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The Contribution of Acadia PRIMENet Research to Science and Resource Management in the National Park Service

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Abstract: Acadia National Park was one of the fourteen sites included in the Park Research and Intensive Monitoring of Ecosystems network (PRIMENet). For eight years the EPA monitored ultraviolet (UV) radiation at this site, with the National Park Service (NPS) sponsoring a total climate and air monitoring station. Under the auspices of PRIMENet, research projects were initiated that investigated the effects of UV on amphibians, and the developed a model of deposition along an elevational gradient. The monitoring data and research results have been used by park management to protect vegetation and water resources from ozone and deposition. These data are not being used to develop a "vital signs" monitoring program under the NPS' Inventory and Monitoring Program. These data sets have been used in regional, national and international programs to protect human health and resources from air pollution. Public outreach has been accomplished through web site resources and via the Schoodic Education and Research Center.

Key Words: National Park Service; Acadia National Park; ecological effects; air monitoring; water quality; resource management

1. Short history of PRIMENet monitoring and research in Acadia

In 1996 the National Park Service, Air Resources Division (NPS-ARD) and the Environmental Protection Agency (EPA) established a network of fourteen parks that would be used as sites for stressors monitoring and ecological effects research. This program evolved into the Park Research and Intensive Monitoring of Ecosystems network (PRIMENet), with sites representing the range of ecosystem types from arid lands to estuaries

[http://www.forestry.umt.edu/research/MFCES/programs/primenet]. The idea behind PRIMENet was to set up long-term monitoring sites that included the following variables: ultraviolet radiation, climate, wet and dry atmospheric deposition, visibility, tropospheric ozone concentrations, and, at some sites, mercury deposition. This array of "stressor monitoring" was tied to research on effects at these park sites (Summers and Tonnessen 1998). This network used National Parks as "outdoor laboratories" to examine global and regional environmental stressors, with limited confounding effects due to local pollution and changing land use within the parks selected.

Acadia National Park was chosen as one of the PRIMENet sites, jointly funded by EPA and USGS BRD in a competitive grant proposal process. In addition to the management opportunities afforded by this project as described in this overview, the funding of this research represented another management and planning success: addressing a need that had been identified in the comprehensive Water Resource Management Plan for the park (Kahl et al. 2000).

Acadia represented the following northeastern United States ecosystem types: (1) rocky fjord ecosystems, (2) northeastern coastlines, and (3) high elevation vegetation, lakes and streams. Managers at Acadia welcomed the additional research and monitoring investment, because one of the major external stresses on natural resources at Acadia is air pollution, primarily transported from the most industrialized areas of North America.

Research projects that were funded under PRIMENet at Acadia included the watershed research described in this volume, and an assessment of UV dose to wetlands in the park and possible impacts on amphibian species (Diamond et al., 2005, in review). Collaborative research with scientists from the Institute for Ecosystem Studies and Oak Ridge was funded to develop

deposition models in complex terrain in both Acadia and Great Smoky Mountains NPs (NPS-ARD, 2002) (see http://www.forestry.umt.edu/research/MFCES/Programs/primenet).

The monitoring component of PRIMENet at Acadia NP (McFarland Hill) included: 1) IMPROVE monitoring for visibility, 2) NADP/NTN monitoring for wet deposition, 3) CASTNet monitoring for dry deposition, 4) climate and weather monitoring, 5) ozone monitoring at two locations, 6) NADP/MDN monitoring for mercury deposition and 7) EPA Brewer spectrophotometer monitoring for ultraviolet radiation (see http://www2.nature.nps.gov/air/Monitoring/MonHist/parkrpt.cfm).

At the end of 2004 PRIMENet UV monitoring was suspended. However, the other air quality monitoring and ecosystem monitoring continues with support from the park, the NPS-ARD, EPA, and the State of Maine. PRIMENet research and monitoring brought together multiple Federal agencies and university to augment existing research and monitoring in the parks, and much of that scientific activity continues. The PRIMENet program demonstrated that resources can be pooled to (1) provide useful monitoring and research data to all participating agencies, (2) incorporate research ideas and activities of academia to answer policy and regulatory questions concerning the effects of man's activities on natural ecosystems, and (3) use national parks to examine trends in global and regional environmental stressors and the responses of natural systems and populations.

2. Managing Air Quality in Acadia and the Northeast region

The park managers and the staff of the NPS Air Resources Division are the users of these research and monitoring data. The Clean Air Act Amendments of 1977 require that the NPS

provide advice and information to the State of Maine and the EPA to protect the Class 1 air quality at Acadia NP. The details of that mandate are included in compilation "Air Quality in the National Parks, second edition" (NPS-ARD, 2002).

