Water Resources Management Plan

Acadia National Park · Maine

WATER RESOURCES MANAGEMENT PLAN

Acadia National Park

Mount Desert Island, Maine

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ACADIA NATIONAL PARK
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TABLE OF CONTENTS

LIST OF FIGURES c
LIST OF TABLES ..... d
LIST OF ACRONYMS AND ABBREVIATIONS ..... e
ACKNOWLEDGEMENTS ..... g

EXECUTIVE SUMMARY i

1.0 INTRODUCTION 1-1
- 1.1 Plan Purpose 1-1
- 1.2 Overview 1-1
- 1.3 Public Participation 1-2
  - Native American Traditional Uses 1-2
- 1.4 Legislative and Regulatory Responsibilities 1-2
  - Federal Legislation 1-3
  - State Legislation 1-4
- 1.5 Management Objectives 1-4
- 1.6 Identification of Water Resources Issues 1-5
  - Atmospheric Deposition and Climate Change 1-6
  - Recreational Use and Management of Surface Waters 1-6
  - Wetland and Estuartine Environments 1-7
  - Watershed Management 1-7
  - Protection of Public Health 1-7

2.0 THE HYDROLOGIC ENVIRONMENT 2-1
- 2.1 Description of the Area 2-1
- 2.2 Climate 2-3
  - Weather 2-3
  - Precipitation Chemistry 2-3
  - Fog Chemistry 2-4
  - Air Quality 2-4
  - Impacts of Atmospheric Deposition 2-5
- 2.3 Geology, Topography and Soils 2-6
  - Bedrock Geology 2-6
  - Topography and Glacial Geology 2-6
  - Soil Characteristics 2-7
- 2.4 Watershed Characteristics 2-7
  - Drainage Districts 2-7
  - Watersheds 2-9
  - Drainage Systems 2-9
  - Land Use 2-9
  - Vegetation and Fire History 2-9
- 2.5 Surface Water Resources 2-13
  - Streams 2-13
    - Stream Hydrology 2-13
    - Stream Chemistry 2-14
    - Biological Data for Streams 2-15
  - Natural Springs 2-15
  - Lakes and Ponds 2-17
    - Chemistry of Lakes and Ponds 2-19
    - Lake Sediment Chemistry 2-19
    - Biological Data for Lakes and Ponds 2-19
      - Mercury 2-19
      - Bacteria 2-20
- 2.6 Groundwater 2-20
  - Groundwater Chemistry 2-20
- 2.7 Wetlands 2-21
- 2.8 Marine Resources 2-24
  - Marine Hydrology and Chemistry Data 2-25
  - Biological Monitoring of Marine Resources 2-25

Marine Intertidal Areas 2-25
Estuaries 2-25
2.9 Aquatic and Riparian Resources and Habitats 2-26
Fisheries 2-26
Flora 2-28
Fauna (other than fish) 2-28
Federally Threatened or Endangered Species 2-29
2.10 Consumptive and Non-consumptive Uses of Water Resources 2-30
2.11 Legal Relationships and Responsibilities 2-31
2.12 Artificial Hydrologic Control Structures 2-31
2.13 Threats to Water Resources 2-32

3.0 ISSUES AND MANAGEMENT ALTERNATIVES 3-1
Introduction 3-1
Planning Versus Implementation Process 3-1
3.1 Atmospheric Deposition and Climate Change 3-7
Introduction 3-7
Statement of Problem 3-7
Management Objectives 3-8
Recommendations 3-9
Management Actions Considered But Not Recommended 3-11
3.2 Recreational Use and Management of Surface Waters 3-13
Introduction 3-13
Statement of Problem 3-14
Hunting and Trapping 3-14
Fisheries Management 3-14
Recreation 3-16
Management Objectives 3-17
Recommendations 3-17
Management Actions Considered But Not Recommended 3-19
3.3 Wetland and Estuarine/Marine Environments 3-21
Introduction 3-21
Statement of Problem 3-21
Management Objectives 3-23
Recommendations 3-23
Management Actions Considered But Not Recommended 3-25
3.4 Watershed Management Issues 3-26
Introduction 3-26
Statement of Problem 3-26
Park Operations and Development 3-26
Wastewater Management 3-27
Other Non-Point Sources of Pollution 3-27
Management Objectives 3-29
Recommendations 3-29
Management Actions Considered But Not Recommended 3-30
3.5 Protection of Public Health 3-32
Introduction 3-32
Statement of Problem 3-32
Park-Based Water Supplies 3-32
Municipal Water Supplies 3-34
Water Quality at Swimming Beaches 3-34
Management Objectives 3-35
Recommendations 3-35
Management Actions Considered But Not Recommended 3-36

4.0 REFERENCES 4-1

5.0 APPENDIX A. Summary of Public Comments on Draft Acadia National Park Water Resources Management Plan 5-1

LIST OF FIGURES

Figure 1. Acadia National Park 2-2

Figure 2. Watersheds and Named Streams, Mount Desert Island 2-8

Figure 3. Water Resources, Isle au Haut 2-10

Figure 4. Water Resources, Schoodic Peninsula 2-11

Figure 5. Area of 1947 Fire, Mount Desert Island 2-12

Figure 6. Springs and Dams, Mount Desert Island 2-16

Figure 7. Lakes and Ponds, Mount Desert Island 2-18

Figure 8. Wetlands, Mount Desert Island 2-22

LIST OF TABLES

Table 2A. National Atmospheric Deposition Program Precipitation Data at Acadia National Park, 1982 – 1990 2-4

Table 2B. Changes in Lake Acidity Status 1982-1995..... 2-5

Table 2C. Mount Desert Island Major Drainage System..... 2-9

Table 2D. Named Streams of Acadia National Park 2-14

Table 2E. Named Springs of Acadia National Park 2-17

Table 2F. Named Lakes and Ponds of Acadia National Park.....2-17

Table 2G. Mercury Content of Fish Sampled in Acadia National Park 2-20

Table 2H. Radon in Mount Desert Island Wells 2-21

Table 2I. Named Wetlands in Acadia National Park.....2-23

Table 2J. Wetland Systems in Acadia National Park 2-23

Table 2K. Freshwater Fish of Mount Desert Island 2-26

Table 2L. History of Fish Stocking in Mount Desert Island Lakes and Ponds 2-27

Table 2M. Recreational Uses and Restrictions for Acadia National Park Lakes and Ponds.....2-30

Table 2N. Park Ownership of Intertidal Areas.....2-31

Table 2O. Water Bodies Affected by Dams 2-32

Table 2P. Licensed Point Source Discharges Adjacent to the Park.....2-33

Table 3.0A. Overview of Issues 3-2

Table 3.3A. List of Major Wetland Values 3-22

Table 3.4A. Recent History of Wastewater Management Facilities Development in Acadia National Park 3-28

Table 3.5A. Portable Water Supply Rehabilitation and Improvement Recommendations.....3-33

LIST OF ACRONYMS AND ABBREVIATIONS

ac	Acre
ANC	Acid Neutralizing Capacity
BAT	Best Available Technology
B/C	B – Soil Horizon; C – Soil Horizon
BMP	Best Management Practices
CEC	Cation Exchange Capacity
Cfr	Code of Federal Regulations
Cfs	Cubic feet per second
Cl	Chlorine
cm	centimeter
DDT	Dichlorodiphenyltrichloroethane, an insecticide
DEP	Department of Environmental Protection
E. coli.	*Escherichia Coli*
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
FONSI	Finding of No Significant Impact
ft	feet or foot
GIS	Geographical Information System
GPA	Great Pond Act
ha	Hectare (2.47 acres)
Hg	Mercury
IaH	Isle au Haut
IF&W	Inland Fisheries and Wildlife
in	Inch
km	Kilometer
m	Meter
MDI	Mount Desert Island
MDHS	Maine Department of Human Services
MDN	Mercury Deposition Network
MDOT	Maine Department of Transportation
ME	Maine
mg	Milligrams
ml	Milliliter
mou	Memorandum of Understanding
MRSA	Maine Revised Statutes Annotated
Msl	Mean Seal Level
µg/L	Micrograms/Liter
N	Nitrogen
NADP	National Atmospheric Deposition Project
NEPA	National Environmental Priorities Act
NH	New Hampshire
NOAA	National Oceanic and Atmospheric Agency
NTN	National Trends Network
NWI	National Wetlands Inventory
O_2	Oxygen
P	Phosphorus
PCB	Polychlorinated Biphenyls
pers. comm.	Personal Communication

pH	Measurement of acidity and basicity
PL 99-420	Public Law 99-420
Rt	Route
SA	Surface Water Quality Rating A (Best)
SB	Surface Water Quality Rating B (Good)
SDWA	Safe Drinking Water Act
SO_4	Sulfate
SPO	State Planning Office
SWTR	Surface Water Treatment Rule
TMDL	Total Maximum Daily Load
ueq	Microequivalent
ug/g	Micrograms per gram (= parts per million)
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UV-B	Ultraviolet Radiation
WRMP	Water Research Management Plan
WWII	World War Two
210Pb	Lead Isotope (mass = 210 atomic mass units)

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The completion of this plan involved a host of contributions by many people in addition to the editors and authors of the plan and its chapters. The WRMP steering committee was actively involved in the process that lead to the first draft. In addition to authors, the members of the committee were: Heidi Beal and Tammis Coffin, Friends of Acadia; Don Cass, College of the Atlantic; Bill Ferdinand, State Planning Office; Dana Reed, MDI League of Towns; Chad Smith, Bar Harbor; Eileen Woodford and Bruce Craig of the National Parks and Conservation Association; Lee Worcester, Southwest Harbor.

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A WATER RESOURCES MANAGEMENT PLAN FOR ACADIA NATIONAL PARK

EXECUTIVE SUMMARY OF RECOMMENDATIONS

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David Manski	Acadia National Park
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This Water Resources Management Plan for Acadia National Park will guide water resource protection and research in the Park for the next five to ten years. The plan addresses management alternatives for the following water-related issues:

Chapter 3-1: Watershed response to acidic deposition and climate change,
Chapter 3-2: Management of recreational uses on water bodies,
Chapter 3-3: Protection of wetlands and estuarine environments,
Chapter 3-4: Watershed management for water quality protection, and
Chapter 3-5: Protection of public health.

The recommendations fall into three broad categories:

- *Research, monitoring, and inventory* of the status and trends in basic ecosystem function (including precipitation, streams, lakes, wetlands, and their watersheds);
- *Management of water resources* (including aquatic wildlife management, public health related to water supplies and beaches, and non-point source pollution); and,
- *Public education and visitor impact management* to maintain ecosystems and the visitor enjoyment of these ecosystems.

The recommended actions associated with each issue often overlap one another, especially for watershed management. Some of the recommendations include changes in management procedures, and some involve collection of samples in a non-destructive manner.

Research, Monitoring and Inventory: Because of the substantial data gaps and uncertainties in trends for water resources, this plan recommends a commitment to improved monitoring of selected lakes, wetlands, and two 'representative' stream watersheds. The factors causing the concern for aquatic ecosystem integrity include climate change, non-point source pollution, and atmospheric deposition of acidic substances and toxic chemicals. Many of the analyses required for these assessments are the same for lakes, streams, or wetlands, and the field work involves similar methods and seasonal timing. Therefore, addressing one of these issues will also provide information about another. For example, monitoring two stream watersheds (an action already initiated by the National Park Service and the University of Maine) is providing new information on changes in seasonal episodic acidification, nutrient cycling, forest health, mercury biogeochemistry, and the season patterns of water yield. Such data are essential baseline information for the interpretation of status and trends for all water resources in the Park.

There is one recommendation for *'no new action'* under Research, Monitoring and Inventory:

Recommendation 3.1.1. *Continuation of seasonal lake monitoring and the National Atmospheric Deposition Program precipitation collection site* and the associated meteorological station. The existing program provides information pertinent to the effects of, and trends in, lake acidification, eutrophication (non-point source pollution) and atmospheric deposition.

One major recommendation has already been implemented during the preparation of this plan:

Recommendation 3.1.2a. *Implementation of a gauged-watershed research study of paired streams (initial funding provided by the US Environmental Protection Agency, US Geological Survey Biological Resources Division, and the National Park Service).* The lead agencies for this project include the University of Maine Water Research Institute, Acadia National Park, and the U.S. Geological Survey. By studying watersheds located inside and outside of the 1947 burn area, this research program will:

- provide details on seasonal episodic acidification unavailable with other methods,
- determine trends in nutrient cycling and loss (with important inferences for forest health), in both older softwood and younger hardwood forests,
- define long term trends in chemistry, temperature and water yields driven by climate or forest succession,
- investigate the controlling factors on mercury export from differing watersheds, and,
- provide the framework on which to build and attract other research on aquatic resources.

The recommendations that involve *new action* include:

Recommendation 3.1.2b. *Expanding the seasonal sampling of lakes* to include spring and fall overturn of a subset of lakes. These data will provide baseline information on a) the trends in spring acidification and b) fall baseflow chemistry as an 'index' of long term trends in acid-base chemistry.

Recommendation 3.1.2c: *Monitoring of benthic invertebrates and zooplankton communities.* A pilot program of biomonitoring by the Maine Department of Environmental Protection is expected to provide the framework for a longer term effort.

