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Northeast Region
Boston, Massachusetts



Acadia National Park: Assessment of Long-term Air Quality Programmatic, Monitoring and Research Needs

Natural Resources Report NPS/NER/NRR—2004/002



ON THE COVER

View of Otter Cliffs from Thunder Hole at Acadia National Park
Photo courtesy of Acadia National Park

Acadia National Park: Assessment of Long-term Air Quality Programmatic, Monitoring and Research Needs

Natural Resources Report NPS/NER/NRR—2004/002

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Executive Summary

Acadia National Park (NP), as a Class I air quality area, is afforded special air quality protection by the 1977 amendments to the federal Clean Air Act. Since 1979, the park has conducted a comprehensive program that includes 1) ambient air quality monitoring and research; 2) research and monitoring of the effects of air pollutants on visibility, surface water chemistry, soils, sediments and aquatic and terrestrial biota; and 3) public outreach and education regarding air quality. Collected data are used to assess the current and potential effects of air pollution on natural resources in Acadia NP.

In October 2002, staff of Acadia NP and the National Park Service (NPS) Northeast Regional Office initiated a process to assess long-term programmatic, monitoring and research needs relative to park air quality. The process involved both independent and group evaluations, and included a number of NPS and non-NPS participants. The resulting report, completed in fall 2004, is divided into two main sections.

The Background section summarizes the extensive ambient air quality data sets collected in and near the park through spring 2004 including wet, dry and fog/cloud (occult) deposition of anions, cations and mercury, and ambient concentrations of ozone and volatile organic compounds. This section also contains brief summaries of the air pollution effects-related research and monitoring that has taken place in and near the park. Researchers have investigated the effects of 1) atmospheric deposition on park ponds, streams and estuaries, 2) mercury on ecological processes and park biota, and 3) ozone and deposition on park vegetation. Results indicate loss of buffering capacity in park surface waters due to atmospheric deposition and elevated mercury concentrations in fish, amphibians, and piscivorous birds and mammals.

The Long-term Needs Assessment section describes the assessment process in detail, and discusses prioritized long-term air quality programmatic, monitoring and research needs. The section also includes a list of criteria that will be used by staff at Acadia NP to evaluate the usefulness of future project proposals. Continuation of existing ambient and surface water chemistry monitoring is a high priority programmatic need, and mercury will be a focal pollutant for future air pollution effects monitoring and research. NPS staff view the long-term needs assessment as an iterative process. Because the science of air pollution chemistry and effects is a rapidly-advancing field, Acadia NP staff intend to revisit the assessment every five to ten years to add new projects, re-prioritize projects, and reflect any changes in emphasis or direction of the air quality program at Acadia NP.

Introduction

Acadia National Park (NP), designated in 1929, is comprised of a cluster of islands on the Maine coast. Steep slopes of deciduous and coniferous forest rise above the park's rocky shoreline. Acadia NP includes a wide variety of freshwater, estuarine, forest, and intertidal resources.

Under the 1977 amendments to the federal Clean Air Act, Congress designated Acadia NP a Class I air quality area. The Class I designation affords the park special legal protection for its air quality and related resources. It provides the National Park Service (NPS) with an affirmative responsibility to protect the air quality and related values (i.e., visibility, soils, vegetation, surface waters, wildlife, and cultural resources) in Acadia NP from the adverse impacts of air pollution. The NPS uses this affirmative responsibility, for example, to review air quality permit applications for sources proposed near the park to ensure increased emissions will not harm park resources.

In 1979, in response to the 1977 Clean Air Act Amendments, an air resources management program was initiated at Acadia NP. This program has become one of the most comprehensive in the NPS. The primary goal of the air resources management program at Acadia NP is to provide managers with science-based information related to the condition of park resources. Specific objectives are to 1) identify and establish baseline conditions for key air quality indicators, 2) determine air quality-related changes and trends over time, 3) provide scientifically-valid research and monitoring data to determine adverse impacts on park resources, and 4) provide data and information necessary to a) make decisions regarding the potential consequences of new air pollution sources proposed near the park, and b) support changes in state and federal air quality regulations that will better protect park air quality and air pollution-sensitive resources. An important component of the air resources management program has been to educate the public and potential collaborators about Acadia NP's air resource issues. This outreach effort is accomplished through published technical reports and journal articles, park interpretive displays and brochures, newspaper articles, science seminars, and the park's natural resource management website.

A number of ambient air quality parameters are monitored in the park. Park staff also monitor freshwater chemistry indicators of acidification and eutrophication. Many studies have investigated the effects of air pollutants on biological resources and ecological processes in the park. Thanks to research and monitoring funded and conducted by other federal agencies, the Maine Department of Environmental Protection (MDEP), universities, and private organizations, as well as the NPS, a great deal of information has been collected regarding the effects of air pollutants on many resources in Acadia NP.

Because of its Class I designation, visibility impairment is a significant concern at the park, and a great deal of emphasis has been placed on identifying the amount and causes of visibility impairment. Less is known about the ecological and biological effects and implications of air pollution at Acadia NP, so the long-term needs assessment focused on collecting that type of information. The assessment was framed by three key questions. First, what have we learned to date from data collected in and near the park? Second, what are the gaps in information? Third,

is there any type of data collection Acadia NP is uniquely suited for that would contribute to the overall information base of the national NPS air quality program?

NPS staff envision many uses for the air quality needs assessment. It is a tool for communicating synthesized air quality data, as well as information needs, to universities, federal and state agencies, and other potential partners. It can be used to leverage support for projects whose benefits extend beyond the boundaries of Acadia NP. NPS staff will also use the assessment to solicit and develop proposals for monitoring and research, as well as to help them evaluate the merit of proposals submitted independently to the park.