Based on years of data on fog chemistry, annual ozone and mercury health advisories, and 20+ years of NADP precipitation chemistry, it is clear that Acadia National Park is recipient of some of the highest levels of atmospheric inputs in the northeastern United States. Concern for the ecological, aesthetic, and public health attributes of both air and water resources is one of the most important management issues at the park. The Water Resources Management Plan for Acadia National Park (Kahl et al., 2000) identified the need to better understand lake and watershed ecosystem conditions and to determine to what extent atmospheric deposition is adversely impacting park water resources. This report also recommended long-term monitoring and research in paired calibrated watersheds to enhance understanding of fundamental watershed ecosystem status and function and to serve as a baseline for which future chemical and hydrologic trends can be compared. The results presented in this volume begin to help the National Park Service at Acadia National Park address these important resource management issues.

Data collected at Acadia NP are critical to the national assessment of changes in deposition of nitrogen and sulfur, resulting from control programs under the Clean Air Act amendments of 1990. The most recent National Atmospheric Deposition Program/ National Trends Network (NADP/NTN) analysis of wet deposition for the period of 1985-2002 used data from Acadia NP (station ME 98). These data helped researchers draw regional isopleths of chemical concentrations in rain and snow. The results of this trend analysis show decreases in regional sulfate concentrations, with no significant trend apparent for nitrate and ammonium

concentrations (Lehman et al., 2005). Continuing this uninterrupted data stream on wetfall can assist NPS managers in determining the deposition stressors and the monitoring needed to see changes in sensitive resources, such as low alkalinity lakes, streams and ponds. The lack of a detectable trend in inorganic nitrogen in deposition argues for vigilance in monitoring ecosystems to detect changes associated with fertilization and eutrophication.

A recent strategic assessment of the status of air quality at Acadia (Maniero and Breen, 2004) recommended a number of priority air resource science needs, including:
(1) continuation of existing long term air monitoring, (2) research to identify pollutant concentrations above which specific deleterious effects to park resources may occur (i.e., establish critical loads), (3) studies to assess pollutant effects on important biological and ecological endpoints, and (4) process-based mercury experiments, particularly in the paired watersheds that have served as the study sites for much of the research results presented in this volume.

2.1. Critical Loads Analysis

Federal Land Managers (FLMs) in the Northeast region, including the NPS, US Fish and Wildlife Service, and USDA-Forest Service, are all charged with protecting Class 1 area resources from damage due to deposition of nitrogen and sulfur. In March 2004 the three FLMS convened an interagency workshop on Critical Loads, to investigate how managers could coordinate their activities to protect sensitive ecosystems that are vulnerable to these atmospheric loads of sulfur and nitrogen. The setting of target loads and critical loads by the NPS will require both deposition data and dose-response information for sensitive resources. The

information generated at Acadia under the PRIMENet program will definitely assist the FLMs in setting these “critical loads” and then working with states, EPA and international organizations to regulate emissions to meet “target loads” for sensitive areas, such as national parks and wilderness areas. The final workshop report and FLM recommendations are found at http://www2.nature.nps.gov/air/pubs (US DOI and USDA-FS, 2004).

2.2. Regional air quality management, modeling and forecasts

Ozone data from NPS sites, including Acadia NP, are included in the EPA’s new “Airnow” alert system. The Air Quality Index (AQI) is an index for reporting daily air quality and is used to inform the public about health threats from ground-level ozone, particle pollution (also known as particulate matter), carbon monoxide, sulfur dioxide, and nitrogen dioxide. For each of these pollutants, EPA has established national air quality standards to protect public health. Maps of air quality forecasts are found at http://www.epa.gov/airnow/. This alert system can assist visitors to Acadia NP and park staff in making decisions about protecting their health during air pollution episodes.

Another way that the NPS is participating in air quality management in the Northeast region in through participation in MANE-VU (Mid-Atlantic/Northeast Visibility Union), one of the Regional Planning Organizations set up by the Mid-Atlantic and Northeastern states, tribes, and federal agencies to coordinate regional haze planning activities for the region, see the MANE-VU web site at http://www.manevu.org/. This group was formed to encourage a coordinated approach to meeting the requirements of EPA's regional haze rules and reducing visibility impairment in major national parks and wilderness areas in the Northeast and Mid-

Atlantic region. MANE-VU provides technical assessments and assistance to its members, evaluates linkages to other regional air pollution issues, provides a forum for discussion, and encourages coordinated actions Their web site includes a real time web cam of visibility conditions at Acadia NP. http://www.hazecam.net/acadia.html.

2.3. International air quality management

Acadia NP has also used its air quality monitoring and research information to assist with international data exchange between Canada and the United States under the U.S.–Canada Air Quality Agreement, signed in 1991. Two of the major areas of cooperation between the two countries include addressing acid rain and transboundary flows of ozone. Progress reports that document progress under the agreement can be found at the EPA web site [http://www.epa.gov/airmarkets/usca/]. The 2004 report covers each country's progress in achieving the requirements of the Acid Rain Annex and actions taken to meet new reporting requirements under the Ozone Annex. Scientific and technical cooperation and research among the two countries is described, highlighting such areas as transboundary particulate matter assessment, health effects, emission inventories, and mapping efforts.