Recommendation 3.1.2d. *Funding an inventory of metals and organic toxins* of atmospheric origin. Except for mercury this information is lacking at Acadia National Park. Based on bioaccumulation studies on predator birds, we know that atmospheric deposition of substances such as dioxins and PCBs is occurring in the Park. The approach would include sampling of soils and sediments to develop the history and inventory of accumulations. If high concentrations exist, then follow-up studies on aquatic bioaccumulation would be advised.

Recommendation 3.2.4. *Funding an aquatic ecosystem inventory* to assess the present condition and distribution of fish species, invertebrates and amphibians in selected

waters. This action would provide the baseline on which to formulate cooperative management of these resources as outlined under management recommendations below.

Recommendation 3.3.1a. *Designing and implementing an integrated long-term monitoring program for representative estuarine and intertidal environments*. A monitoring strategy should be based on recommendations of recently completed studies in Bass Harbor Marsh and Somes Sound, and on results from ongoing research in Northeast Creek and the intertidal sea caves.

Recommendation 3.3.1b. *Expansion of non-native species management.* Actions are needed to evaluate and mitigate threats from invasive non-native flora other than purple loosestrife, the only exotic presently under management by the Park.

Recommendation 3.3.1c. *Evaluation of hydrologically-altered wetlands.* Wetlands with dikes, ditches, or human-made structures should be evaluated to assess hydrologic effects. Sites that are significantly altered will be considered for restoration.

<u>*Management of water resources*</u>: Water resource management in the Park is complicated by multiple or uncertain jurisdictions. The Department of Inland Fisheries and Wildlife stocks native and non-native fish species, and manages forage species in lakes in the Park, with little input from the Park. Present state policy allows hunting and trapping in the 'Great Ponds' that are within the Park, regardless of Park policy or the general perception by the public that the Park is a no-hunting zone. An important aspect of National Park Service policy is to provide for visitor enjoyment, yet four lakes in the Park are public water supplies which require special protection and thus recreational restrictions.

There is one recommendation for *no new action* under management:

Recommendation 3.5.1. *Continuation of the present monitoring of water quality at swimming beaches.* Due to a lack of detected public health violations, the present periodic schedule of monitoring will be continued rather than expanding the program.

The recommendations that involve *new actions* for addressing management concerns seek to balance potential conflicts, and to cost-effectively manage resources in need of attention:

Recommendation 3.2.1. *Establishing a cooperative agreement* with the State for the management of fish and wildlife in the Park. The National Park Service believes that state, local, and federal interests can be best served by cooperation and compromise among agencies, local interest groups, and the Park, within the guidelines of National Park Service policies.

Recommendation 3.2.2. *Creation of a designated no-hunting/trapping zone* in the Park. The public perception is that Acadia National Park is already a wildlife sanctuary, and is a safe place to hike during hunting season. Legislation creating a no-hunting, no-trapping zone would make this perception a reality.

Recommendation 3.2.3. *Developing a fisheries management plan* in conjunction with the Department Inland Fisheries and Wildlife, National Park Service fisheries specialists, the University of Maine Cooperative Fish and Wildlife Research Unit, and local sports

interests. This plan would make use of the information gathered in the recommended inventory of aquatic biota and build on the cooperative agreement identified in 3.2.1.

Recommendation 3.2.5. *Protecting the natural visitor experience on Great Ponds*. The National Park Service will actively work with local communities, Friends of Acadia, and the Maine Department of Inland Fisheries and Wildlife to develop appropriate management strategies that protect the special qualities of the Great Ponds of Acadia National Park.

Recommendations 3.4.1 and 3.5.1. *Increasing multi-jurisdictional coordination for addressing watershed-related issues*. Under this recommendation, Acadia National Park would be an active partner in lake associations or forums with state agencies, towns, water utilities, and citizens to address water resources management issues. The Park would facilitate coordination among interest groups for watershed protection to protect water quality.

Public education and visitor impact management. One of the keys to successful water resource protection is educating and involving the local population and visitors to the Park. A related action is proper design of visitor facilities and access to resource areas. Trail and boardwalk design, access closure, and site maintenance can be an important part of resource protection and public education.

Recommendations to expand education and visitor programs to reduce impacts are:

Recommendation 3.1.2. *Developing educational signs, displays, and public presentations* to educate the public about ongoing research and inventory activities, and the importance of such taxpayer-funded work for resource protection and the maintenance of the visitor experience at Acadia. Educational displays are needed near instrumentation for the calibrated watershed research, and at the trailheads of these watersheds.

Recommendation 3.3.2. *Conducting a survey of wetland, estuarine, and marine habitats* near trails, roads, and parking areas. Areas with heavy impact would be evaluated for restoration, site hardening, or closure.

Recommendation 3.4.1 and 3.5.1. *Developing educational displays in heavy use areas* so that the public understands appropriate ways to minimize human impacts on the landscape and water resources.

Recommendation 3.5.1. *Enhancing public awareness of the need for source water protection* through public workshops, brochures, and school programs to increase watershed-based resource protection.

CHAPTER 1. INTRODUCTION TO THE WATER RESOURCES OF ACADIA NATIONAL PARK

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1.1 PLAN PURPOSE

This Water Resource Management Plan supports the National Park Service decision-making process for the protection, conservation, use, and management of water resources in Acadia National Park. As the only national park in the northeastern United States, Acadia protects approximately 40,000 acres of land and water resources including 41 miles of rocky headlands along the Maine coast. Water resources management is consistent with the park's overall mission to preserve and protect *"outstanding scenic, natural, scientific, and cultural values for present and future generations"* (National Park Service, 1992).

The plan is based on recommendations outlined in a water resources scoping report (National Park Service, 1991); and reflects federal laws, regulations, and National Park Service policy. The primary authority for natural resource management in national parks is the 1916 National Park Service Organic Act which charges park managers to "*conserve the scenery and the natural and historic objects and wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations".* The fundamental objectives of natural resource management in the National Park Service, as prescribed in policy, are to manage natural resources to maintain, restore and perpetuate their inherent integrity; and to allow for natural processes to evolve minimally influenced by human action.

This plan recognizes the importance of seeking coordination and consultation with local and state governments in managing water resources that cross a fragmented and complex park boundary in 2 counties and 11 towns. The plan is intended to provide information and guidance to park managers for the next 5 to 10 years. It is also anticipated that the plan will provide an important frame of reference for other land managing decision makers in the protection, preservation, use, and management of water resources of mutual concern.

In the plan, goals and objectives are identified, alternative actions are discussed and preferred actions are recommended (Chapter 3). Alternatives range from no new action to significant changes in current management policy. In developing this document, the planning team relied on literature listed in the reference section, the input of park staff and organizations with jurisdictional and functional responsibilities in or adjacent to the park, as well as significant input during three periods of public comment which included a public hearing.

1.2 OVERVIEW

Maintaining the quality of water resources is essential for ecological and human health at Acadia. Water resources provide habitat for freshwater and salt water species, and forage for two federally endangered species, the bald eagle (*Haliaeetus leucocephalus*) and peregrine falcon (*Falco peregrinus*). Six lakes within or adjacent to Acadia supply drinking water to Mount Desert Island communities, and groundwater supplies water for users within and adjacent to the park. Water resources also form an integral part of the Acadia scenery for the visitor experience.

Acadia water resources are generally considered healthy and well suited to their uses. However, Acadia is among the top ten most visited parks in the nation. Many of the park's resources, including water, are vulnerable to heavy direct usage, or inappropriate watershed land use. In addition, recreation, resource protection, and residential withdrawals often present conflicting uses. Overlapping and sometimes conflicting management responsibilities complicate management of water resources in the park. A mixed pattern of adjacent land ownership and management responsibilities complicates the park's efforts to protect water resources in a manner consistent with National Park Service policies (National Park Service, 1988). Issues such as drinking water supply, wastewater treatment, flow

control structures, swimming, boating and sight-seeing activities affect water resources through consumptive withdrawals, wastewater discharges, manipulation of water levels and the introduction of pollutants, and aquatic plants and animals.

1.3 PUBLIC PARTICIPATION

Public participation in the development of this plan was recognized as important to future public acceptance of changes in Park management (if any), and to the Park's relationship with other jurisdictions. A variety of public outreach efforts were initiated to better understand important issues and public attitudes toward various future management alternatives.

An oversight committee comprised of members from Acadia National Park, the Acadia National Park Advisory Commission, the Mount Desert Island League of Towns, a local water company, academia, environmental organizations, and state government, was formed to provide broad guidance to the planning team. Approximately 60 questionnaires were mailed to individuals and organizations to elicit opinions about water resource issues at Acadia National Park. Sixteen completed questionnaires were returned and results helped the authors in preparing a draft plan. Articles were placed in local weekly and daily newspapers to publicize the planning process and to solicit public input. Focus groups were organized to discuss drinking water supply issues, point/non-point pollution, watershed development, fisheries management, and jurisdiction. Participants included federal and state biologists and policy makers, environmental organizations, local town government officials, and members of local water companies. An informational meeting was also held at College of the Atlantic to discuss the planning options and to gather additional public input. Draft plans was made available for public review *twice* prior to final acceptance. Over 140 copies of the 1999 draft were distributed to individuals and organizations and 19 comments were received. A summary of the public comments and copies of the individual responses is included in the Appendix.

Native American traditional uses. National Park Service policies (1988) direct its managers to develop and execute its programs, to the extent consistent with each park's legislated purposes, in a manner that reflects knowledge of and respect for the cultures of Native American tribes or groups with demonstrated ancestral ties to particular resources in parks. Access to and use of natural and cultural resources in parks are to be applied in an informed and balanced manner that is consistent with park purposes, does not unreasonably interfere with Native American use of traditional areas or sacred sites, and does not result in any degradation of park resources.

There are four federally recognized Native American tribes in Maine: the Penobscot Nation, Passamaquoddy Tribe, Houlton Band of Maliseets, and the Aroostook Band of Micmacs (Maine Indian Claims Settlement Act of 1980 and Aroostook Band of Micmacs Settlement Act of 1991). Acadia National Park has been working to establish and maintain a consulting relationship with these tribal governments about ongoing park operations and new planning and development activities. It was beyond the scope of this Plan to determine and evaluate the number and variety of traditional Native American uses of the water resources of Acadia National Park. None of the research, monitoring, administrative, or planning recommendations in this Plan, however, will change the rights of Native Americans at Acadia National Park, consistent with applicable laws and National Park Service policies. The National Park Service is interested in learning more about Native American traditional uses and sacred sites at Acadia National Park and is committed to working cooperatively with tribal governments to address issues of access and uses of the park's water resources for religious and/or cultural purposes

1.4 LEGISLATIVE AND REGULATORY RESPONSIBILITIES

Water resources are an integral part of Acadia. The 1986 boundary legislation (PL 99-420) recognizes water in its statement of purpose: *"to protect and conserve the land and water resources of Acadia National Park"*. The Act explicitly provides for the purchase of easements on parcels which have significant scenic value or adjacency to water. The Acadia boundary includes park lands on Mount Desert Island, Schoodic Peninsula and offshore islands. Authorization of Acadia boundary extension to include Isle au Haut is contained in separate legislation. Federal and state laws that affect the management of Acadia water resources are described below.

Federal Legislation

National Park Service Organic Act (1916) - The Organic Act specifies that the National Park Service is responsible for the preservation and conservation of natural resources in all park lands under its jurisdiction. This act was reinforced by Congress in 1970 with legislation stating that all park lands are united by a common purpose, regardless of title or designation. Hence, all water resources in the National Park System are protected by federal law, and it is the fundamental duty of the National Park Service to protect those resources unless otherwise indicated by Congress.

Federal Water Pollution Control Act (Clean Water Act) 1972 and Amendments (1977, 1987) - This law is designed to restore and maintain the chemical, physical and biological integrity of the nation's waters. As part of the act, Congress recognizes the primary role of the states in managing and regulating the nation's water quality within the general framework developed by Congress. All federal agencies must comply with the requirements of state law for water quality management, regardless of jurisdictional status or land ownership. States are directed to implement the protection of water quality through best management practices and water quality and technology-based standards. These standards involve the designation of uses made of a water body or segment, water quality necessary to protect those uses, and an anti-degradation provision to protect existing water quality. Section 404 of the Clean Water Act requires that a permit be issued for discharge of dredged or fill materials in waters of the United States including wetlands. A triennial review of the state water quality regulatory program is conducted by each state to determine if its standards are adequate to meet federal standards; these standards are then forwarded to the EPA for approval.

Safe Drinking Water Act (1974) and Amendments (1986) - This act sets national minimum water quality standards and requires regular testing for developed public drinking water supplies. Most significantly for MDI, the act requires filtration for all uncovered public surface drinking water supplies. Waivers from filtration require evidence of adequate watershed control and protection. This requirement affects one municipal and three private water companies on MDI who draw their waters from lakes and watersheds within or adjacent to the park boundary.

Coastal Zone Management Act (1972) and Amendments (1990) - This federal act provides assistance and encouragement to coastal states in the effective protection and careful development of the coastal zone. Maine's coastal program was approved in 1978 and is administered by the Maine State Planning Office (SPO), with other regulatory functions carried out by the Department of Environmental Protection, Department of Marine Resources, and Department of Economic and Community Development. In Maine, all federal properties are excluded from the state's designated coastal zone. However, any park activity with an off-site impact on the coastal zone must be consistent with Maine's coastal zone management plans (William Ferdinand, Maine State Planning Office, 1995, pers. comm.).

Water Quality Improvement Act (1970) - This act requires federally regulated activities to have state certification that they will not violate water quality standards.