The Background section contains a brief description of aquatic and terrestrial resources in Acadia NP. It includes summaries of available wet deposition, dry deposition, mercury deposition, and ozone and volatile organic compound data collected in the park. When possible, for context, the park data are placed in a regional or national perspective. The section includes brief summaries of past and ongoing air pollution effects studies conducted in and near Acadia NP. It also includes descriptions of unfunded project proposals that have been submitted to the park, as well as recommendations for additional monitoring and research discussed in final project reports. Studies are classified under the categories of Terrestrial, Freshwater, Estuarine/Marine or Wildlife. Note that many of the projects at Acadia NP have investigated watershed processes or bioaccumulation, and so do not fit neatly into these categories.

The Assessment of Long-term Needs section describes in detail the process used for the assessment and discusses the identified prioritized projects and data needs. In brief, the assessment was conducted through an iterative process. First, the Background section of the report was sent to a group of subject matter experts who have not been directly involved with past and ongoing projects in Acadia NP. The experts provided recommendations for additional air pollution-related monitoring and research. In a subsequent workshop involving NPS staff from Acadia NP and the Northeast Regional Office, as well as staff from the MDEP, the U.S. Environmental Protection Agency (EPA), and the U.S. Fish and Wildlife Service (FWS), participants reviewed and refined the subject matter expert recommendations, composed a set of project ranking criteria, and used the criteria to develop a prioritized description of needed projects. Both sections were sent out for another round of review, this time by natural resource managers reviewer comments were then incorporated into the final report. The air quality assessment will be revisited at five-to-ten year intervals to remove funded projects from the list, add new project statements, and reflect any changes in program emphasis or direction at Acadia NP.

Background

Area Description

The following brief area description is excerpted from the Acadia NP Water Resources Management Plan (Kahl et al. 2000) and Acadia NP Vegetation Mapping Program (Lubinski et al. 2003).

Acadia NP occupies rocky headlands on the Maine coast, including Cadillac Mountain, which at 466 m (1,530 ft) is the highest point on the U.S. Atlantic coast. The park encompasses approximately 19,291 ha (47,633 acres) in three primary units on Mount Desert Island, Isle au Haut, and the Schoodic Peninsula (Figure 1). Smaller outlying islands are also part of the park. The largest part of Acadia NP is found on Mount Desert Island, where the park occupies almost half of the island. Isle au Haut lies west and seaward of Mount Desert Island, 8 km (5 mi) south of Stonington, and is accessible only by boat. Roughly half of the island is part of the park. Schoodic Peninsula is located 8 km east of Mount Desert Island on the eastern shore of Frenchman Bay. With three million visitors per year, Acadia is one of the most heavily visited national parks.

The park has a maritime climate, with cool weather and frequent fog. Due to its location, Isle au Haut is subject to a more pronounced maritime climate than Mount Desert Island. At Bar Harbor, on Mount Desert Island, rain averages about 123 cm (49 in) annually, and snow about 1.5 m (5 ft). Temperatures can range from -9°C (-16°F) in winter to 41°C (105°F) in summer, with a mean annual temperature of 8°C (46°F). The coast of Maine differs from inland portions of the state in having cooler summers, warmer and wetter winters, a narrower range of temperature extremes, a longer frost-free season, and less snowfall. Seasonal variation in weather patterns affects the intensity and duration of rainfall in the park. Convective storms are more common in summer; these produce intense rainfall of short duration compared with the broad frontal systems that tend to produce longer periods of less intense rainfall at other times of the year. Limited research conducted on microclimates within the park suggests that there is considerable local variation in temperature, precipitation and evaporation.

The marine environment is an important part of the park setting. The cool ocean waters surrounding Acadia NP have a profound effect on climate, atmospheric deposition, scenery, habitat and the diversity of plant and animal species. Marine waters support a variety of life forms, from tidepool creatures to sea mammals. Frenchman Bay lies to the east of Mount Desert Island and Blue Hill Bay to the west, and estuaries include Northeast Creek, Somes Sound and Bass Harbor Marsh. Many terrestrial birds and mammals of Acadia NP rely on the saltwater resource for habitat and food. The NPS does not have any management authority in marine waters beyond the intertidal zone.

On Mount Desert Island, glacial and post-glacial activity has left a series of north-south trending ridges separated by deep U-shaped valleys. Extensive areas are treeless, standing out sharply above the predominant forest cover of the region. Upland soils are mostly thin and granitic, with many areas of bedrock or talus where soil development is minimal at best. All park soils have a

