaluating the population effects resulting from estimated fatalities is important so these impacts can be placed in proper perspective. Likewise, habitat impacts are of concern, primarily if they result in increased mortality or decreased reproduction in affected populations. Habitat impacts must be evaluated in relation to population effects to truly understand the total effects of wind energy development. Better methods, metrics, and predictive models are needed to more accurately predict the potential for impacts to wildlife populations from various levels of wind energy development in New York.

Research Focus

- Determine the significance of the fatality and non-fatality impacts of wind facilities on wildlife populations.

New York State Relevance

Significance of avian and bat fatalities to populations, both direct and indirect, in New York is difficult to ascertain based on the limited data on wildlife populations. Though no bird species reported as fatalities at the Maple Ridge Wind Farm are listed as rare, threatened, or endangered, some of the species (e.g., forest-interior songbirds, such as warblers and thrushes) are thought to be declining throughout North America, in some part due to impacts resulting from pollution associated with traditional electricity generation facilities. The majority of bird species found as fatalities at the Maple Ridge wind facility are common species occurring throughout New York. Additionally, the small number of individuals reported as fatalities (e.g., one individual American Kestrel found at Maple Ridge Wind Farm) are impacts to individuals and not populations (i.e., unlikely to negatively impact local populations of the species). Overall impacts to bat populations are not clear, as little is known about populations of tree-dwelling bats, the most common species found as a fatality. Bat fatalities often involve greater numbers of fewer species as compared to birds. Estimates of bat populations in New York are mostly limited to cave-dwelling bats with known hibernacula that can be assessed relatively easily on a regular basis. Data on migratory bat populations in New York are very limited. Populations of endangered bats, such as the Indiana bat, are documented in New York; however, to date, no fatalities of an endangered bat species have been found at a wind facility in the U.S. While fatality rate and avian/bat species found during the pilot study at the Maple Ridge Wind Farm suggest some similarities with the other two eastern facilities that have been studied, these variables are likely site-specific and vary by region, topography, and land cover. Indirect impacts, such as fatalities resulting from loss of habitat, are even more difficult to assess.

Relation to Other Research in the Region and the Nation

Many of the bird and bat populations impacted by wind energy development are regional, national, and even international in their range. Thus, research related to population effects must cross state and international boundaries. With the exception of the golden eagle population study at Altamont Pass Wind Resource Area (Hunt 2002), no population-level empirical evaluation of the impact of wind energy development has occurred. Model-based evaluations with existing data in Washington and Oregon suggest that the relatively low fatality rate for most birds is unlikely to have a measurable demographic effect on bird populations. Nevertheless, as information on fatalities becomes available for newly studied landscapes, it would be prudent to reassess this conclusion, particularly with regard to rare species and populations of concern.

Topic D.1.e: Baseline Information on Bird and Bat Populations and Behavior

Problem Statement

More empirical data are needed to thoroughly assess the potential impacts of wind power development on avian and bat species. Areas of particular interest in New York State include population estimates; concentration areas; behavioral avoidance of wind facilities by different species; and migration patterns and routes. Risk of birds and bats colliding with wind turbines is a function of density and behavior. Thus, to predict risk in relation to a proposed wind energy development, one must know what species of birds and bats are present at the site, in what abundance, how they use the site, and how these estimates of exposure translate into fatalities and/or habitat use response. Methods exist for estimating presence, use patterns, and behavior for diurnally active birds. Nocturnal bird activity is more difficult to measure, and the existing methods, including marine radar and acoustics, need further evaluation. New York has recommended relatively extensive use of marine radar to predict nocturnal migration patterns at proposed wind project sites, and these data, when compared to post-construction fatalities, will be extremely important in evaluating this methodology. Bat presence/absence and behavior is much more difficult to study, and the existing methods, primarily acoustic monitoring, require evaluation by comparison with concurrent post-construction fatality estimates. NEXRAD holds promise as a tool to evaluate migratory patterns of nocturnally active species, but as with the other methods, it must be evaluated in relation to post-construction impacts and may not be effective for all wind projects, depending on location relative to a NEXRAD station. Models are needed to estimate risk given the above parameters. The influence of density and behavior are likely transferable among sites from region to region for the same species. However, this can only

be confirmed when models are developed and data from multiple regions for the same species are used to evaluate model predictions. On the other hand, the presence or absence of a species at a specific site, and how the site is used, will likely be unique; data may be required for each site.