Endangered Species Act (1973) - This act provides for the conservation, protection, restoration, and propagation of selected native species that are threatened with extinction. All entities using federal funding must consult with the Secretary of the Interior (through the U.S. Fish and Wildlife Service) on activities that potentially affect federally listed flora and fauna.

National Environmental Policy Act (1969) - This law requires systematic analysis of major federal actions, including a consideration of reasonable alternatives and an analysis of short- and long-term irretrievable, irreversible, and unavoidable impacts. Specifically, NEPA requires that an environmental impact statement (EIS) be prepared as part of the review and approval process by federal agencies of major actions which significantly affect the quality of the human environment. The primary purpose of an EIS is to ensure evaluation of the impacts of proposed projects and facilitate public review. An environmental assessment may be prepared prior to initiating an EIS. This assessment is used to make a determination if the preparation of an EIS is required. An EIS is not required when the review of an environmental assessment results in the "Finding of No Significant Impact (FONSI)."

Executive Orders on Wetlands and Floodplain Management (1977) - Executive Order 11990, the "Protection of Wetlands," requires all federal agencies to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands. Unless no practical alternatives exist, federal agencies must avoid activities in wetlands that have potential for adversely affecting the integrity of the ecosystem. Executive Order 11988 entitled "Floodplain Management" requires federal agencies to implement floodplain planning and properly

mark areas where park resources fall within flood hazard areas to increase public awareness of potential flood dangers. National Park Service guidance for compliance with Executive Order 11990 (Protection of Wetlands) may be found in Floodplain 'Management and Wetland Protection Guidelines,' published in the Federal Register 45 FR 35916, Section 9 and for Executive Order 11988 (Floodplain Management) in National Park Service Floodplain Management Guideline (National Park Service, 1993).

State Legislation

Great Ponds - Great Ponds are defined in Maine Statutes as any inland body of water which in its natural state has a surface area in excess of 10 acres (4 ha) or impoundments more than 30 acres (12 ha) in size (Title 38, Chapter 3, 1973, c. 608 Article 1-A, subsection 381). Maine law currently recognizes the 1641-1647 Colonial Ordinance of the Massachusetts Bay Colony in common law. Under this ordinance, rights to fishing, fowling, and navigation of Great Ponds (codified in Maine statute) as well as of the intertidal zone of the coastline (under the so-called Public Trust doctrine), are held by the public in perpetuity.

Classification of Maine Waters - The federal Clean Water Act requires Maine to establish water quality standards for all water bodies in the state. Maine's anti-degradation policy (38 MRSA §464 4.f.2) gives the Maine Department of Environmental Protection the authority to classify waters in national and state parks as "an outstanding national resource (where) water quality must be maintained and protected". Streams within the boundaries of Acadia are currently classified as AA "outstanding natural resources", a designation which requires aquatic life to be "as naturally occurs", meaning they must have essentially the same physical, chemical and biological characteristics as found in situations with similar habitats free of measurable effects of human activity (MRSA 38, Title 4-A, §466, 1993). All Great Ponds and "natural lakes and ponds less than 10 acres in size in the State of Maine are classified GPA, a designation which bans new discharge of pollutants or the erosion of materials placed on lakeshores into the water.

While marine waters beyond low tide are outside National Park Service jurisdiction, they are an integral part of the park's setting. The State of Maine classifies marine waters directly adjacent to park owned shoreline as "SA" which requires estuarine and marine life, dissolved oxygen and bacteria levels to be as naturally occurs (MRSA 38, Article 4-A, Water Classification Program). No direct discharges of pollutants are allowed in "SA" waters. Marine waters within 500 feet of privately owned shoreline on Mount Desert Island, Isle au Haut and the Cranberry Isles are classified "SB", a classification which allows existing discharges as long as they do not impair naturally occurring habitats or exceed bacterial standards.

Land Use Regulations - Although Maine towns have home rule authority, water management policies outside the park generally stem from both local zoning and state laws such as the Maine Plumbing Code, the Natural Resources Protection Act and the Mandatory Shoreland Zoning Act. The Maine Department of Environmental Protection oversees the adoption of mandatory shoreland zoning regulations, and the Department of Economic and Community Development oversees comprehensive planning which recognizes water quality objectives.

Maine's Nonpoint Source Management Plan identifies projects for future consistency review purposes. The plan calls for projects at the park to be reviewed by the Maine State Planning Office for their effects on water quality and their consistency with the state plan (Maine Department of Environmental Protection, 1989).

The Maine Natural Resources Protection Act (MRSA §480) recognizes "resources of state significance". These include Great Ponds, outstanding river segments, coastal wetlands, fragile mountain areas and significant wildlife habitat. The Act requires permits for ground disturbing activities such as dredging, dewatering, filling or construction which could cause soil erosion, affect fisheries or change natural water flows. The National Park Service at Acadia makes every effort to comply with the Natural Resources Protection Act to protect soil and water resources and respect the state's desire to protect resources of state significance.

1.5 MANAGEMENT OBJECTIVES

National Park Service policy (National Park Service, 1988) calls for water resources to be maintained in their natural condition free from pollutants generated by human activity. The General Management Plan for Acadia (National Park Service, 1992) includes water resources in the overall management zoning scheme. Offshore islands and all wetlands are placed in the "Protected Natural Area Subzone" which seeks to perpetuate "*geological or ecological values without*

any or with minimal human intrusion". However, the plan creates special use zones which include, among other areas, municipal water supply pump stations, dams and the 14 Great Ponds within or adjacent to park boundaries. Acadia shares management responsibilities in these zones with other organizations. Based upon federal regulations, National Park Service policies and park enabling legislation and planning documents, park managers have developed the following specific water resource objectives for Acadia:

1. Maintain high water quality to protect public health and maintain ecosystem integrity.
2. Preserve and/or restore natural water flow regimes, to the degree practicable, to sustain freshwater discharge and perpetuate naturally functioning wetland and estuary systems.
3. Promote and conduct inventory, monitoring, and research necessary to understand and detect trends, and if necessary, develop mitigation strategies for addressing potential effects of acidic atmospheric deposition, point source and non-point source contamination, climate change and other influences upon park water resources.
4. Foster fisheries management activities that restore and perpetuate, to the greatest degree practicable, natural assemblages of indigenous fish species and aquatic communities.
5. Work cooperatively with the Maine Department of Inland Fisheries & Wildlife (IF&W) and local groups to provide a diversity of quality fishing experiences, including finding opportunities in which the number or size of fish caught is not the primary recreational goal.
6. Promote scientifically-based watershed management activities and visitor education, and institute appropriate visitor use regulations for all lakes that are public water supplies in order to meet federal and state safe drinking water standards.
7. Seek appropriate designations around park waters to protect wildlife from hunting and trapping to ensure visitor safety, minimize public confusion concerning permitted activities and promote outdoor recreation experiences consistent with the mission of the National Park Service.
8. Provide park visitors with high quality potable water while assuring that park operations and development do not adversely affect park water resources or water-dependent environments.
9. Cooperate with local and state planning and regulatory agencies in developing watershed-wide strategies that respect local municipal needs to provide drinking water while recognizing National Park Service obligations to prevent adverse impacts on water-dependent resources within and adjacent to the park.
10. Promote public awareness and education of local water resources, water quality protection, and water conservation as well as the potential for human impacts upon these resources.
11. Cooperate with state and town officials to regulate water-based recreation to foster visitor safety, minimize conflicts among user groups, and provide a spectrum of recreational opportunities (including uncrowded visitor experiences).

These management objectives serve as a guide for the consideration of management alternatives relating to the water resource issues identified below.

1.6 IDENTIFICATION OF WATER RESOURCES ISSUES

Concern for the protection of drinking water sources, and the ecological, aesthetic and recreational attributes of water resources on MDI have been a dominant themes for park managers, state agencies and local communities for nearly a century. Recognition of the need for a Water Resource Management Plan was identified in the Acadia National Park General Management Plan (1992). A Water Resources Management Plan Scoping Report was prepared for Acadia by the National Park Service Water Resources Division (National Park Service, 1991), which outlined plan needs and identified the following eight water resources issues of concern to park management:

1. Impacts of atmospheric deposition on sensitive lakes and ponds
2. Water quality impacts of development and "overboard" discharges
3. Jurisdictional and management issues relating to "Great Ponds"
4. Monitoring and management of fisheries resources
5. Management and protection of wetlands and riparian zones

6. Radon-222 in potable water supplies
7. Giardia and "backcountry" drinking water
8. Water resource issues related to existing and proposed park operations and development

Subsequent discussions during preparation of the plan modified and refined the key water issues selected for emphasis in this plan. The issues identified in the Scoping Report on jurisdiction and management of Great Ponds (issue 3) and fisheries management (issue 4) have been combined into Recreational Use and Management of surface Waters (Chapter 3-2). Issues on development and overboard discharges (issue 2) and park operations (issue 8) are incorporated into Watershed Management (Chapter 3-4). Radon-222 (issue 6) and "backcountry" drinking water quality (issue 7) are included in the general discussion of Protection of Public Health (Chapter 3-5). The five categories of issues selected for this plan are summarized below and discussed in detail in Section 3.

Chapter 3-1. Atmospheric Deposition and Climate Change

There is a need to better understand lake and watershed ecosystem conditions with respect to potential stress from continued atmospheric deposition of both acidic and toxic substances. Park managers need to determine to what extent atmospheric deposition is adversely impacting park water resources. This basic knowledge about the functioning of watershed scale ecosystems is necessary to anticipate the ramifications of these potential changes. The potential for biological impacts as a result of episodic acidification, deposition and bioaccumulation of toxic substances such as mercury or dioxin, is poorly understood. The need exists for additional research and monitoring.

This plan also considers the issue of climate change in conjunction with atmospheric deposition. The research and monitoring information needs for addressing both issues are similar and thus will be considered together.

Chapter 3-2. Recreational Use and Management of Surface Waters

The Great Ponds at Acadia offer particular management challenges to the National Park Service, because other agencies also have special interest and/or responsibility for their management. As compared to the National Park Service, each of these organizations has distinct authorities and sometimes conflicting management objectives for these waters. There are nine Great Ponds completely within the legislative boundary of the park and five Great Ponds partially bordering park lands.

The laws establishing Acadia as a unit of the National Park System require the National Park Service to protect and preserve the outstanding scenic, natural, scientific, and cultural values for present and future generations and to provide programs and opportunities for non-consumptive, resource-based recreation. National Park Service responsibilities for all water resources within the park focus on the protection of water quality, aquatic ecosystem integrity, public drinking water supplies and visitor experiences. At the park, the Maine Department of Inland Fisheries and Wildlife has historically taken the lead in managing fish and wildlife and regulating public use on Great Ponds. Local towns and water companies manage surface uses on six of the Great Ponds in the park that serve as public water supplies for four Mount Desert Island communities. As suppliers of drinking water, they are required to comply with the 1986 Amendments to the Safe Drinking Water Act and therefore have regulatory authority over surface water use within these water bodies.

The National Park Service desires that Great Ponds be managed in a manner compatible with the purposes for which Acadia was established. These ponds and their associated water dependent resources have special value because they are located within a unit of the national park system and most of the visiting public considers them to be an integral part of their Acadia experience.

At present, some recreational and management activities on these waters do not reflect National Park Service policies and park goals because of historic management practices. For example, recreational fishing programs administered by the Maine Department of Inland Fisheries and Wildlife include on the management and introduction of some non-native fish in park waters. National Park Service policies emphasize protection of natural assemblages of fish populations and aquatic communities. In addition, hunting and trapping occur on Great Ponds within the park, despite no authorization for these activities in any federal legislation pertaining to Acadia.

In order to meet National Park Service natural resource objectives, protect public drinking water supplies and maintain the visitor experience at Acadia, there is a desire to work collaboratively to develop appropriate and cooperative management strategies that incorporate the objectives of all the governmental entities with interests in these waters.

Chapter 3-3. Wetland and Estuarine Environments

The wetlands and intertidal areas of Acadia have been inventoried by Calhoun *et al.* (1994). Threats to wetland and intertidal ecosystems include increased visitation of increasingly popular, yet fragile, habitats such as peatlands, salt marshes, and the intertidal zone. Trampling of wetlands, particularly peatlands, can alter species composition and change local water flow patterns. Increased demands for on-site wastewater systems can lead to greater enrichment of fresh and brackish waters with nitrogen and phosphorus, which could alter wetland community structure and function. In addition, oil spill impacts can potentially impact sensitive intertidal and estuarine systems. This plan will build upon the work of Calhoun *et al.* (1994) to address issues relating to habitat protection and the impacts of non-point pollution, changes in hydrology, and visitor usage upon park wetlands. It will also address inventory and research needs necessary to gain insight into the potential impacts of oil spills, storms, and chemical releases upon the resources and ecological function of intertidal and estuarine areas.

Chapter 3-4. Watershed Management

There is a need to develop a method of identifying point and non-point pollution impacts to park resources and to determine actions to remediate, mitigate or eliminate the impacts. Point and nonpoint pollution sources can affect the chemical, biological and physical aspects of water quality. Identifying specific water quality problems and linking them to specific sources requires careful investigation and an assessment of all potential sources. Potential nonpoint sources (such as eroding trails, roads, and the atmosphere) exist within all watersheds located in the park. Management of nonpoint sources is the responsibility of local, state and federal organizations, including Acadia.