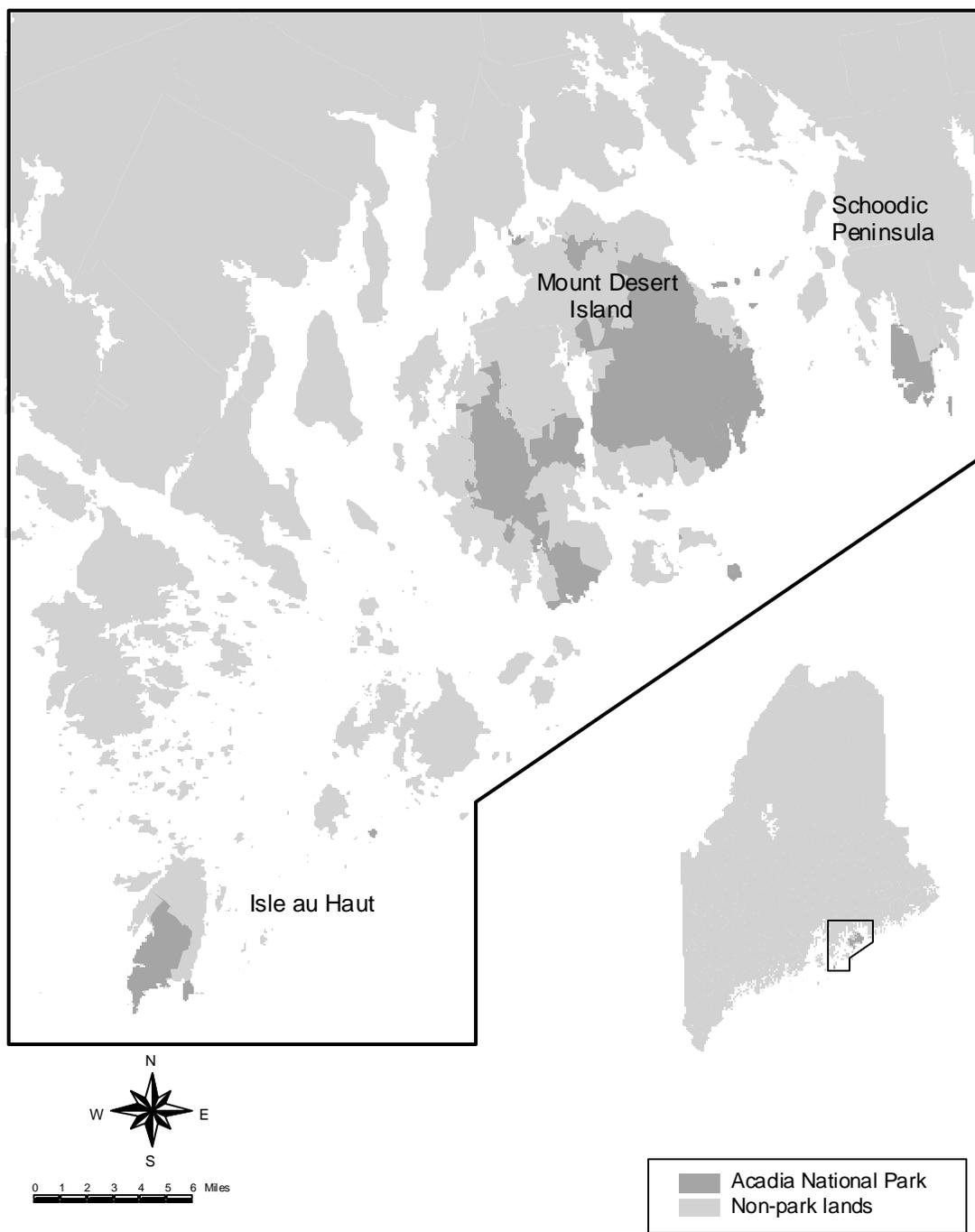


Figure 1. Map of Acadia NP (from Kahl et al. 2000).

pH of 6.5 or lower (Figure 2). Wetlands are underlain by marine deposits or poorly drained tills and include both mineral soil and organic soil wetlands. Soil survey and wetlands classification data are available for the park.

Acadia NP lies at the southern edge of the spruce-fir-northern hardwoods region. The vegetation reflects this transitional position with several species and plant communities at the edge of their ranges. Some areas exhibit a boreal influence. Much of the undeveloped region is characterized by various expressions of spruce-fir forests or forests in transition toward spruce-fir forests. Schoodic Peninsula has distinctive plant associations including stands of jack pine (*Pinus banksiana*) and plants of sub-arctic affinity growing at the southern limit of their range.

A history of major fires, i.e., large fires at 100 to 150 year intervals, has strongly influenced park vegetation. The 1947 Bar Harbor fire was the last major fire, which burned approximately one third of Mount Desert Island. Areas unburned by the 1947 Bar Harbor fire are dominated by spruce-fir forests. Red spruce (*Picea rubens*) is predominant and balsam fir (*Abies balsamea*) is common. White spruce (*Picea glauca*) occurs along shoreline areas, and black spruce (*Picea mariana*) is found in bog areas in association with eastern larch (*Larix laricina*). Mixed conifer stands with scattered hardwoods are dominated by red spruce with northern white cedar (*Thuja occidentalis*), balsam fir, red maple (*Acer rubrum*), paper birch (*Betula papyrifera*), red pine (*Pinus resinosa*) and white pine (*Pinus strobus*) present. Sheltered moist sites in Acadia NP valleys support small stands of northern hardwoods dominated by beech (*Fagus grandifolia*), with sugar maple (*Acer saccharum*) and other hardwoods forming dense canopy and seedlings and saplings of beech, striped maple (*Acer pennsylvanicum*) and red spruce forming the understory. The fire of 1947 extensively destroyed softwood forest stands on eastern Mount Desert Island allowing regeneration of hardwood, birch-aspen communities with quaking aspen (*Populus tremuloides*), bigtooth aspen (*Populus grandidentata*), paper birch and gray birch (*Betula populifolia*). Vegetation mapping in the late 1990s identified 53 natural/semi-natural vegetation communities and 19 ecological systems (Figure 3) in the park.

The hydrology of the park is influenced by the steep slopes, thin soils and maritime climate. Acadia NP's watersheds are small, short and steep, averaging less than 5 km (3 mi) from headwaters to the sea. Precipitation and frequent sea fog deliver moisture throughout the year. However, streamflows are usually very low in late summer and early fall because of rapid runoff and poor moisture retention by the upland soils.