The National Park Service also participates in The Northeast Regional Air Quality Committee – NERACQ - which was established in 1995 to foster cooperation between the United States and Canada on air pollution issues in national parks, wildlife refuges and other protected areas in New England and Atlantic Canada (see: (http://capita.wustl.edu/NEARDAT/transflo/NERAQC/NERAQC.htm). The committee is made up of international, federal, state and provincial representatives and provides a means for

information exchange on air pollution research, air monitoring, and mitigtation efforts that impact on parks and protected areas.

Much of the PRIMENet related research and monitoring data have been included in these international programs. In particular, the long term monitoring of wet deposition in the two countries has allowed for the development of “borderless” maps of sulfate and nitrate wet deposition to evaluate the efficacy of air pollution control programs in both countries. SO2 emission reductions resulted in a significant decrease in wet sulfate deposition over a large section of eastern North America. During these same time periods, however, wet nitrate deposition remained relatively unchanged.

3. Guiding research, long term monitoring and public outreach

Scientific research and long term monitoring are the foundations for park management decisions aimed at protecting, preserving and restoring natural resources. In addition, outreach to the park visitors and the general public is an important mission for park managers. The PRIMENet data and information has “set the stage” for expanded monitoring and educational activities at Acadia NP through programs funded under the NPS Natural Resource Challenge (NRC) [http://www.nature.nps.gov/challenge/].

For Acadia National Park, the logical extension of the PRIMEnet activities has been collaboration with new programs under the NRC: (1) the Northeast Temperate Inventory and Monitoring Network (NETN) [http://www1.nature.nps.gov/im/units/netn/index.cfm], (2) the Schoodic Education and Research Center (SERC) [http://www.nps.gov/acad/rm/sercinfo.htm] and (3) the North Atlantic Cooperative Ecosystem Studies Unit [http://www.ci.uri.edu/naccesu].

The current research needs list and the selection of "vital signs" for long term monitoring at the park reflect the knowledge gained during the PRIMENet monitoring and research. Much of the park's focus on science questions revolve about air contaminants and their effects on natural resources, and the NETN vital signs include many of the variables included in the PRIMENet program and related watershed investigations: ozone, atmospheric deposition, climate, water quality, water chemistry, nutrient enrichment, and amphibians.

The park is now constructing a research catalog to be included on their resource management web site [http://www.nps.gov/acad/rm/resman.htm]. A Research Opportunities catalog for Acadia National Park will assist park managers in their efforts to secure funding for high priority studies, and such a catalog will encourage the research community to consider Acadia National Park as a wonderful place to initiate scientific studies and seek non-NPS research support, or partner with the NPS for funding. Acadia National Park, with research support and housing facilities at the Schoodic Education and Research Center (SERC), should be able to attract outside researchers who wish to pursue both short- and long-term research programs.

Located within a day's drive from many large cities within the northeastern United States and Canada, nearly three million people visit Acadia National Park annually. Local residents and visitors value good air quality. In a survey of over 1,000 visitors (Littlejohn 1999), the features or qualities of the park that received the highest "extremely important" and "very important" ratings were scenic views (99%), clean air (97%) and clean water (96%). The National Park Service has a tremendous opportunity and valuable role to play in informing the public about a variety of park air related issues and science activities. The results of the research documented in

this journal volume thus have an immediate and important educational application that goes beyond informing future research efforts.

Through the use of interpretative displays, webcams, brochures and student curricula, Acadia and SERC staff are reaching more of the public with information about natural resource threats to the park. Examples of educational outreach by Acadia staff on the issue of air quality are found at http://www2.nature.nps.gov/air/Pubs/pubEd/acad/acad2.htm, including an interpretive display titled "Downeast and Downwind".

Another web resource under development is SPARC (Searchable Park Access to Research Catchments), a collaboration between University of Maine, Plymouth State University, and the NPS (Grygo et al., 2005). This web site will include small catchment data from a variety of PRIMENet parks, which should allow the scientific community and park managers to be able to compare watersheds and stressors across ecosystems. Once developed this web site will be housed at the SERC.

4. Conclusions

Resource managers at national parks make an array of decisions that affect natural and cultural resources and visitor enjoyment of those resources. The programs and networks described here all contribute to the ever-increasing knowledge of trends in the "dose" of pollutants that can elicit "responses" in ecosystem properties. The NPS needs to continue these interagency and university collaborations to allow us to protect the resources that we manage for the "enjoyment of future generations".

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Figure Caption:

Figure 1. Locations of PRIMENet research watersheds at National Parks across the U.S.