Chapter 3-5. Protection of Public Health

There is a need to protect the health of visitors, staff and area residents from potential health related problems stemming from park operations. Issues relevant to water resources include exposure to water-borne diseases and compliance with state and federal regulations. Acadia monitors selected surface waters for parameters related to human health and cooperates with public water suppliers to protect the watersheds of drinking water sources. Wells which serve park visitors and staff are also monitored and wastewater treatment systems are maintained to ensure proper sanitary conditions.

CHAPTER 2. THE HYDROLOGIC ENVIRONMENT OF ACADIA NATIONAL PARK

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2.1 DESCRIPTION OF THE AREA

Acadia National Park occupies the highest rocky headlands on the Atlantic coast of the United States. The park encompasses approximately 16,500 ha (40,777 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 park's holdings are noncontiguous and are juxtaposed with private lands throughout (privately held parcels within the legislated boundary are not shown on Figure 1 due to the scale), complicating resource protection and management.

Mount Desert Island has been a magnet for scientists and naturalists for over a century due to its pronounced glacial features, interesting bedrock geology and diversity of plant and animal life. Acadia is positioned within the broad transition zone between southern deciduous and northern coniferous forests and hosts several species and plant communities at the edge of their ranges. Uplands at Acadia are composed of resistant granite, with older stratified rocks underlying lower elevations (Gilman and Chapman, 1988). Soils are acidic and thin (or absent) on granite slopes and may overlie several meters of till or glaciomarine sediments on valley floors. 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 (Kahl *et al.*, 1985). Spruce-fir forests are common in the park, with red spruce (*Picea rubens*) predominant. A history of major fires has strongly influenced the vegetation. Fast-growing hardwoods are presently abundant in areas burned by the 1947 fire (Patterson *et al.*, 1983).

The hydrology of the park is influenced by the steep slopes, thin soils and maritime climate. Acadia's watersheds are small, short and steep, averaging less than 5 km (3 mi) from headwaters to the sea. Average annual precipitation of 140 cm (55 in) 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. November has the most rainfall (Kahl *et al.*, 1991; Perrin, 1994), which increases lake levels and stream discharge in late fall.

Water resources associated with the park include 14 Great Ponds (those water bodies larger than 4 hectares (10 acres)), and 9 smaller ponds. There are more than two dozen streams named on U.S.G.S. topographic maps and 10 named wetland areas. The park contains 41 miles of rocky shoreline, about 1,052 ha (2,600 acres) of lakes and ponds, and approximately 1,670 ha (4,127 acres) of wetlands.

The largest part of Acadia is found on Mount Desert Island, with the park's most dramatic topography and impressive scenery. The coastal mountain range of Mount Desert rises to a height of 464 m (1,530 ft). Almost half of Mount Desert Island is part of the park, totaling approximately 12,000 ha (30,000 acres). Mount Desert Island is accessed by a bridge from the mainland and has a well-developed system of roadways. Mount Desert Island is the chief destination for most park visitors and has been the subject of most of the most scientific research.

Isle au Haut (IaH) 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, totaling approximately 1,200 ha (3,000 acres). The island rises to 163 m (535 ft), with portions of its coast sharing the bold relief found at Mount Desert Island. Due to its location, Isle au Haut is subject to a more pronounced maritime climate than Mount Desert Island. Its forests more visibly display the damaging effects of airborne pollutants traveling from urban and industrialized regions outside the state (Jagels *et al.*, 1987; see section 3.1).

Schoodic Peninsula is located 8 km (5 mi) east of Mount Desert Island on the eastern shore of Frenchman Bay. The park owns 800 ha (2,000 acres) at the southern tip of the peninsula where elevations rise to 134 m (440 ft). 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.

Figure 1: Acadia National Park

2.2 CLIMATE

Weather. Acadia is located in a coastal region with a cool moist climate where fog is common. Thornwaite (1958) classifies Maine coastal temperatures as "warm microthermal" and the humidity as "perhumid". The former is one classification stage warmer than temperatures of taiga regions, while the latter is remarkable in that perhumid climates in the U.S. are limited to the coast of Maine, the coast of the Pacific Northwest, and high elevations of selected mountain regions. 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.

Daily weather records for Mount Desert Island exist for over a century. Data available from NOAA and the National Weather Service include temperature (maximum, minimum and average daily), precipitation (duration and amounts), snowfall, snowpack conditions, state of the weather (cloud, rain, fog, etc.), and observations of wind direction and speed. The NOAA weather observation station has been located at park headquarters on McFarland Hill since 1981. National Atmospheric Deposition Program (NADP) data for precipitation amounts and precipitation chemistry have also been collected at McFarland Hill since 1981. Earlier National Weather Service stations were located at the park visitor center in Hulls Cove (from 1968 to 1981) and in Bar Harbor (from 1893 to 1968). The potential for local variation in climate between the Bar Harbor, Hulls Cove, and McFarland Hill sites should be considered when comparing meteorological data between different time periods.

Seasonal variation in weather patterns affects the intensity and duration of rainfall. 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. Variations in temperatures, precipitation, and spring thaw dates were documented for five spruce-fir forest stands on Mount Desert Island (Davis, 1961). Precipitation and evaporation rates were measured for different forest associations, also on Mount Desert Island (Moore and Taylor, 1927). Heath *et al.* (1993) compared precipitation chemistry and volume between the Hadlock Pond watershed and the NADP (National Atmospheric Deposition Program) station at McFarland Hill, demonstrating that even over short distances, there are gradients in chemistry and differences in volume related to topography and proximity to the ocean.

Other historical weather data collection locations relevant to Acadia are listed by Greene *et al.* (1992), including the summit of Cadillac Mountain (operated by the US Air Force during WW II), Seal Cove Pond, Coast Guard lighthouse stations and Bowditch Mountain on Isle au Haut. Greene *et al.* (1992) recommended that permanent weather stations be established at Cadillac Mountain, western Mount Desert Island, Schoodic Peninsula, and at Baker Island to assist with long term monitoring of Acadia's natural resources. Remote area weather stations located on Isle au Haut and Schoodic have periodically been out of operation due to funding problems, but are currently operational as part of the park's fire program.

National Atmospheric Deposition Program data for a recent eight year period (1982-1989) indicate an average annual precipitation of 140 cm (55 in) measured at Acadia (Heath *et al.*, 1992). An analysis of NOAA and National Weather Service data for Acadia over a longer 41 year period (1940-80) revealed that precipitation averaged approximately 123 cm (48.4 in) annually, while temperatures over this period ranged from -9 C (16 F) in winter to 41 C (106 F) in summer with a mean annual temperature of approximately 8C (46 F) (Patterson *et al.*, 1983). Precipitation totals are variable from year to year, ranging from 185.3 cm (72.9 in) in 1983 to 98.8 cm (38.9 in) in 1965 (Perrin, 1994).

Precipitation Chemistry. Excellent data exist since the end of 1981 for wet precipitation chemistry (National Atmospheric Deposition Program, 1982-1994; Kahl *et al.*, 1991; 1993a). Data are also collected on ozone, particulates, and sulfur dioxide gas. The data collection site across Rt. 233 from Park Headquarters on McFarland Hill. Precipitation chemistry data (Table 2A) are collected using standard and well-accepted field and laboratory methods as part of the National Atmospheric Deposition Program (NADP/NTN, 1981-99). There is an additional National Atmospheric Deposition Program compatible site with two collectors operated at Lead Mountain by the University of Maine Water Research Institute, 48 km (30 mi) north of Mount Desert Island. Mercury wet deposition monitoring was initiated in 1995 as part of the Mercury Deposition Network (MDN).

Table 2A. NADP Precipitation data at Acadia National Park, 1982-1990 (from Kahl *et al.*, 1993a).

	Mean (μeq/l)	Mean (mg/l)	Trend (μeq/l) (units per year)
depth (cm)	138.0		-2.46
pH	4.55		-0.002
Ca (eq/l)	4.0	0.080	-0.12*
Mg (eq/l)	9.0	0.109	-0.22
K (eq/l)	1.0	0.023	-0.06*
Na (eq/l)	33.9	1.324	-0.46
NH_4 (eq/l)	5.5	0.100	-0.27
Cl (eq/l)	41.2	1.471	-1.45
NO_3 (eq/l)	12.6	0.782	-0.23
SO_4 (eq/l)	31.9	1.534	-0.56

* indicates significance at p less than 0.05.

The pH of precipitation at Acadia has averaged 4.6 since measurement began, with a typical intra-annual range of 4.0 to 5.4 (NADP/NTN annual data summaries, 1982-1999). This pH is considered to be three to four times more acidic than pre-industrial precipitation chemistry in eastern North American (Charlson and Rodhe, 1982). An evaluation of trends in National Atmospheric Deposition Program data by Kahl *et al.* (1993a) indicates that although no prolonged droughts or major changes in chemistry occurred at the park in the 1980s, precipitation at Acadia became slightly more acidic between 1981 and 1989. This trend was confirmed for the period 1981-1993 by National Atmospheric Deposition Program (Lynch *et al.*, 1995). Precipitation pH has increased slightly (less acidic) in the period immediately following the implementation Phase I emission controls of the Clean Air Amendments of 1990 (Lynch et al., 2000).

Analysis of National Atmospheric Deposition Program data illustrates that the chemistry of Acadia precipitation has distinct seasonal differences. Sodium, Mg, and Cl concentrations are low during the summer when precipitation is often derived from localized convective storms. The concentrations are high during fall and winter when coastal frontal systems rich in marine aerosols generate much of the precipitation (Heath *et al.*, 1992).

Summaries of National Atmospheric Deposition Program data are also compiled by the Maine Department of Environmental Protection (DEP) in annual reports on air quality (e.g. Emery, 1983-1994). Graphical and numerical summaries of the 1981-1984 data have been compiled by Cowan (1985) and Hepburn (1985). Summaries of the 1979-1981 data were compiled by Potter (1982).

Fog chemistry. Fog is very acidic in the vicinity of Acadia in coastal Maine. Fog pH values are frequently below 3.5 and have been recorded as low as 2.9 at Isle au Haut (Jagels, 1986b). Fog chemistry data collected at the park since 1985 by University of Maine researchers has been summarized by Kimball *et al.* (1988) and Jagels *et al.* (1987).

Comparative studies by Weathers *et al.* (1986, 1988a,b) analyzed cloud water and found that Bar Harbor had the highest concentrations of sulfate and nitrate and the lowest pH of the 10 non-urban field sites in New England. The field pH of fog water in Bar Harbor averaged 3.8 in 1984 and 1985. One third of the samples had a pH of less than 3.5.

Air quality. Ozone levels at the park are among the highest in Maine. Prevailing southwesterly winds move polluted summer- time air up the eastern seaboard from industrialized regions and across the Gulf of Maine to central coastal Maine. The topography of Isle au Haut and Mount Desert Island intercepts these air masses, depositing pollutants in both wet and dry form. The levels of ozone and input of acids and related atmospheric pollutants to

natural ecosystems at Acadia may be among the highest of the non-urban National Parks. Historical inferences from lake sediment and peat bog cores indicate that polluted precipitation has been falling on Acadia for at least 150 years (Norton and Kahl, 1986; Kahl *et al.*, 1985).

Impacts of Atmospheric Deposition. Several studies on atmospheric deposition and its impact on the surface waters and flora and fauna have been performed at Acadia. The following conclusions are based on data through 1995:

- Major lakes and ponds at Acadia are circumneutral, but have very low alkalinity. The pH trend appears to be stable based on the data available (Kahl, 1999; Kahl, 1995; Kahl *et al.* 1993; Table 2B). Many lakes on Mount Desert Island are clear and have minimal influence from the organic acidity expected to be present in Acadia wetlands (Kahl *et al.*, 1985, 1989). Duck Pond in the Long Pond watershed is acidic (pH 5), and is associated with wetland drainage. Sargent Mountain Pond is acidic (pH 4.7), apparently due largely to acidic precipitation. Deposition of marine salts upon park soils leads to occasional episodic acidifications of Acadia's headwater streams (Kahl *et al.*, 1985; Heath *et al.*, 1992; 1993).
- Acid fog and ozone levels are contributing to the decline of red spruce at low elevations on the Maine coast; this phenomenon is particularly pronounced for Isle au Haut forests (Jagels, 1986a). Research by Jagels (1986b) determined that the threshold for plant injury from acidic mist occurs at pH levels between 3.0-3.5.
- A listing has been developed of Acadia vegetation sensitive to ozone. Big broad-leaved aster (*Aster macrophyllus*) and spreading dogbane (*Apocynum androsaemifolium*) are plants that have been recommended for use as ozone bioindicators at Acadia by Eckert *et al.* (1995).
- There is no known research documenting either the impacts of atmospheric deposition on Acadia's pH sensitive organisms such as amphibians and invertebrates (see Section 2.9.1), or the long term effects on ecosystems.

Table 2B. Changes in Lake Acidity Status 1982-1995. Reproduced from Kahl *et al.*, 1993a; none of these changes were judged to be significant due to the small numbers of samples. Acid Neutralizing Capacity (ANC) is listed instead of pH, because pH values are strongly influenced by factors such as dissolved CO_2 concentrations in the water. ANC is more stable than pH, and not influenced by complicating short-term factors.