There are 12 major watershed systems that drain the interior of Mount Desert Island. The alignment of these watershed systems roughly parallels the north-south orientation of the park's ridges and valleys. These drainages are characterized by bold topographic relief of up to 450 m (1,477 ft) across a distance of only 6-8 km (4-5 mi). Most watersheds of the park lie at least partially outside the park boundary. The park owns the upland portions of most watershed systems.

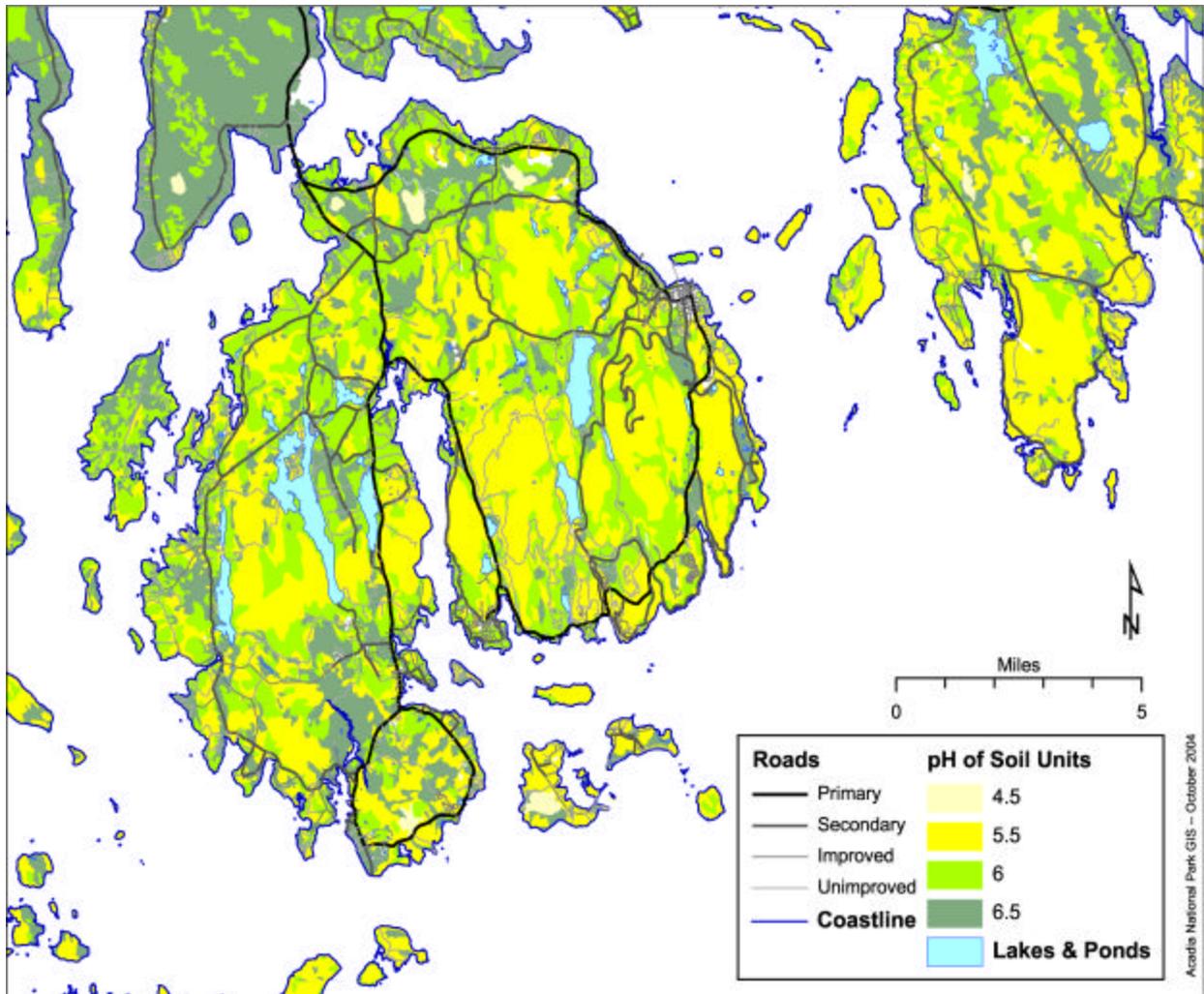


Figure 2. Soil pH at Acadia NP (map produced by Acadia NP GIS Program).