Research Focus

- General/broad studies of birds and bats to determine population sizes, trends, and concentration areas at local, state, and continent-wide scales.
- Determine background mortality levels or rates for birds and bats outside of, and within, wind developments.
- Studies of birds and bats to describe and quantify behavioral avoidance of turbines or wind power facilities.
- Migration studies of birds and bats specifically to include low-altitude nocturnal and diurnal migrants (< 200m agl), including a statewide approach (simultaneous sampling at multiple stations) using multiple and coordinated methods. This should investigate how topography (including coastlines) influences migration, determine seasonal/temporal variation, identify "flyways" and stopover areas, and compare/evaluate different methods.

New York State Relevance

An overall objective of NYSDEC is to use the cumulative information from multiple studies in an overall statewide assessment of issues such as the location and magnitude of nocturnal migration. Based on the number and distribution of wind proposals for New York State, future evaluations in different landscape types could be made under a set of assumptions related to the applicability of the data over time and consistency in study methods. For example, multiple studies of nocturnal migration around the state provide information about migration over large landscape features, which can in turn provide information on the relative risk of developments in different physiographic regions (e.g., coastal plains, foothills, mountains). However, application of these types of data to specific sites is problematic, and more data are needed on the effect of site-specific features on avian and bat abundance and migration.

Relation to Other Research in the Region and the Nation

Although birds and bats have been heavily studied in some landscapes, particularly in agricultural areas of the Pacific Northwest and Midwest, empirical data are lacking to thoroughly assess the potential impacts of wind power development on avian and bat species in most regions of the country. As in New York, areas of particular interest include population estimates; concentration areas; behavioral avoidance of wind facilities by different species; and migration patterns and routes.

Topic D.1.f: Synthesize and Analyze Existing Data

Problem Statement

A good deal of information about the impacts of wind power development on birds, bats, and other wildlife already exists, including data on impacts in New York State. However, the data that exists is of variable quality and is possessed by a variety of different parties. Thus, there is a need to collect and review the information that exists in New York and other similar areas, assess its quality, and synthesize and summarize it to the greatest degree possible. Taking this step would consolidate data collected to date and add value by providing direction for future research. With the rapidly expanding development of wind energy, it is essential that studies of the new facilities be incorporated into the evaluation of wind energy impacts on wildlife. All of these new developments should be considered learning opportunities to augment the limited information currently available for this region.

Research Focus

- Identify and analyze existing spatial information on wildlife populations, migration, and landscape variables to address issues at a programmatic level in New York, including the

development of GIS layers for use in identifying high-risk areas or ecologically suitable areas for wind development. Identify gaps in existing information that potentially limit this analysis.

- Develop a detailed synthesis and meta-analysis of New York radar studies and make these data readily available to decision makers.
- Conduct a cumulative effects analysis of wind power development and wildlife migrating through New York State at multiple scales such as a local, in-state region, or multi-state region.
- Produce a report covering existing information on wildlife impacts from wind power development with a focus on the northeastern United States and make it available to stakeholders and decision makers. This report should build off the recently released reviews of this subject by the National Academy of Sciences and The Wildlife Society.
- Identify and evaluate databases and studies that can be used in permitting decisions under differing levels of anticipated risk.
- Evaluate the need for a New York State public repository where existing and future worldwide publications and reports can be housed and made publicly available.