Lake Name	1995 ANC*(μeq/l)	ANC Change since 1982 (μeq/l)	1995 SO_4 (μeq/l)	SO_4 Change since 1982 (μeq/l)
Aunt Betty Pond	132	16	23	-27
Bear Brook Pond	176	20	28	-20
Breakneck Pond	107	27	46	2
Bubble Pond	52.3	-6	74	-17
Duck Pond	-8.3	6	57	-20
Eagle Lake	46.6	6	72	-11
Echo Lake	86.6	12	89	-4
Halfmoon Pond	73.1	3	32	-4
Hodgdon Pond	66.2	8	60	-19
Jordan Pond	63.2	12	80	-16
Lake Wood	80.3	6	43	-12
Little Long Pond	228	97	397	62
Long Pd North	50.6	13	82	-11
Lond Pd South	50.8	17	86	-8
Lower Hadlock	47.7	14	76	-17
Round Pond	39.1	10	60	-11
Sargent Mtn Pond	-19.6	9	65	-30
Seal Cove Pond	61.7	10	75	-13
The Bowl	33.8	2	58	-17
The Tarn	91.4	-4	71	-17
Upper Hadlock	56.6	16	73	-25
Witch Hole	55.7	8	35	-14

2.3 GEOLOGY, TOPOGRAPHY, AND SOILS

Bedrock Geology. The geology of the Mount Desert Island region has been extensively studied since the late 1800s. The larger geologic units were first mapped by Crosby (1891), Davis (1881), Shaler (1889), Frazer (1906), Bascom (1919), and Raisz (1929). Several early geologic maps were prepared (Shaler, 1889; Keith, 1933; Perkins, 1933). Chapman (1970) and Gilman and Chapman (1988) updated the work of the early geologists.

Granite underlies most of Acadia, including much of Mount Desert Island, Isle au Haut and all of the park on Schoodic Peninsula (Gilman and Chapman, 1988; Chapman, 1970). This resistant bedrock makes up the high elevations and steep valleys that give the park its rugged character. Granites at Acadia vary slightly in texture, color, percentages of accessory minerals and chemical composition (Carl *et al.*, 1984), and a number of sub-types have been described and mapped (Gilman *et al.*, 1988). The granite underlying most of Mount Desert Island is a pink coarse-grained hornblende granite that contains minor biotite (the Cadillac Mountain Granite), while the other granites, including those at Schoodic and Isle au Haut are mostly fine-grained biotite granites (Gilman and Chapman, 1988).

Gabbro-diorite bedrock borders the granites on Mount Desert Island and Isle au Haut. A variety of older stratified rocks make up the margins of these islands. On Mount Desert Island, these include a schist, a siltstone/sandstone formation, and a volcanic series of tuff, felsite and interbedded volcanic and sedimentary rocks. In addition, a shatter zone exists at the contact between Mount Desert Island coarse-grained granite and the older stratified rocks of the Bar Harbor Formation (Gilman, *et al.*, 1988). On Isle au Haut, most of the park shoreline is composed of volcanic rocks.

Chemically-resistant granites and rapid runoff result in surface waters with low alkalinity and low nutrient concentrations. Marine aerosols (Na and Cl) are the dominant ions in most surface waters and contribute more than half of the conductivity of Acadia waters. The mean conductivity of Acadia lakes is 44 µS/cm. Without contributions from Na and Cl, the typical lake conductance would be in the range of 15 to 20 µS/cm, compared to the mean value for all Maine lakes of 36 µS/cm. Upland streams that drain granitic terrain are typically even more dilute than lakes, whereas the valley streams have higher alkalinity and higher ionic strength from weathering and ion exchange reactions in thicker glacial and glaciomarine deposits.

Topography and Glacial Geology. The topography of Acadia consists of a series of barren ridges separated by glacially deepened U-shaped valleys. Mountains within the park rise to heights of 464 m (1,530 ft). The ridges and valleys trend north-south, as modified by glacial scouring. Many park landforms have a distinctly asymmetric profile, displaying gentle slopes to the north and northwest and steeper slopes to the south and southeast. This landform is the textbook example of the *roches moutonnees* geomorphology that results from glacial action on resistant bedrock (Flint, 1971).

The U-shaped valleys at Acadia are probably pre-existing drainages, which were considerably deepened and modified by Wisconsinan glacial ice that is inferred to have been up to one km thick over Mount Desert Island 14,000 to 30,000 years ago. Some lakes within the valleys were formed during deglaciation as glacial materials were deposited at the ends of the valleys, creating natural dams (Gilman *et al.*, 1988). Acadia's glacial legacy is most evident in the dramatic topography surrounding its lake-filled valleys.

The centermost valley on Mount Desert Island is connected to the sea. This deep valley, known as Somes Sound, represents the only fjord-like feature on the Atlantic Coast of the United States. The unique features of Somes Sound include its extreme depth (50 m/150 ft.), a shallow sill at its entrance (10 m/30 ft deep), and a hanging valley waterfall on the west shore (Man o' War Brook).

Lowell and Borns (1988) mapped the surficial geology of Mount Desert Island. Deposits of till and glacio-marine sediments (the Presumpscot Formation) are discontinuous and limited to low-lying areas of the park of less than 25 m (90 ft) in present elevation (Kahl *et al.*, 1985). These deposits tend to be found in locations that were protected from the energy of the open ocean during the period of rising sea level immediately following deglaciation. The presence of Presumpscot formation in Maine watersheds has recently been shown to increase the trophic status of lakes in Maine (Nieratko *et al.*, 1992). In the park, this formation generally occurs in valley stream watersheds, and less commonly in lake watersheds, due to the higher elevations in lake watersheds.

Extensive areas of bare rock or areas with only a thin veneer of surficial glacial/soil material occur on all of Acadia's upland areas and ridges, and along much of the shoreline. The absence of soil over significant portions of the park landscape is an important characteristic of the hydrologic environment, leading to poor infiltration of rainwater, rapid surface runoff, stream flows that rise and fall quickly in response to precipitation, and low alkalinity and nutrient concentrations in surface waters.

Soil Characteristics. Soils are an important component of the hydrologic environment. Soils store and govern the transport of water, as well as contribute cations, anions, dissolved organic carbon and other constituents to ground and surface waters through decomposition and weathering processes. The USDA Natural Resource Conservation Service (formerly Soil Conservation Service) has recently mapped Acadia soils. The predominant soil classification is a shallow-to-bedrock, stony Schoodic-rock outcrop-Lyman complex, derived from granite and schist tills. This classification includes extensive areas of exposed bedrock, along with areas where soils exist as thin deposits of gravelly sandy loam less than 15 cm (6 in) deep (Schoodic soils) and areas where soils form a black and reddish sandy loam less than 50 cm (20 in) deep (Lyman soils). This soil complex is described as excessively well drained, with slopes that range from 0 to 100 percent for bare rock, and from 0 to 80 percent in areas with soil. On steep slopes these soils are usually droughty. Lyman and Schoodic soils are Spodosols -- acidic forest soils characterized by an accumulation of Fe, Al, and organic matter in the B horizon.

Soils in valleys at Acadia are typically part of the Hermon-Monadnock-Dixfield complex. These are mainly sandy loams derived from granite and schist tills. They range from excessively to moderately well drained with regolith depths less than 5 m (15 ft) and slopes up to 60 percent. Below elevations of approximately 25 m (90 ft), these soils are commonly underlain by, or developed from, glaciomarine silts and clays of the Presumpscot formation.

Organic soils, known as Lithic Borofolists, are common on bedrock where mineral soil is absent. Depending on orientation and slope, Lithic Borofolists may range from poorly to excessively drained. The drainage characteristics influence vegetation types and surface water chemistry. Organic soils are also associated with wetlands. A range of poorly to well (fibric to sapric) decomposed peats are present, with fibric peats found in raised bogs such as Big Heath near Southwest Harbor. Sapric peats are associated with forest, shrub fen and emergent shrub/fen communities (Calhoun *et al.*, 1994).

The Lyman soils are traditionally considered low productivity soils even for forestry land use (Rourke *et al.*, 1978). These soils are stony, excessively drained, and have a low cation exchange capacity (CEC). In these droughty soils, the contact time for equilibrium between soils and solutions is often insufficient for significant base cation release from weathering reactions. As a result, the nutrient ions and CEC are derived mainly from organic matter overlying mineral soils or bedrock and the organic carbon reserves in the mineral soil horizons.

Properties of park soils that are of greatest significance to the hydrologic environment include: 1) their shallow depth which reduces infiltration and increases surface runoff in watersheds following storm events, 2) their poorly buffered, acidic nature, and 3) the steep slopes which further hasten runoff. Precipitation percolating through the shallow mineral or organic soils in the steeper upland watersheds becomes enriched in weak organic acids which may contribute acidity (hydrogen ions) to solutions. Aluminum, potentially toxic to terrestrial and aquatic organisms, may be mobilized from soils, rocks, and stream sediments in this acidic environment. When thicker mineral soils are present, acidic soil solutions in the upper soil profile are neutralized as they react with the constituents of the B and C horizons of mineral soils. As a result of these processes, the ephemeral upland streams have the lowest pH and exhibit greater episodic acidifications than perennial streams in the valleys (Kahl *et al.*, 1985). Lake alkalinity tends to be intermediate between the upland brooks and valley streams.

2.4 WATERSHED CHARACTERISTICS

In this document the term "watershed" refers to the land area directing precipitation, groundwater, seepage, and runoff down slope to a hydrologically common location in a basin (a wetland, a stream outlet, or outlet to a pond). Perrin (1996) delineated general watersheds of MDI (Figure 2).

Drainage Districts. Runoff drains to the ocean from the land area of Mount Desert Island by a total of 65 stream channels. The island can be divided into three broad drainage districts: an east district draining into Frenchman Bay

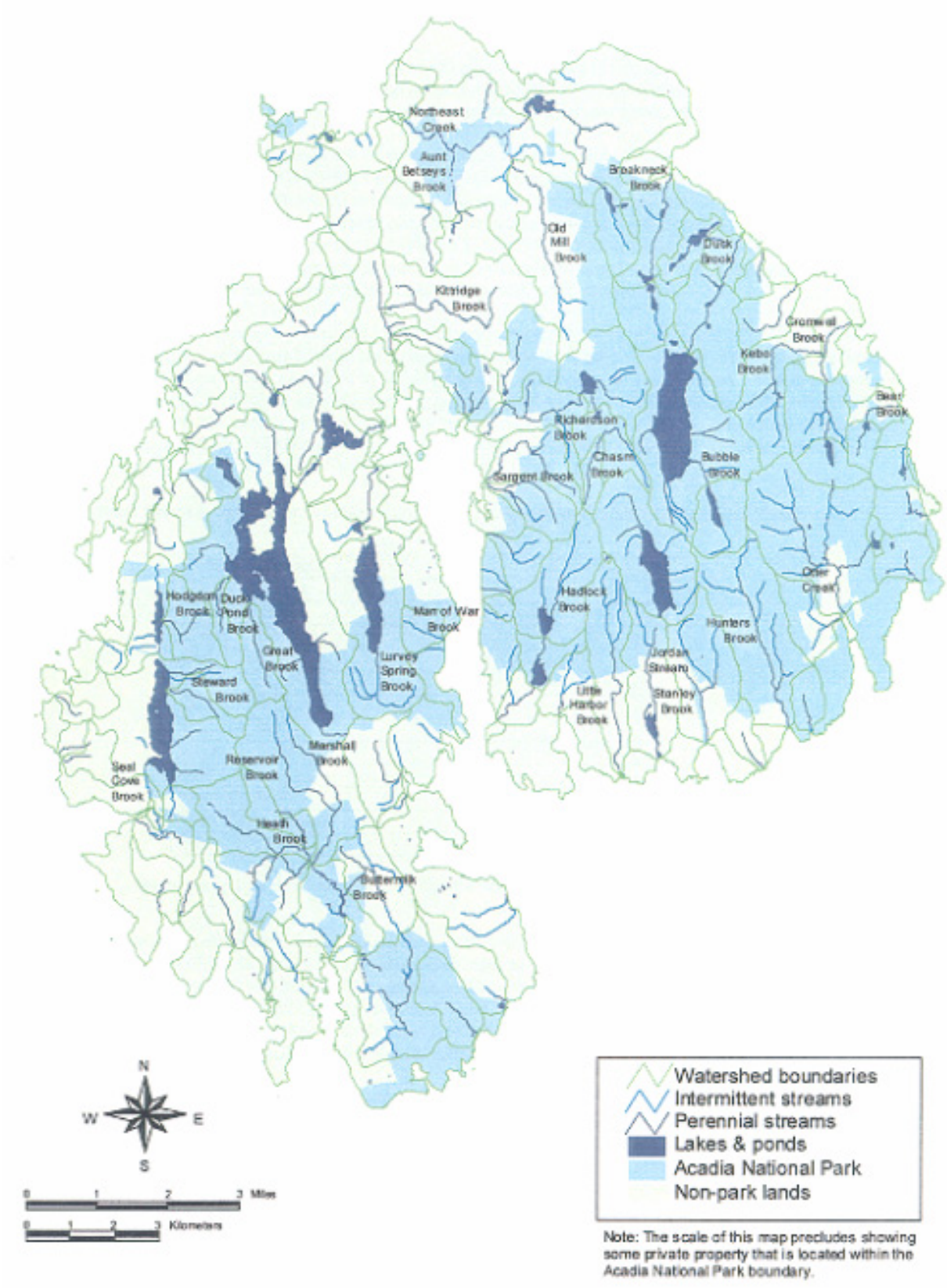

Figure 2: Watersheds and Named Streams, Mount Desert Island

(more or less) by 23 stream channels and 24 non-channelized areas; a west district draining into Blue Hill Bay (more or less) by 27 stream channels and 28 non-channelized areas; and a central district draining into Somes Sound by 14 stream channels and 15 non-channelized areas. Most of these stream channels are small, ephemeral and unnamed.