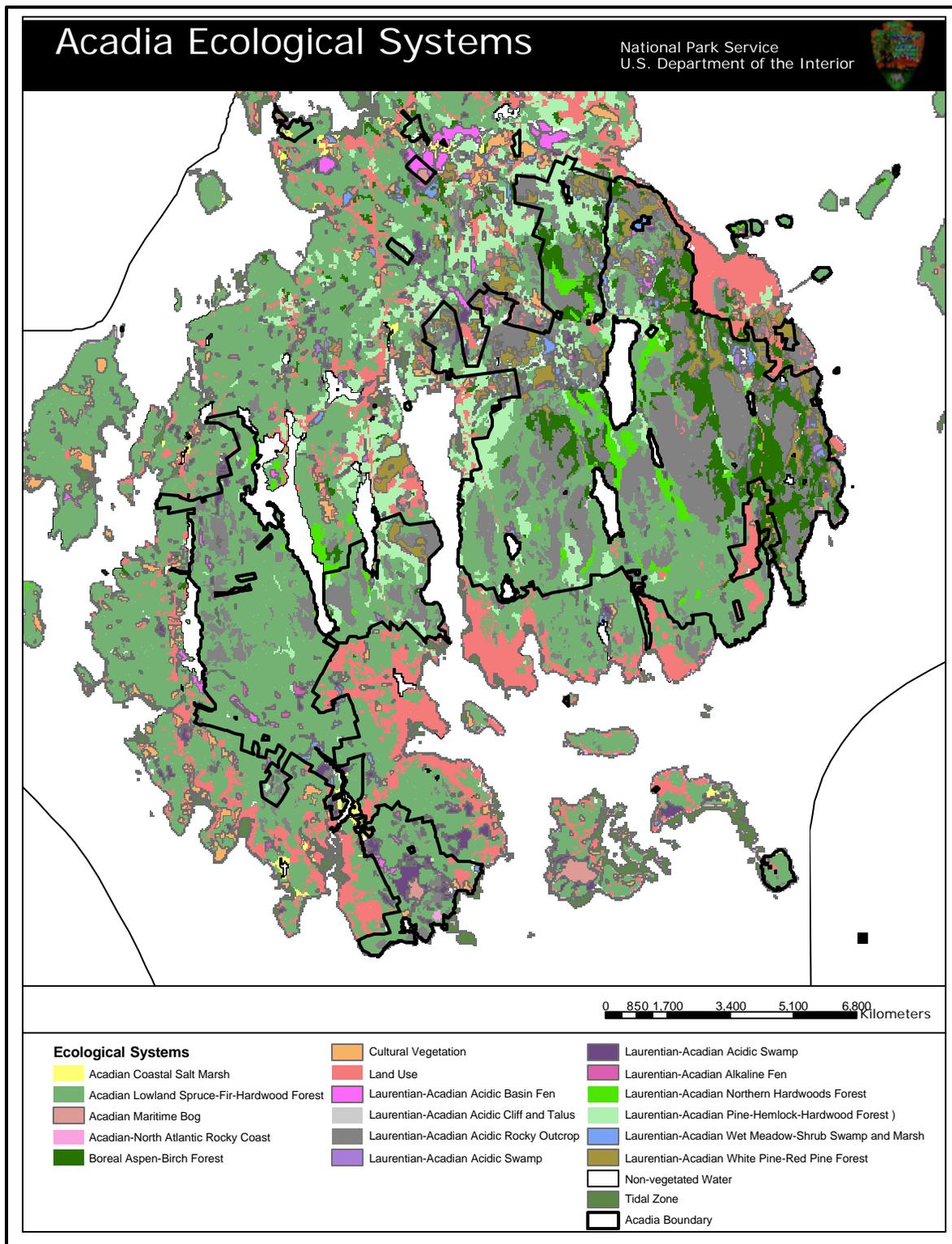


Figure 3. Ecological systems of Acadia NP (map produced by NPS Northeast Temperate Network Inventory and Monitoring Program).

Water resources associated with the park include 14 Great Ponds (those water bodies larger than 4 ha (10 acres), 9 smaller ponds, more than two dozen named streams, 10 named wetland areas, and five named springs (Figures 4, 5 and 6). The park contains 65 km (41 mi) of rocky shoreline, about 1,052 ha (2,600 acres) of lakes and ponds, and approximately 1,670 ha (4,127 acres) of wetlands. Freshwater lakes in the park span the typical range of water quality found in Maine. The larger lakes such as Eagle Lake and Jordan Pond are generally clear and oligotrophic, with circumneutral pH.

Acadia NP has an extensive and long-term ambient air quality monitoring program. The following “core” parameters are monitored: ozone, sulfur dioxide (SO₂), nitrogen oxides (NO_x), volatile organic compounds (VOC), fine particulates, visibility, meteorology, wet deposition of mercury, and wet and dry deposition of a number of anions and cations (Table 1; Figure 7). The park also has a long-term surface water monitoring program to detect chemical changes due to atmospheric deposition. In addition to the core ambient air quality monitoring program, additional parameters have been monitored on a short-term basis to collect baseline data, support research projects, or provide input for atmospheric transport models.