New York State Relevance

Within New York there have been multiple studies conducted for proposed wind projects within the past 4-5 years. Most of the data contained in these studies are publicly available through the permitting process, local agencies, or NYSDEC. Data are available for a synthesis or meta-analysis for the state, regions, or physiographic provinces (e.g., coastal plains, foothills). Additional data are being added to the overall study pool annually. There is currently the potential for a cumulative-effects analysis to be conducted using pre-project data. Additional post-construction monitoring data as new projects are built would greatly enhance the effectiveness of the impact assessment

Relation to Other Research in the Region and the Nation

As mentioned above, much of the research on bird and bat interactions with wind energy development can be transferred across state and regional boundaries where common species in similar landscapes exist. Many of the impacted populations are regional or national in distribution, and aspects of some risk factors can be transferred among states and regions. For example, research conducted at the Mountaineer site in West Virginia (Kerns and Kerlinger 2004) deals with many of the same species that occur on mountain ridge tops in New York, and it is assumed that results from research at similar sites on the same species will inform siting decisions in New York. The National Academy of Sciences examined data on the environmental impacts of wind energy development for the Mid-Atlantic Highlands region of the northeastern U.S. This review could be combined with a more intensive review of the ongoing studies in New York and the surrounding states.

Topic D.1.g: Methods Evaluation and Development

Problem Statement

There is a need to compare existing research methods, and/or develop new methods, in order to determine which methods are most effective for addressing outstanding questions related to the impacts of wind power facilities on birds, bats, and other wildlife in New York.

Research Focus

- Conduct a simultaneous comparison of different methods and metrics (e.g., radar, acoustics, thermal imaging) for estimating pre-construction nocturnal and diurnal abundance, behavior, and migration at one or more sites proposed for development and one or more reference sites. This could help determine which methods and metrics, singularly or in combination, are most effective at producing pre-project data that can be used to estimate impacts and predict risk.
- Develop and verify models that best predict bird and bat risk and impacts.
- Use stable isotopes and genetics to determine avian and bat population sizes.

- Develop a GIS tool that can be used to identify ecologically suitable areas in wind resource regions.
- Evaluate a case/control methodology approach to fatality analysis.
- Evaluate methods for use in present and/or future site development for minimizing both impact and risk.
- Evaluate the estimation of resident bat mortality rates using a banding/band recovery at selected wind sites.

New York State Relevance

Currently, most study recommendations around proposed wind projects in New York are from NYSDEC, which has requested similar pre-project studies following methods and protocols used previous studies. In addition, based on comments on environmental impact analyses for proposed projects, NYSDEC has requested that similar post-construction monitoring studies be conducted for all projects, including simultaneous evaluation of fatalities and nocturnal migration using marine radar and acoustic monitoring of bats. While these studies do not necessarily determine which methods are best suited for predicting or measuring impacts, the information gained should improve the overall ability to predict or estimate impacts.

Relation to Other Research in the Region and the Nation

NYSERDA is funding a research project at the Maple Ridge Wind Farm that will serve as a test facility to evaluate monitoring strategies and techniques, and correlate them to pre-construction efforts. This effort will supplement post-construction monitoring efforts already underway. The project will integrate radar, acoustic detection, and enhanced visual observation data collected in spring and fall of two years (2007 and 2008) to assess potential risks to birds and bats. Two radars will operate simultaneously from sunset to sunrise, one in the vertical plane and one in the horizontal plane. The dual radar system will provide data on target passage, flight direction, and altitudinal distribution. The two radars operating simultaneously also will allow for correlation analyses between passage estimates to validate their performance. Night-vision goggles will be used simultaneously with the radar. Bat acoustic detectors will also be set up throughout the site. Avian nocturnal flight calls will be recorded from two monitoring stations in close proximity to the radar site, and will be classified by species, temporal occurrence, and loudness. The data will be correlated with the radar, bat acoustic, and night-vision data. Collision acoustic data will also be collected. This will be the first evaluation of the acoustic strike-detection method. The data to be collected, and the analyses and comprehensive reporting, will contribute to efforts that (1) quantify relationships between risk and effect (i.e., mortality), (2) determine relationships between pre and post construction risk assessments, and (3) evaluate the accuracy and efficacy of monitoring and assessment methods. This project pairs independent methods for quantifying passage and relative altitudes of birds and bats, and tests an independent method for monitoring flying animal mortality.