Watersheds. Some outlets to the ocean drain the valley of a single stream (such as Breakneck Brook, Bear Brook, Hunters Brook, Stanley Brook, and Little Harbor Brook on the east, Sargent Brook and Man o' War Brook on Somes Sound, and Webster Brook and Prays Brook on the west). A number of the park's small coastal watersheds contain features of geological or ecological interest, including the barrier beach-lagoon at Sand Beach, the Somes Sound fjord, and the peatland at Big Heath. The Isle au Haut (Figure 3) and Schoodic (Figure 4) portions of the park have few streams and lack defined sub-basins, except for small sub-basins located near Long Pond on the west shore of Isle au Haut. Park watersheds are small, which is an advantage for watershed protection.

Drainage Systems. There are 12 major watershed systems that drain the interior of MDI (Table 2C). The alignment of these watershed systems roughly parallels the north-south orientation of Acadia ridges and valleys resulting from glacial action. These drainages are characterized by bold topographic relief of up to 450 m across a distance of only 6-8 km (4-5 mi). Northeast Creek drains an extensive low-lying wetland and Bass Harbor Marsh on the southwest side of MDI drains another. The largest of these watershed systems cover close to 2,700 ha (1,080 acres) comprising up to nine stream sub-watersheds. The major watershed systems (named for their outlets) are listed in Table 2C.

Table 2C. Mount Desert Island Major Drainage Systems (clockwise from the head of the island (Perrin 1996).

DRAINAGE SYSTEM	**AREA (ha.)**
Northeast Creek	2693
Duck Brook	1498
Cromwell Brook	732
Otter Creek	793
(Little) Long Pond	782
Babson Creek	759
Hadlock Brook	569
Richardson Brook	972
Mill Pond	2101
Denning Brook	856
Bass Harbor Marsh	1518-2177*
Seal Cove Pond	1254

- Boundaries for Bass Harbor Marsh drainage imprecise due to absence of topographical relief.

Land Use. Most watersheds of the park lie at least partially outside the park boundary (Figure 2). For example, the park holds lands within 74 of the 94 Mount Desert Island GIS-mapped stream sub-basins, but holds exclusive ownership of lands within only 30 sub-basins. The park owns the upland (upstream) portions of most watershed systems, with the exception of Northeast Creek, Long Pond, Echo Lake, and Seal Cove Pond, and portions of Bass Harbor Marsh. Since much of the shoreline of these three Great Ponds lies outside the park boundary the responsibility for maintaining water quality is shared with the state and local communities.

An extensive system of motor roads, hiking trails and carriage roads permit visitor access throughout the park. Most park lakes and ponds are accessible by road or carriage road. Figures on the number of homes, roads and trails within each Mount Desert Island watershed were compiled by Dubuc *et al.* (1988) to evaluate the effect of human land use and recreation activities on otter (*Lutra canadensis*) distributions.

Vegetation and Fire History. Fire has been a major historical influence on vegetation throughout Acadia. Research by Patterson *et al.* (1983) on fire occurrence indicates that large fires have occurred at 100-150 year intervals for the past several thousand years. The 1947 Bar Harbor fire was the last major fire, which burned approximately one third of Mount Desert Island (Figure 5). The 1947 fire is providing the natural experimental design for the pair-

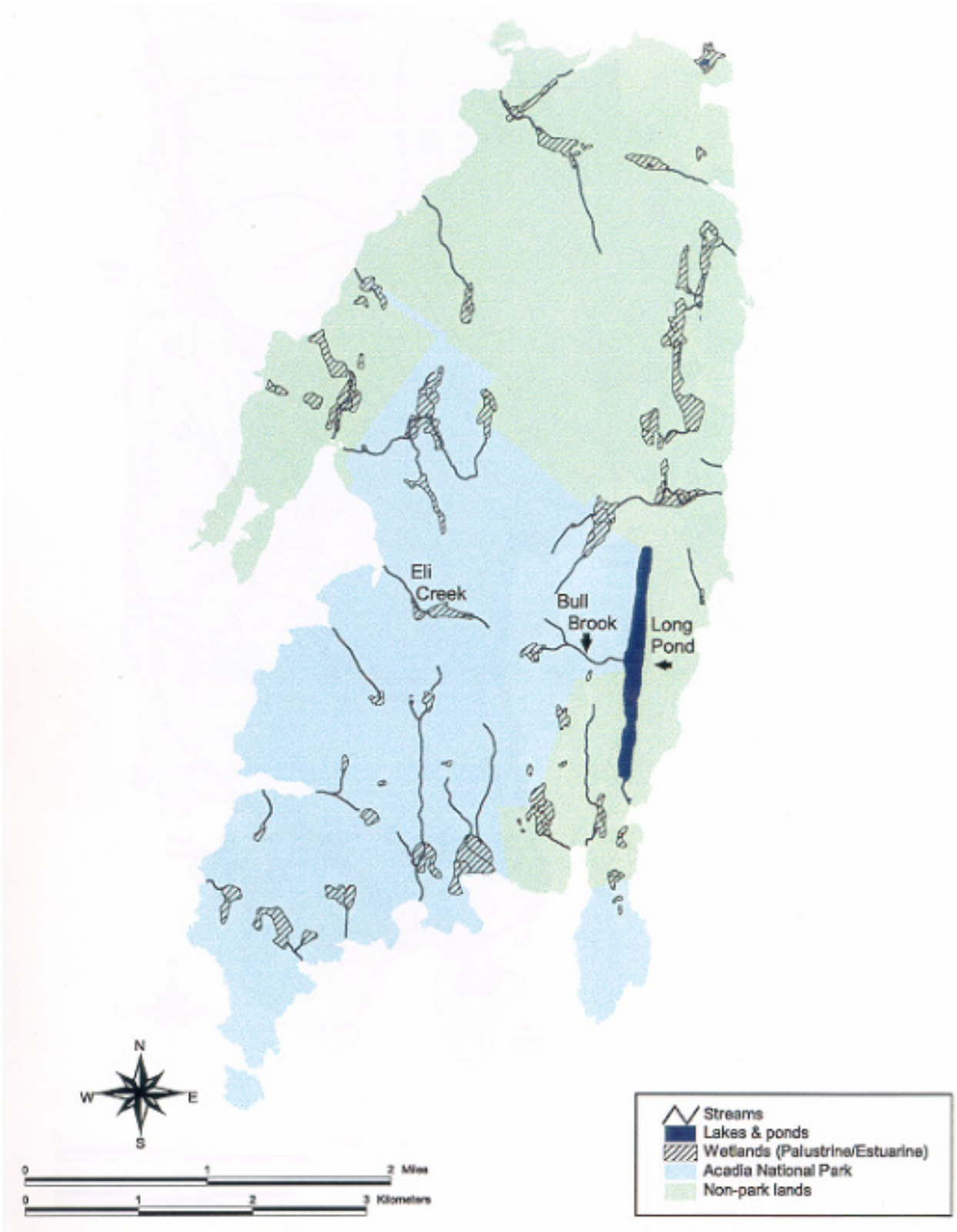

Figure 3: Water Resources, Isle au Haut

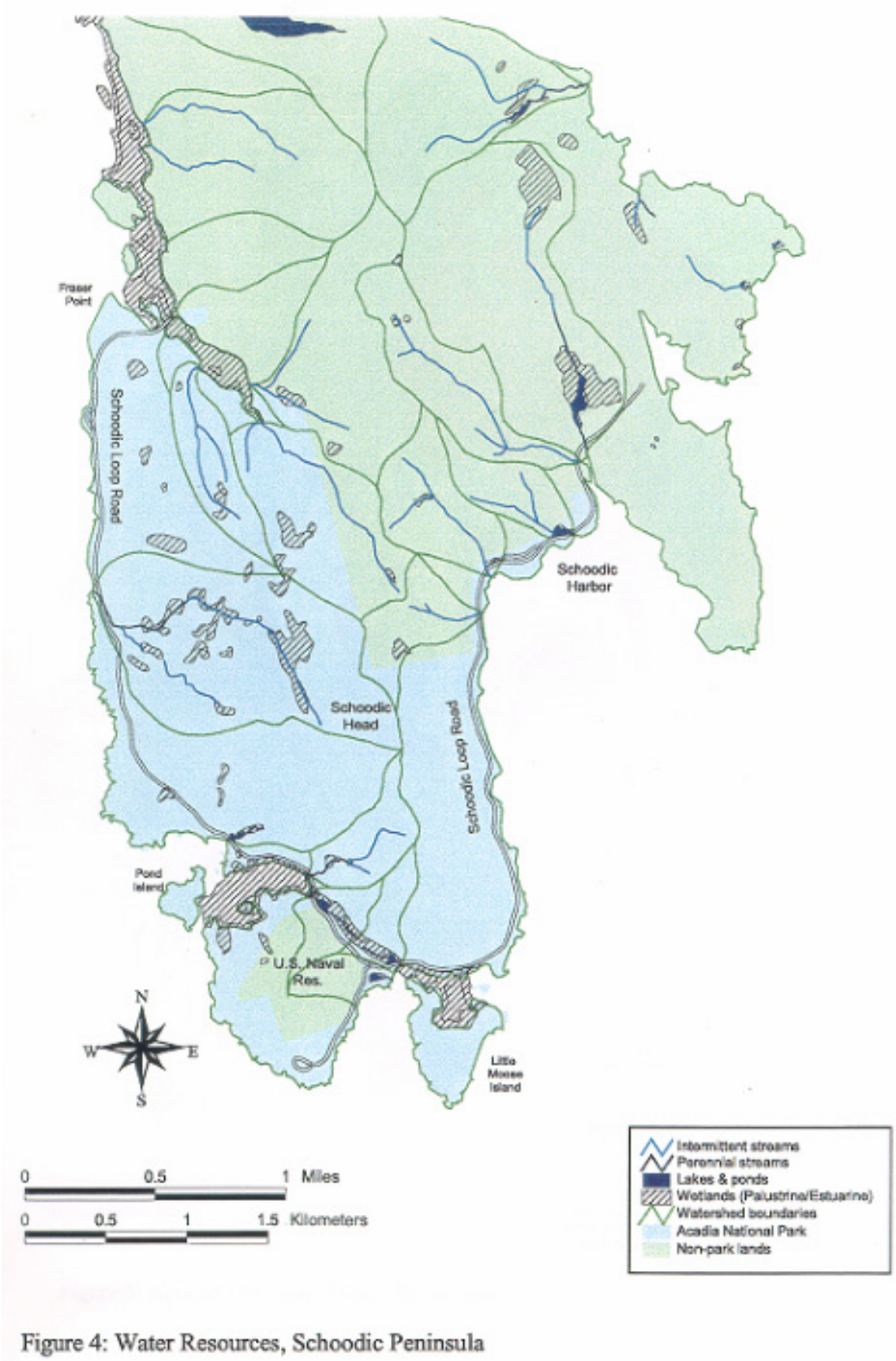

Figure 4: Water Resources, Schoodic Peninsula

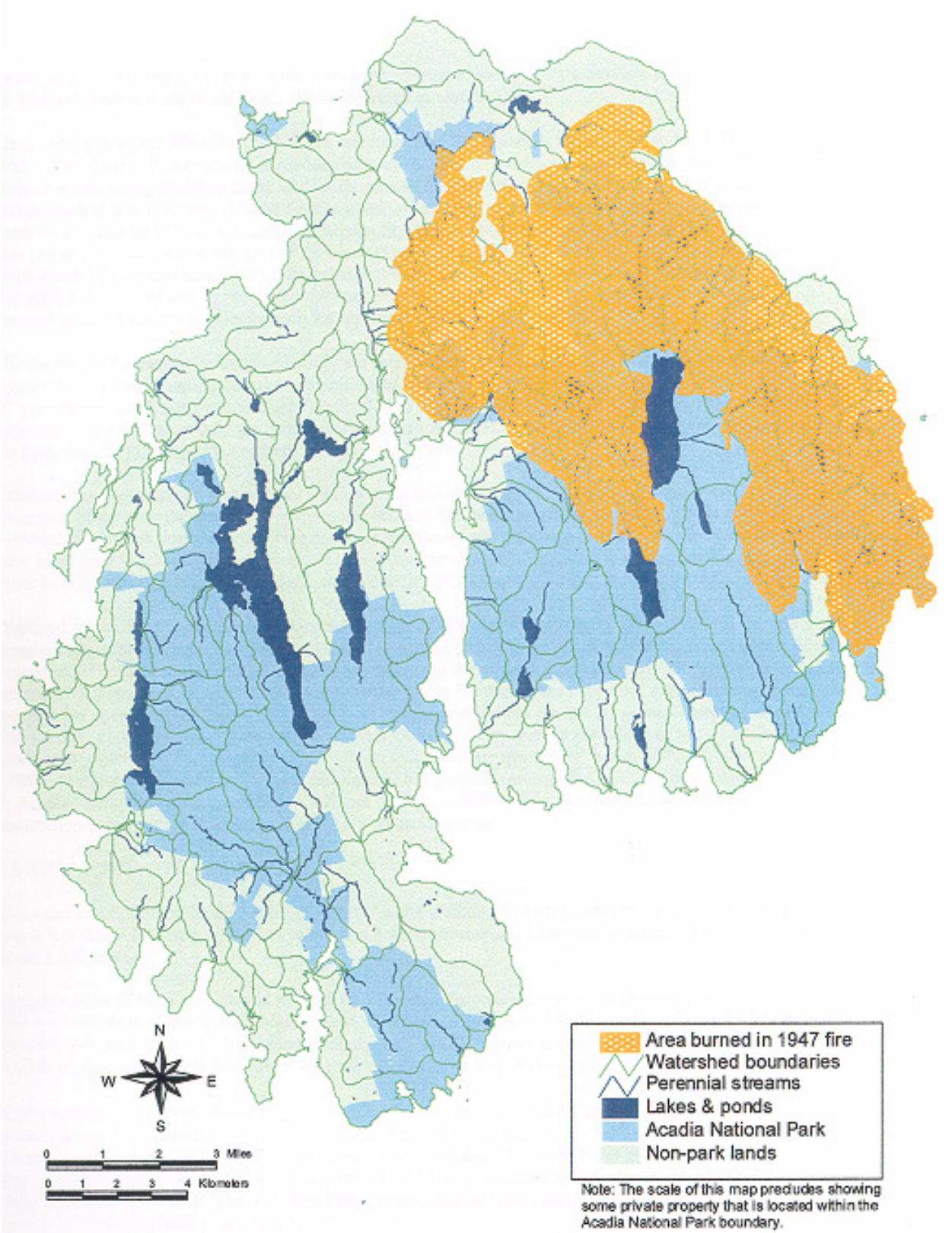

Figure 5: Area of 1947 Fire, Mount Desert Island

watershed research begun in 1998 by the University of Maine, National Park Service, U.S. Geological Survey, and the USDA Forest Service (Kahl *et al.*, 1998; described in section 3.1).