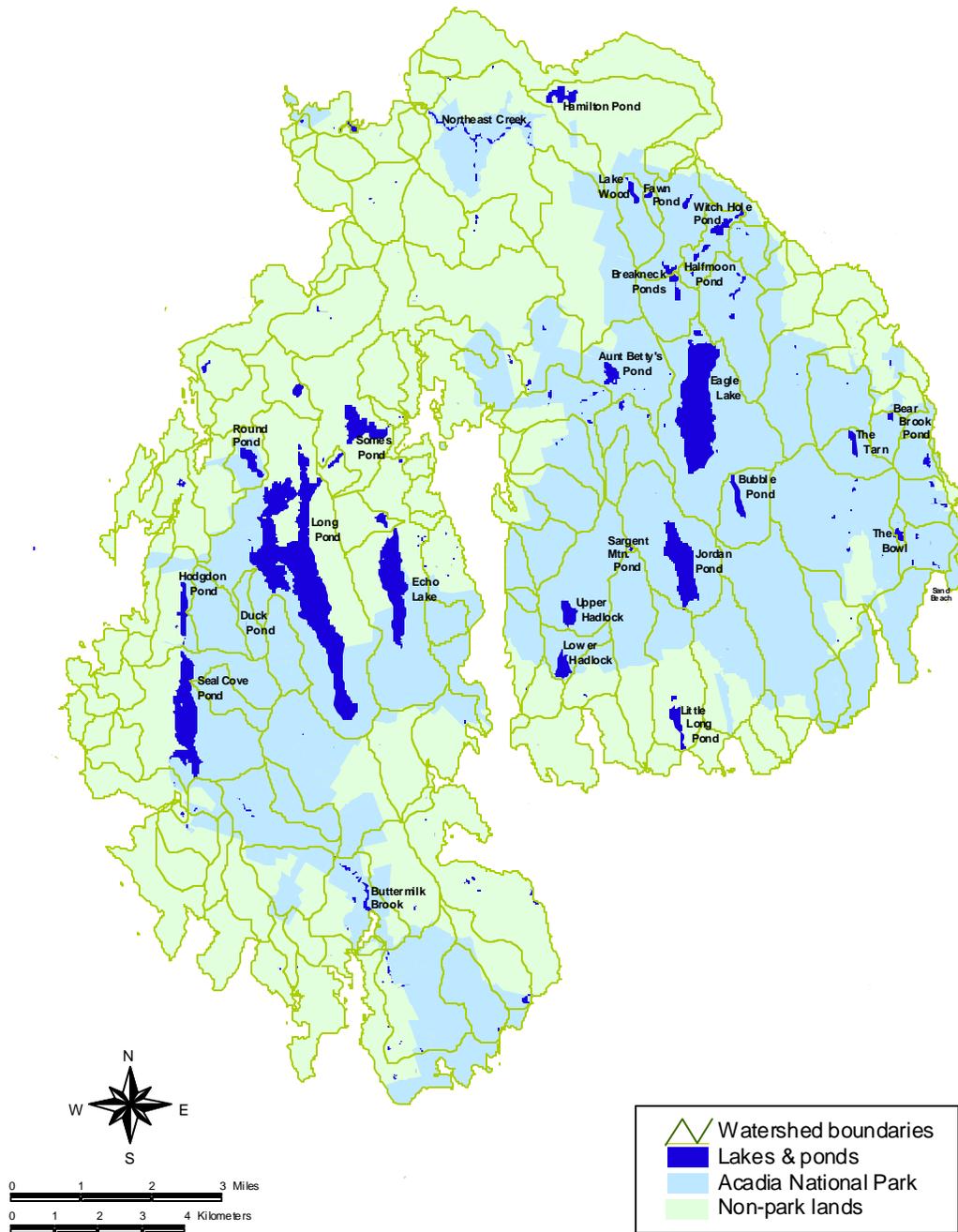


Figure 4. Named lakes and ponds, Mount Desert Island (from Kahl et al. 2000).