Anderson et al. (1999) described common methods and metrics that should be used in studying the effect of wind energy development on wildlife. In general, these methods can be used in all states and regions throughout the U.S. in the study of wind energy impacts on wildlife. Nevertheless, each site and proposed project will be unique enough to require specific research and monitoring protocols so that these common methods and metrics can be tailored to each site and the species using the site. Unfortunately, the application of a method in the arid west may be somewhat different than application of the same method in upland forests or farmlands in the northeast. Thus, the evaluation of existing information from various regions of the country is necessary to determine its applicability to New York. The National Renewable Energy Laboratory is currently planning to update Anderson et al. (1999) to take advantage of recent information from studies at wind energy facilities. Kunz et al. (In Press) recently reviewed methods and metrics for the National Wind Coordinating Committee for the study of nocturnally active species and concluded that most methods are at best indirect measures of abundance and use, and at worst, still experimental. Kunz et al. identified a number of these experimental approaches that could be evaluated as new projects are planned and implemented. While these reviews were valuable, their recommendations need evaluation through independent studies at new wind energy facilities.

Other General Research Needs Identified at the August 2006 Workshop

The following questions were raised at the August 2006 workshop sponsored by NYSERDA, but are not necessarily research questions related to wind development and wildlife interactions and/or were too broad to categorize.

- Identify where wind power potential and important wildlife resources overlap on public lands and evaluate this overlap in relation to potential impacts from wind energy development.
- Determine/develop a standardized framework for the study of wildlife impacts from wind projects, including information needs and appropriate methods and metrics.
- Establish a funding pool of contributions from developers, agencies, or other stakeholders, and use these resources for research.
- Compare impacts from wind development to other types of power generation and publicize the results.
- Evaluate the impact of mitigation measures on power production and effects to the power grid.
- Coordinate research in the U.S. and Mexico.
- Explore more aesthetic arrangements of turbines in the landscape.

D.2. KINETIC HYDRO

- In-stream kinetic hydropower energy generation systems are an emerging renewable energy technology with significant potential for generating and delivering electricity in New York State and other economies throughout the world. On the Roosevelt Island Tidal Energy (RITE) Project in New York City=s East River, Verdant Power, in partnership with NYSERDA, is leading the development of kinetic hydropower in the United States with its Kinetic Hydropower Systems (KHPS). The environmental studies conducted in this work scope, developed in collaboration with the New York State Department of Environmental Conservation, U.S. Fish & Wildlife Service, U.S. National Marine Fisheries Service, the U.S. Army Corps of Engineers, and the U.S. Department of Energy Oak Ridge National Laboratories, will provide the industry benchmark for environmental fish impacts of kinetic hydropower and KHPS technologies. The NYSERDA-supported project includes fixed and mobile hydro-acoustic studies to evaluate fish movement and protection aspects; a DIDSON sonar study to supplement the acoustic study; an underwater noise assessment to measure and assess the potential effects of the sounds associated with turbine operation on aquatic life; and a hydrodynamic study to address concerns regarding potential changes in flow patterns of the East River resulting from turbine deployment and operation.