Areas unburned by the 1947 Bar Harbor fire are dominated by spruce-fir forests (Davis, 1961; Patterson *et al.*, 1983). 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 (*P. strobus*) present. Sheltered mesic (moist) sites in Acadia 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 (Patterson *et al.*, 1983).

The fire of 1947 extensively destroyed softwood forests stands on eastern Mount Desert Island allowing regeneration of hardwood, birch-aspen communities with quaking aspen (*Populus tremuloides*), bigtooth aspen (*P. grandidentata*), paper birch and gray birch (*Betula populifolia*) (Patterson *et al.*, 1983). The change in vegetation induced beaver (*Castor canadensis*) populations to flourish. Their dams, many now abandoned, affect the hydrology of the burned watersheds (Dubuc *et al.*, 1988).

Extensive areas of exposed bedrock and shallow soils at Acadia support vegetation communities that are characterized as xeric (adapted to dry environments) and nutrient poor (Patterson *et al.*, 1983) and which display evidence of repeated, intense fires. Tree canopies are patchy and are dominated by jack pine (*Pinus banksiana*), red pine, pitch pine (*Pinus rigida*) or red spruce. Extensive heath shrub understories are usually present, dominated by black huckleberry (*Gaylussacia baccata*), low blueberry (*Vaccinium spp.*) and sheep laurel (*Kalmia angustifolia*).

Digitized maps of park vegetation have been developed from aerial photography flown in 1997. Several plant communities in the park such as jack pine forest, scrub oak stands (*Quercus ilicifolia*) and some plants of island communities are at the edge of their range or are unique to the region. Approximately 20 species are listed as endangered, threatened, or of special concern by the Maine Natural Areas Program. An additional dozen species on the state list once found in the park have not been documented within the last 20 years. Twenty-one of the extant and possibly extirpated species are associated with wetlands. Two aquatic plants found in Acadia are extremely rare. Alga pondweed (*Potamogeton confervoides*) is a candidate species for federal listing (National Park Service, 1995). The prototype quillwort (*Isoetes prototypus*) is a globally rare species, with the only known U.S. occurrence in Acadia. Many other plant species, though not on state or federal lists, are believed to be locally rare, unusual or uncommon in the park. Of those, at least 54 are wetland species.

2.5 SURFACE WATER RESOURCES

The water resources bordered or entirely within Acadia include 14 Great Ponds greater than 4 hectares (10 acres), 9 ponds less than 4 hectares, more than two dozen named streams and 10 named wetlands. Lakes and ponds cover about 1,052 hectares.

Streams. Most of the MDI's 41 named streams flow through the park at some point (Figure 2; Table 2D). Because the park occupies most of the island's high ground, many of these streams originate within the park. Acadia streams are typically less than 3-5 km (2-3 mi) long (Dubuc *et al.*, 1988). Stream and surface runoff increases rapidly following rainfall or snowmelt events because of the park's steep slopes and shallow soils.

Stream Hydrology. Stream discharge records on Mount Desert Island are sparse and mainly consist of one-time measurements and estimates. These data exist for Canon Brook (Kahl *et al.*, 1985), Somes Sound tributaries (Doering and Roman, 1994; Ketchum and Cass, 1986), Marshall Brook (Soukup *et al.*, 1984) and other tributaries of Bass Harbor Marsh (Doering, *et al.*, 1994), and for 35 Mount Desert Island streams measured once during an otter study (Dubuc *et al.*, 1988). The only data from gauged streams were obtained during a study of the Hadlock Brook system in 1988-89 (Heath *et al.*, 1992).

Otter Creek and Northeast Creek have the highest reported discharge, with mean summer flows of approximately 36,000 liters per minute (equivalent to 1,300 cubic feet per second) and 30,000 liters per minute (1,100 cfs)

Table 2D. Named Streams of Acadia National Park (Source: U.S. Geological Survey topographic maps)

Location	Inside Park Boundary	Partly Outside Park
MDI	Bubble Pond Brook	Aunt Betsy's Brook
	Hunters Brook	Northeast Creek
	Chasm Brook	Old Mill Brook
	Man of War Brook	Breakneck Brook
	Duck Pond Brook	Duck Brook
	Great Brook	Cromwell Brook
	Lurvey Spring Brook	Kebo Brook
	Heath Brook	Bear Brook
	Lurvey Brook	Canon Brook
	Hodgdon Brook	Otter Creek
	Seal Cove Brook	Stanley Brook
	Steward Brook	Jordan Stream
		Little Harbor Brook
		Hadlock Stream
		Richardson Brook
		Sargent Brook
		Kitteredge Brook
		Buttermilk Brook
		Marshall Brook
		Reservoir Brook
IaH	Eli Creek	Bull Brook

respectively. Dubuc *et al.* (1988) measured additional physical and habitat variables of streams on Mount Desert Island, including depth, width and bank heights. Mean stream widths for second order streams were reported to be 2-6 m (6-20 ft) with mean stream depths are 12-24 cm (5-10 in), except for small coastal watersheds at Bear Brook and Sand Beach where mean stream depths are approximately 7-9 cm (3-3.5 in).

Stream Chemistry. Kahl *et al.* (1985) provided the most comprehensive survey of stream chemistry at Acadia. Data were collected for 23 streams for two years, ranging from perennial valley streams such as Canon and Stanley Brooks to ephemeral tributaries and unnamed inlets of Eagle Lake. Major ion chemistry and selected trace metals were determined. The samples were collected over all seasons and a variety of discharge to reflect the annual range of chemical conditions.

Heath *et al.* (1992) studied three tributaries to Hadlock Pond by gauging two streams with V-notch weirs and one stream with a Parshall flume, and collecting streamwater with automated samplers. More than 250 samples were collected from each stream over a period of 19 months. This work documented the range and frequency of chemical excursions and concluded that the causes of episodic acidification included human-induced factors from atmospheric deposition (dilute sulfuric and nitric acids) and two natural factors: organic acids, and an ion exchange salt-effect. Even without long-term, chronic acidification, the short-term episodic acidification of streams documented by Kahl *et al.* (1985) and Heath *et al.* (1992) could affect fish populations and other aquatic species, depending on the timing of the events relative to life stages of aquatic organisms.

In the 1980s, water quality tests were done annually on Marshall Brook to assess the impacts of leachate from the Worcester Landfill (Greene *et al.*, 1992). The first water quality analysis by Hansen (1980) identified the presence of un-ionized ammonia, insufficient levels of dissolved oxygen for protection of aquatic life, along with elevated nitrogen, alkalinity and hardness levels in comparison with a control area upstream of the landfill. National Park Service researchers conducted a three year evaluation of Marshall Brook (1981-84) and found elevated levels of constituents tested by Hansen, along with elevated temperature, pH, specific conductance, iron, nitrate, nitrite,

chloride and sodium (Soukup and Mitchell, 1981; Soukup *et al.*, 1984). The surface waters of Marshall Brook continued to be monitored annually through 1989 (Gerber *et al.*, 1989). In addition, a water quality and habitat evaluation study of Bass Harbor Marsh (including Marshall Brook) was conducted from 1990 through 1992 (Doering *et al.*, 1994).

Stanley Brook was the subject of an investigation by National Park Service and DEP in the mid-1990s. Many residences and businesses border Route 3 in the Stanley Brook watershed, including a sewage treatment plant and property upon which a commercial garage was formerly operated. Much solid waste has been dumped near the stream. Park staff have observed an orange precipitate and oily sheen in soil and seeps near Stanley Brook. Analysis of water samples by Northeast Laboratory (Waterville, ME) in 1992 did not suggest a specific problem. Analysis of soil samples for hazardous chemicals in 1994 by Goff-Chem Inc. revealed the presence of hazardous substances, primarily PAHs (polycyclic aromatic hydrocarbons, persistent environmental contaminants that tend to be associated with fuel oil or used motor oil spills). Results were reported to the Department of Environmental Protection who determined that a buried fuel oil tank at the sewage treatment plant was leaking. The tank was removed in 1995 and monitoring was discontinued in 1996.

In addition to the studies mentioned, stream chemistry data have been collected for Bear Brook (Fletcher, 1985), Somes Sound tributaries (Doering and Roman, 1994; Ketchum and Cass, 1986), and Bass Harbor Marsh tributaries (Doering *et al.*, 1994). Van Sickle *et al.* (1964) tested for heavy metals in stream sediments at Acadia, although their locations were not clearly specified. Future management and research recommendations for these issues are included in Section 3.1 and 3.3.

Biological Data for Streams. Biological inventory and monitoring data are limited for Acadia streams and do not meet minimum National Park Service Level I requirements for inventories of freshwater fish. Fish inventories and research on Brook trout are underway by John Moring, University of Maine. Mack (1988) and Mack and Gibbs (1989) surveyed Marshall Brook, Canon Brook, Duck Brook , Stanley Brook and Northeast Creek for mayflies (*Ephemeroptera*). Myers (1931) surveyed rotifera in Northeast Creek and Duck Brook.

Biological monitoring can provide valuable insights into water quality and aquatic ecosystem health. Typically, benthic macroinvertebrates are evaluated with respect to standing crop, community structure, and community metabolism and condition (Greene *et al.*, 1992). DEP is building a database for biological monitoring of streams in the state. The department has established standard sampling procedures for Maine's waters (Davies, 1987; Davies et al 1993). DEP began work in 1997 in selected streams.

In contrast to park ponds and lakes where some fish stocking and fish data are available, there are few fish data available for park streams (Greene *et al.*, 1992). Anecdotal evidence suggests that park streams were '*teeming with trout*' earlier in this century (Dennis Smith, Trout Unlimited and long time Mount Desert Island resident, pers. comm). This condition of the fishery is not considered to exist today.

The only known biological monitoring for Acadia in relation to stream water quality was done by Boyle *et al.* (1987) to research impacts of the Worcester Landfill leachate on macroinvertebrates, diatoms and fish in Marshall Brook and by Doering *et al.* (1994) for tributaries of Bass Harbor Marsh. According to Doering *et al.* (1994) the Bass Harbor Marsh estuary appeared to support fairly typical New England marsh-estuarine fish and benthic communities, although there were indications that the estuary was becoming more eutrophic. These investigators observed high nutrient loading from Marshall Brook that were coupled with zones of high macro-algal biomass (Doering *et al.*, 199).

Natural Springs. Sieur de Monts spring is an important part of the history of Acadia. It was considered significant by George Dorr, the park's founder, and was the original focal point for the national monument that eventually became Acadia. No known research has been conducted specifically in relation to the hydrology and chemistry of park springs and seeps. U.S.G.S. topographic maps include the presence of other named springs within the park such as Maple, Fern and Birch Springs on Sargent Mountain and Lurvey Spring south of Echo Lake (Figure 6; Table 2E). Historical records indicate the presence of a Red Rock Spring on Kebo Mountain where spring waters were commercially bottled and sold before the park was established (Gladys O'Neil, Bar Harbor Historical Society, pers. comm.). Area residents are known to visit the open portion of Sieur de Monts spring to obtain untreated surface water for household use.