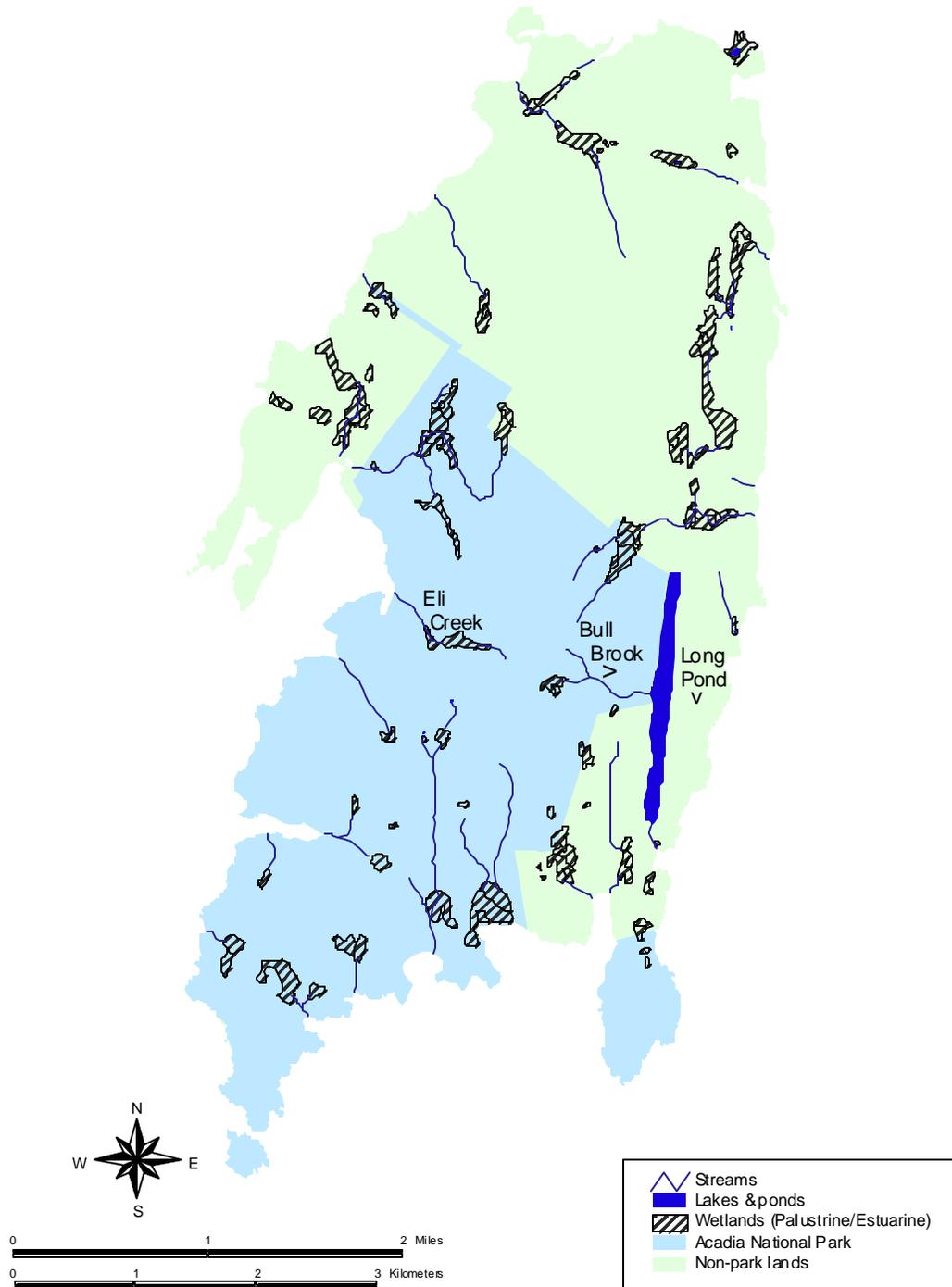


Figure 5. Water resources, Isle au Haut (from Kahl et al. 2000).

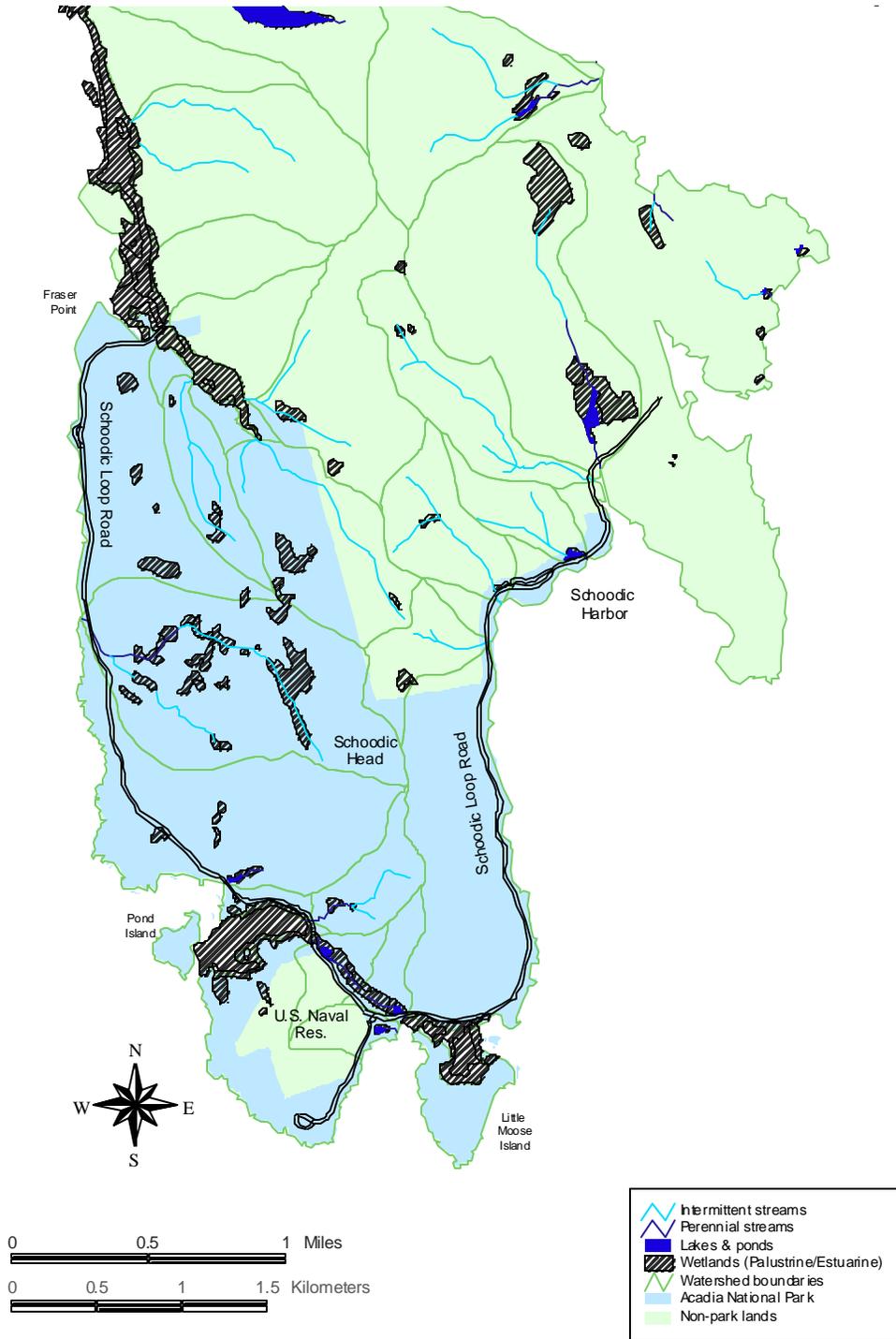


Figure 6. Water resources, Schoodic Peninsula (from Kahl et al. 2000).

Table 1. Ambient monitoring at Acadia NP.