D.3. BIOFUELS

- NYSERDA is supporting a number of initiatives, in close coordination with the New York State Department of Environmental Conservation, exploring the environmental impacts of biofuels. One initiative includes a meta-analysis/literature review of the environmental impacts of biofuels. Specific fuel types to be included are ethanol, biodiesel, and biobutanol, used in the following applications: transportation fuel, heating fuel, and power generation. The project will review and summarize published reports/papers on current and future technologies, with respect to total fuel-cycle analyses of energy and greenhouse gas impacts, air quality and health impacts from combustion and evaporative emissions (both primary emissions and secondary pollutants), technology needs to mitigate environmental impacts, and assessments of other non-air environmental impacts. An economic review will also be conducted.

D.4. DISTRIBUTED GENERATION/COMBINED HEAT AND POWER

- Distributed generation uses various small-scale resources for generating power that are located close to the site where the power will be used. DG systems are energy efficient and have the potential to improve air quality while lowering the costs of electricity for consumers. DG can also improve the reliability of transmission of power and its system of distribution. Combined heat and power technologies use a single fuel to produce both heat and electricity. While much of the heat produced with conventional electricity generation is wasted, with CHP systems that heat is recovered. DG/CHP technologies include fuel cells, reciprocating engines, microturbines, gas turbines, back-pressure steam turbines, and hybrid power systems. NYSERDA is currently exploring how the widespread use of distributed generation (DG) systems operating in combined heat and power (CHP) applications throughout New York State (NYS) would affect emissions of criteria air pollutants and the wholesale electricity market.

Appendix 1: New York Energy $mart[sm] Environmental Monitoring, Evaluation, and Protection Program Project Portfolio

Contract #	Title	Principal Investigator and Research Organizations	Site	Total Project Cost	NYSERDA Cost
Ecological Effects of Deposition of Sulfur, Nitrogen, and Mercury					
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	$10,067,076	$3,845,443
4917	Evaluation of the Recovery from Acidification of Surface Waters in the Adirondacks	Dr. Myron Mitchell, SUNY College of Env. Science and Forestry - Syracuse	Arbutus Pond, Hunt. Wildlife Forest, Statewide modeling	$1,200,896	$962,517
4916	Mercury in Adirondack/Catskills Wetlands, Lakes and Terrestrial Systems	Dr. Ronald Munson, Tetra Tech, Dr. Charles Driscoll, Syracuse University	Sunday Lake (Adirondacks) & various sites in the Catskills	$1,193,597	$727,684
6818	Mercury Deposition Monitoring in the Catskills	Dr. Mike McHale, U.S. Geological Survey	Neversink area, Catskills	$179,738	$116,363
8152	Mercury Deposition Monitoring in the Adirondacks	Dr. Charles Driscoll, Syracuse University	Newcomb, NY	$210,047	$170,064
6086	*Effects of Atmospheric Deposition of S, N, Hg on Adirondack Ecosystems	Dr. Dudley Raynal, SUNY College of Environmental Science and Forestry	Adirondack Region	$413,400	$282,598
6485	*Contributions of Global and Regional Sources to Mercury Deposition in New York State	Dr. Christian Seigneur, Atmospheric & Environmental Research, Inc.	Statewide (modeling)	$203,903	$96,805
6486/ 6490	*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	Adirondack and Catskill Regions (modeling and assessments)	$277,186	$245,506
6487	*Status and Effects of Nitrogen Pollution in North Eastern United States	Kathy Fallon Lambert, Hubbard Brook Research Foundation	Statewide	$379,440	$149,320
6488	*Atmospheric Transport and Fate of Mercury in New York State	Dr. Chris Walcek, Research Foundation of SUNY	Statewide (modeling)	$139,099	$102,828
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
7605	*Assessment of Extent to Which Intensively-studied Lakes are Representative of the Adirondack Mountain Region	Dr. Timothy Sullivan, E&S Environmental Chemistry, Inc	Adirondack Region	$2,531,415	$710,787
7606	*Changes in Stream Chemistry and Aquatic Biota in Response to the Decreased Acidity of Atmospheric Deposition in the Neversink River Basin, Catskill Mountains, 1987 to 2003	Dr. Doug Burns, U.S. Geological Survey	Catskill Region	$63,552	$25,216