PARAMETER	LOCATION	START DATE	END DATE
Wet deposition ¹	McFarland Hill	1981	present
Dry deposition ²	McFarland Hill	1998	present
Mercury deposition ³	McFarland Hill	1995	present
Ozone (continuous)	Cadillac Mountain	1995	present
	McFarland Hill	1982	present
	Schoodic	2003	present
Meteorology ⁴	Cadillac Mountain	1995	present
	McFarland Hill	1991	present
Sulfur dioxide (continuous)	McFarland Hill	1988	1990
Nitrogen oxides ⁵	Cadillac Mountain	91, 93, 1995-	present
Volatile organic compounds ⁵	Cadillac Mountain	91, 93, 1995-	present
Carbon monoxide	Cadillac Mountain	2002	present
UV ⁶	McFarland Hill	1998	2004
Particulate matter (Aerosol)	McFarland Hill	1988	present
Teleradiometer ⁷	McFarland Hill	1980	1986
Transmissometer ⁷	McFarland Hill	1987	1994
Nephelometer ⁷	McFarland Hill	1993	present
35 mm camera ⁷	Cadillac Mountain	1983	1995
	McFarland Hill	1980	1983
Web camera ⁸	Cadillac Mountain	1999	present
Surface water chemistry ⁹	10 park lakes	1997	present

¹National Atmospheric Deposition Program/National Trends Network

²Clean Air Status and Trends Network

³Mercury Deposition Network

⁴Includes wind speed, wind direction, temperature and relative humidity

⁵Continuous and event measurements

⁶Brewer spectrophotometer

⁷Technique used to monitor visibility impairment

⁸Used to interpret current visibility conditions

⁹Acidification and eutrophication-related parameters



Acadia National Park Air Quality Monitoring Sites

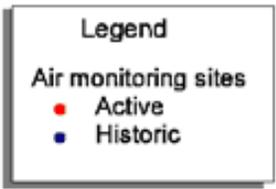
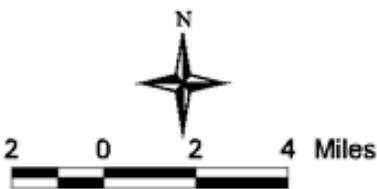
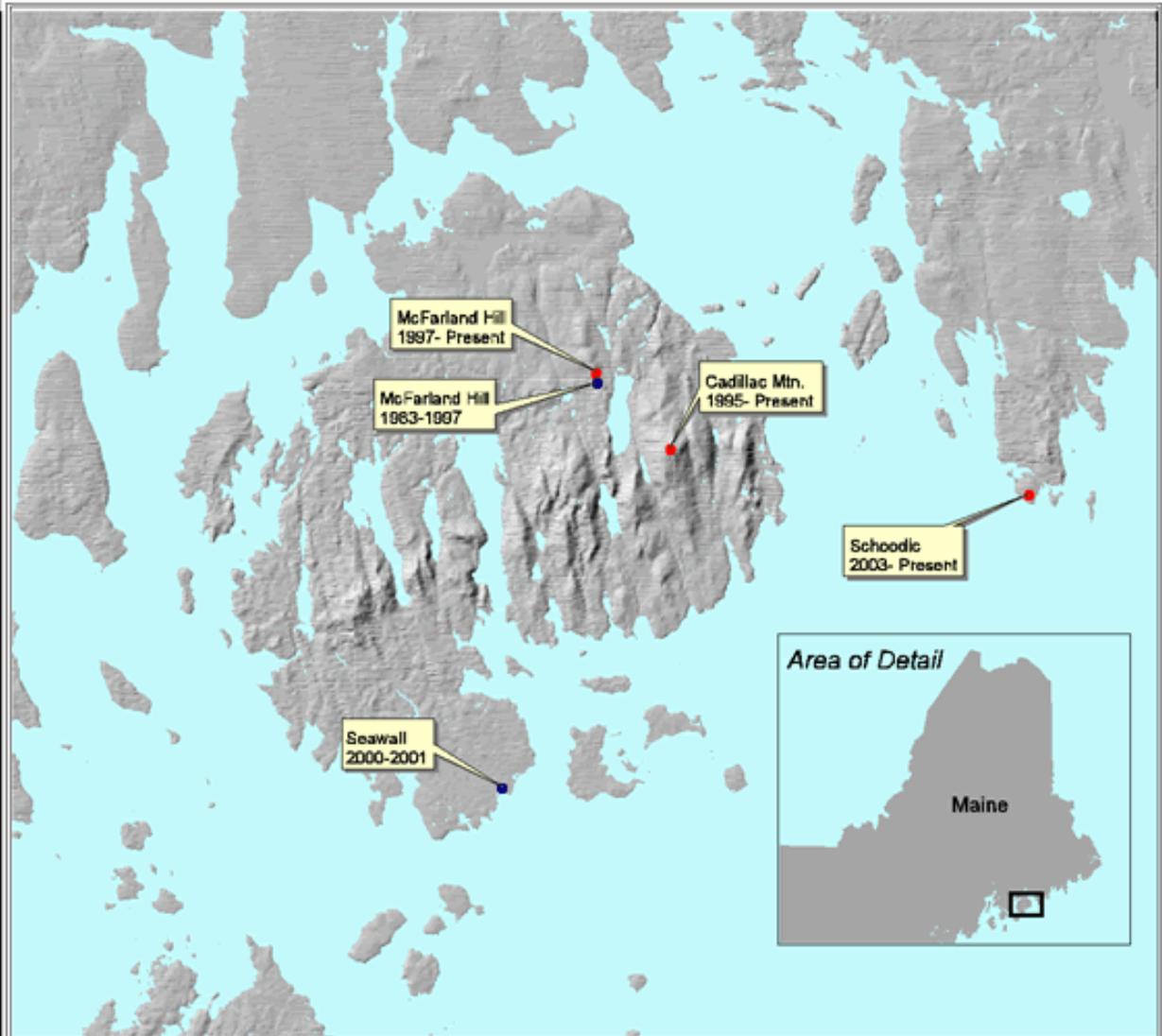


Figure 7. Location of air quality monitoring sites at Acadia NP.