Contract #	Title	Principal Investigator and Research Organizations	Site	Total Project Cost	NYSERDA Cost
7608	Long-term Monitoring and Assessment of Mercury Based on Integrated Sampling using the Common Loon, Prey Fish, Water, and Sediment	Dr. Nina Schoch, Adirondack Cooperative Loon Program/Wildlife Conservation Society	Adirondack Region	$729,090	$380,914
7612/ 7716	Strategic Monitoring of Mercury in New York State Fish	Dr. Howard Simonin, NYSDEC, Karen Roy, ALSC	Statewide	$714,837	$487,226
7613/ 7717/ 7718	Assessment of Chemistry and Benthic Communities in Streams of the Oswegatchie-Black River Basins	Dr. Greg Lawrence, U. S. Geological Survey, Karen Roy, ALSC, Dr. Sophia Passy, Univ. Texas	Adirondack Region	$818,575	$476,020
8644/ 8739	Regional Forest Health and Stream and Soil Chemistry Using a Multi-scale Approach and New Methods of Remote Sensing Interpretation, Catskill Mountains, NY	Dr. Peter Murdoch, U.S. Geological Survey; Dr. Richard Hallet, USDA Forest Service	Catskill Region	$408,630	$256,553
8646	Assessment of Nitrogen and Acidic Deposition Impacts to Terrestrial and Aquatic Ecosystems of Tug Hill	Dr. Myron Mitchell & Dr. Gregory McGee, SUNY ESF	Tug Hill Region	$167,329	$123,762
8649	Assessing the Sensitivity of New York Forests to Cation Depletion	Dr. Ruth Yanai, SUNY ESF	Statewide	$210,132	$166,043
			Totals: Ecological Effects Projects	**$20,041,275**	**$9,425,649**
Air Quality and Health Effects					
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)	$1,538,980	$1,143,118
4914	*Analysis of Ozone and Fine Particles in the Northeast	Dr. S.T. Rao, SUNY-Albany	Statewide (modeling)	$547,749	$547,749
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 Mtn, Pinnacle St. Park, NYC/Queens	$9,584,586	$3,879,617
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

Contract #	Title	Principal Investigator and Research Organizations	Site	Total Project Cost	NYSERDA Cost
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	$239,238	$184,965
6820	*Monitoring Particle Size Distribution in Rochester	Dr. Philip Hopke, Clarkson University	Rochester, NY	$246,555	$165,783
6230**	*Fine/Ultrafine Particulate Emissions Profiles	Dr. Paul Drayton, Gas Technology Institute; Dr. Glen England, GE-EER	New York State (TBD), California, others	$2,053,000	$198,000
7607	*Workshop on Incorporation of Receptor Models into PM and Adverse Health Effects Study	Dr. Phil Hopke, Clarkson University	Statewide	$41,461	$30,112
7616	Chemical Composition of Fine Organic Particles from Urban Regional Background Locations in New York State	Dr. Monica Mazurek, Rutgers University	New York City, Pinnacle State Park, NYSDEC Testing Lab	$1,101,849	$678,890
7618	Formation and Transformation of Particles in Motor Engine Exhaust	Dr. Fangqun Yu, University at Albany	Statewide	$176,576	$100,000
7919	Analysis of PM Data in NY Using Advanced Source Apportionment Methods	Dr. Philip Hopke, Clarkson University	Statewide	$716,830	$200,000
8641	Assessment of Carbonaceous Fine Particle (PM2.5) for New York and the Region	Dr. Phil Johnson, NESCAUM	Statewide and Region	$491,477	$352,974
8643	Physical and Chemical Characterization of Laboratory-Generated Secondary Semi-volatile Organic Particles	Dr. Kenneth Demerjian, SUNY Albany	Albany, NY	$504,777	$299,998
8650	Ultrafine Particles and Cardiac Responses: Evaluation in a Cardiac Rehabilitation Center	Dr. Mark Utell, Univ. of Rochester Medical Center	Rochester, NY	$946,255	$300,000
			Totals: Air Quality and Health Effects Projects	**$21,919,133**	**$9,939,214**
Climate Change in New York State					
6681	*New York City Regional Heat Island Mitigation	SAIC (R. Slosberg), Columbia University (C. Rosenzweig), Hunter College (W. Solecki)	New York City	$130,000	$50,000
9332**	Regional Assessment of Gas Potential in the Marcellus Shale, New York ($50,000 EMEP funds, $100,000 Energy Resources)	NYS Museum Institute	Albany, NY	$250,000	$150,000
9333**	Regional Assessment of Gas Potential in the Utica Shale, New York ($50,000 EMEP funds, $100,000 Energy Resources)	NYS Museum Institute	Albany, NY	$250,000	$150,000
10087	Modeling Zero-Emissions Coal Plants	Columbia University	New York, NY	$130,698	$96,278

Contract #	Title	Principal Investigator and Research Organizations	Site	Total Project Cost	NYSERDA Cost
10107	Auction Design for Regional Greenhouse Gas Initiative	The Rector and Visitors of the University of Virginia	Charlottesville, VA	$244,299	$244,299
10113	Permanent CO2 Sequestration in Ocean Sediments: Flow-Through Reactor Studies	Lamont-Doherty Earth Observatory	Palisades, NY	$311,454	$287,845
10114	Disposing of Greenhouse Gas Through Mineralization Utilizing the Wollastonite Deposits of NYS	Columbia University	New York, NY	$118,056	$88,522
			Totals: Climate Change Projects	**$1,434,507**	**$1,066,944**
Environmental Effects of Alternative Energy and Other Emerging Energy Options					
9059	Wind Power/Wildlife Interaction Project Services ($5,000 EMEP funds, $159,847 SBC Renewables)	Abby Arnold, RESOLVE, Inc	Statewide	$164,847	$164,847
9675	Synthesis of Electricity Generation Impacts to Wildlife	Environmental Bioindicators Foundation	Statewide	$137,071.10	$99,400
9892	Roosevelt Island Tidal Energy Project Phase II: Environmental Impact Studies	Verdant Power New York	New York, NY	$349,933	$250,000
			Totals: Alternative Energy Projects	**$651,851**	**$514,247**
Projects Crosscutting Environmental Science, Energy, Technology, and Policy					
7609/ 8183	Quantifying Atmospheric Nitrogen Sources with New Stable Isotope Techniques	Dr. Carol Kendall, U.S. Geological Survey/Dr. Elizabeth Boyer, SUNY-ESF	Statewide	$649,806	$411,986
7610	*Multi Pollutant Policies for the Electricity Sector and Environmental Quality in the Empire State	Dr. Karen Palmer, Resources for the Future	Statewide	$312,345	$234,261
7615	*Analysis of New Pollution Control Strategy Utilizing Emission Reduction Credits and Small Scale Combined Heat and Power Units	Navigant Consulting	Statewide	$101,890	$79,535
7617	Quantifying the Environmental Benefits of Increased Deployment of Combined Heat and Power Technologies in NY State and the Impact of Proposed Emissions Standards for Small Distributed Generation	Navigant Consulting	Statewide	$217,270	$170,014
8642	Ambient Gaseous Ammonia: Evaluation of Continuous Measurement Methods Suitable for Routine Deployment	Dr. James Schwab, SUNY Albany	Albany, Pinnacle State Park, and Addison, NY	$116,671	$89,430
			Totals: Crosscutting Projects	**$1,397,982**	**$985,226**
Total Funds Committed				**$45,444,748**	**$21,931,280**

*Project complete and report published **Includes Non-SBC Statutory R&D funds