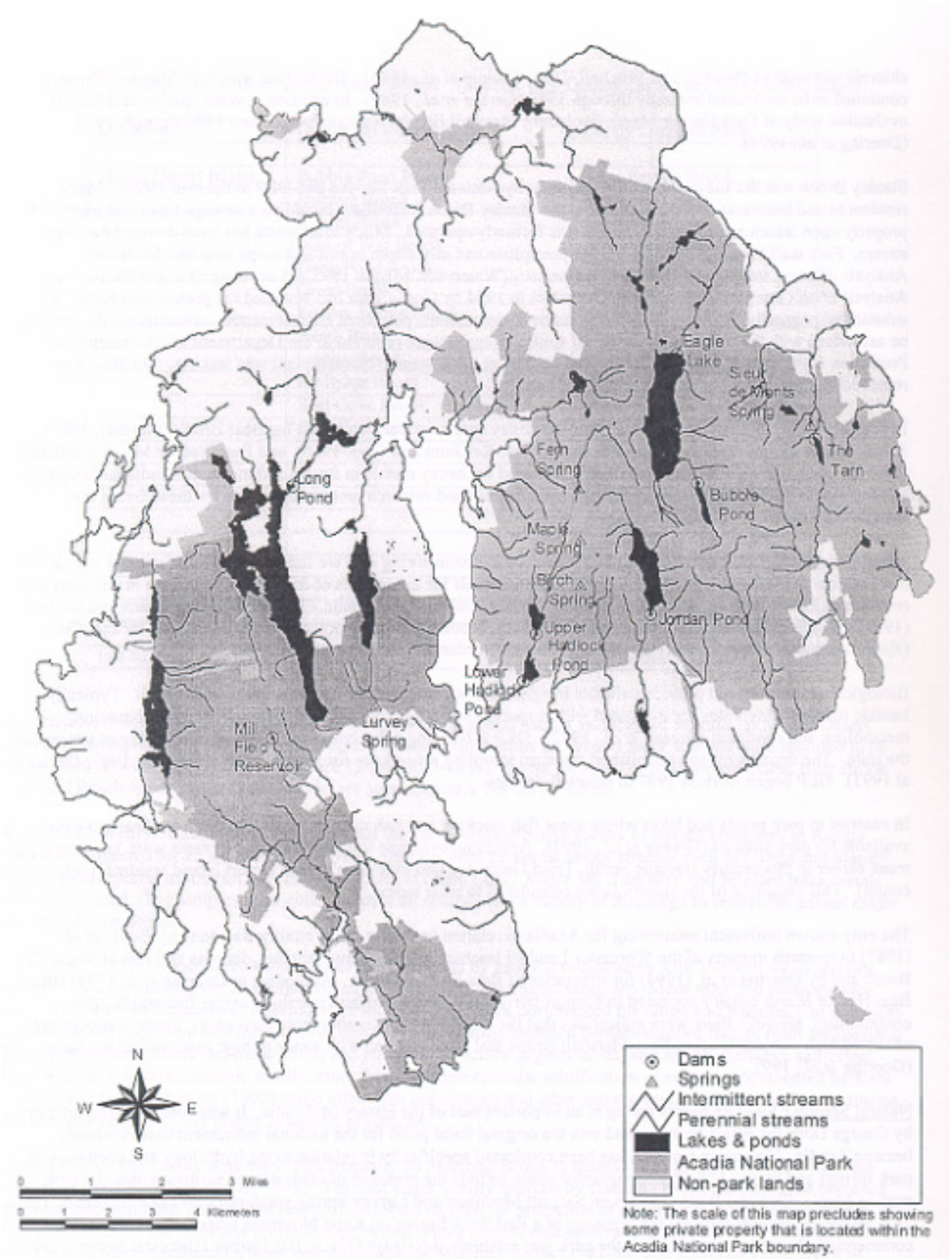

Figure 6: Springs and Dams, Mount Desert Island

Table 2E. Named Springs of Acadia National Park (Source: U.S.G.S topographic maps)

Spring Name	Location
Birch Spring	Sargent Mountain, MDI
Fern Spring	Sargent Mountain, MDI
Lurvey Spring	South of Echo Lake, MDI
Maple Spring	Sargent Mountain, MDI
Sieur de Monts Spring	Base of Dorr Mountain, MDI

Lakes and Ponds. Acadia is a water-rich park, with lakes and ponds serving a key role in the visitor experience (Figure 7). The movement to establish a national park can be traced to early efforts to protect the purity of Eagle Lake and Jordan Pond drinking water supplies (Dorr, 1942). The 14 Great Ponds and 9 smaller ponds range in size from 359 ha (897 acre) Long Pond, a lowland, moderately developed lake, to 0.5 ha (1 acre) Sargent Mountain Pond, located near the top of Penobscot Mountain (Table 2F). Jordan Pond is 46 m deep, whereas The Tarn, and Aunt Betty's Ponds are less than 1 m deep and predominantly covered by emergent vegetation in the summer. Based on the ratio of watershed area to lake volume, flushing times for these lakes range from less than 1 month in several of the small ponds, to approximately 8 years in Jordan Pond, based on an assumption of approximately 0.7 m of runoff annually.

Table 2F. Named Lakes and Ponds of Acadia National Park (Surface area from DEP Lake Name Index)

Great Ponds and Lakes (> 4 ha/10 acres)	
Inside park boundary	At least partly outside boundary
Eagle Lake - 174 ha (436 acres)	Long Pond - 359 ha (897 acres)
Bubble Pond - 13 ha (32 acres)	Echo Lake - 95 ha (237 acres)
Witch Hole Pond - 11 ha (28 acres)	Hodgdon Pond - 14 ha (35 acres)
Round Pond - 15 ha (38 acres)	Seal Cove Pond - 113 ha (283 acres)
Jordan Pond - 75 ha (187 acres)	Long Pond (IaH) - 29 ha (73 acres)
Lower Hadlock Pond - 16 ha (39 acres)	
Upper Hadlock Pond - 14 ha (35 acres)	
Aunt Betty's Pond - 14 ha (34 acres)	
Lake Wood - 6 ha (16 acres)	
Small Ponds and Lakes (under 4 ha/10 acres)	
Inside park boundary	
Lower Breakneck Pond - 3 ha (8 acres)	
Upper Breakneck Pond - 4 ha (9 acres)	
Half Moon Pond - 1 ha (3 acres)	
The Tarn - 3 ha (8 acres)	
Bear Brook Pond - 2 ha (6 acres)	
The Bowl - 2 ha (6 acres)	
Sargent Mountain Pond - .5 ha (1 acre)	
Seawall Pond - 2 ha (5 acres)	
Fawn Pond - 1 ha (3 acres)	
Duck Pond - .5 ha (1 acre)	

Some ponds have water that is colored by dissolved organic matter (Round Pond, Duck Pond, Hamilton Pond), but many are clear due to the freely draining soils that dominte their watersheds. Organic acids in soil solutions are precipitated or complexed by iron and aluminum in the B horizon of well drained spodosols, resulting in clear surface water. Lake waters become significantly colored when watershed soils are poorly drained, or when wetlands predominate near the lake.

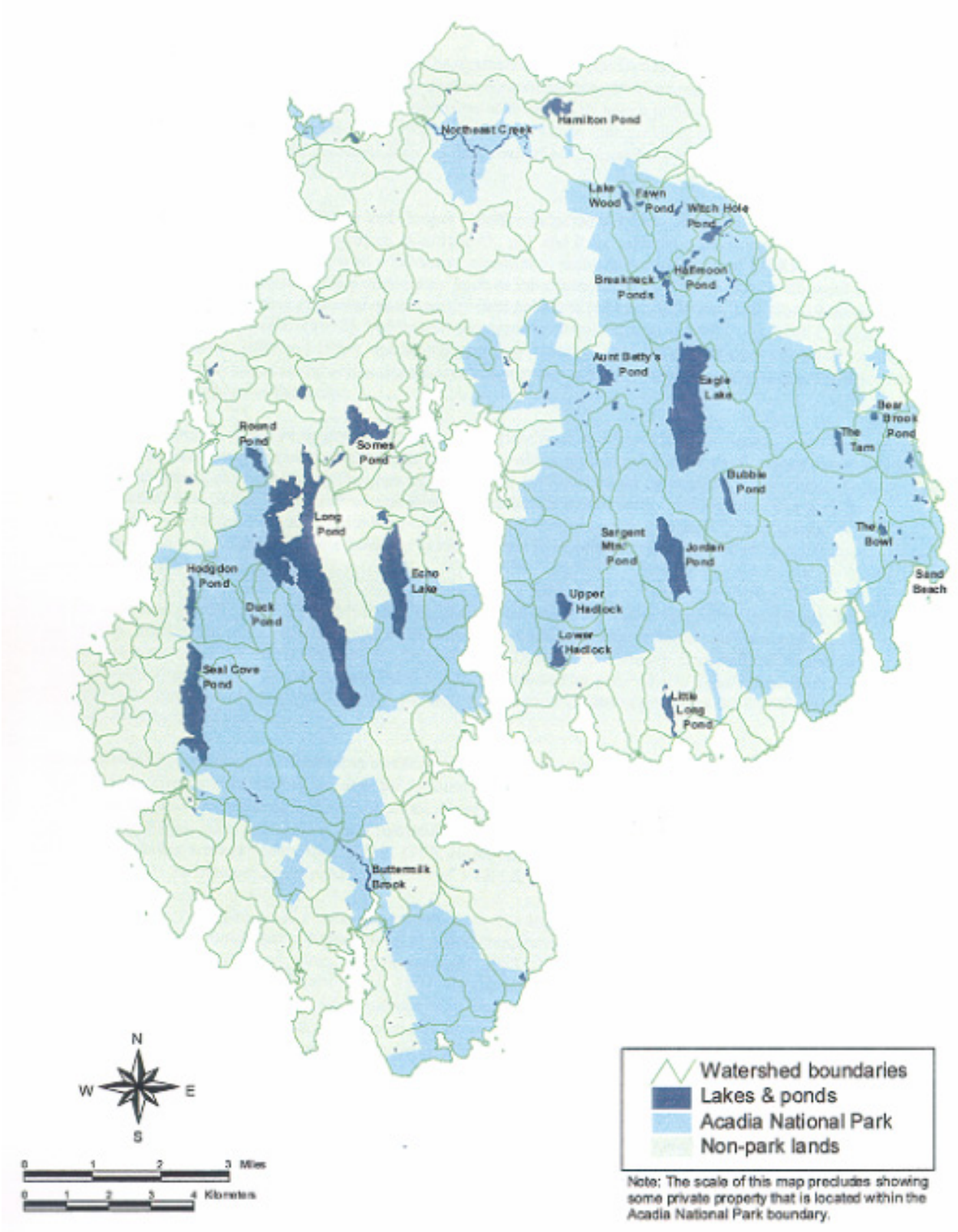

Figure 7: Lakes and Ponds, Mount Desert Island

The 1982 Resource Management Plan describes the characteristics of the five largest lakes on Mount Desert Island and the one lake on Isle au Haut, including size, depth, recreational use, development, water quality, and tributaries. Many of MDI lakes have small impoundment structures at their outlets which pre-date the establishment of the park and which typically raise water levels one or two meters. Hydrologic data on lakes and ponds are very limited. Water levels for Long Pond were recorded daily by the Town of Mt. Desert for one season (Coastal Study Project II, 1980, cited in Greene *et al.*, 1992).

Chemistry of Lakes and Ponds. Fuller and Cooper (1946) conducted the first substantial regional assessment of lake chemistry, reporting depth, temperature, dissolved O_2, pH, and P for selected lakes in eastern Maine, including several on MDI. They measured pH with a LaMotte colorimetric indicator kit. Kahl et al. (1985) conducted the first survey using present-day analytical techniques, such as ion chromatography for negatively charged major ions and Gran Plot alkalinity. Other chemical water quality data collected between 1931 and 1990 for 19 lakes and ponds are listed by Greene *et al.* (1992). Additional data have been collected in the 1990s by Reeb (1992), Lawrence (1993), Kahl (1995 and 1999), and by the park (e.g Gawley, 1995-99). Data were collected for studies on fisheries, septic system impacts and acidic deposition. The number and types of parameters measured vary widely depending on the purpose of the study.

With a few exceptions, Acadia's freshwaters tend to be nutrient poor and unproductive. Jordan Pond is considered to be one of the clearest (most oligotrophic) lakes in Maine, with a typical secchi disk water transparency of over 14 m (50 ft; Volunteer Lake Monitoring Program annual report, 1997-99). Four other lakes are considered oligotrophic based on recent data (Kahl, 1995), and several lakes are borderline mesotrophic-oligotrophic. The park has participated in the Maine Volunteer Lake Monitoring Program for many years, collecting information on temperature and water transparency, expanding in recent years to include nutrients and other chemical parameters (e.g. Gawley, 1995-99).

Of the lakes and ponds, only Sargent Mountain Pond and Duck Pond are acidic (pH 5.0 or less; Kahl, 1995; Kahl *et al.*, 1985). Duck Pond is part of a naturally acidic wetland system and Sargent Mountain Pond has a small watershed, with extensive bedrock exposure. The acidity in Duck Pond is mostly from natural organic matter (Kahl *et al.*, 1989), whereas in Sargent Mountain Pond it is largely caused by atmospheric deposition. Both ponds are less than 0.5 ha (approximately one acre) in area. Neither watershed offers the opportunity for significant neutralization of acids by mineral weathering.

The chemically-resistant granites result in surface waters with low alkalinity and low nutrient concentrations. Sodium and chloride from marine aerosols are the dominant ions in most surface waters, and contribute more than half of the conductance in these waters. The alkalinity of nine of the 24 lakes is in the lowest 10th percentile for all Maine lakes. Of all lakes in the park, only two small ponds (Little Long Pond and Bear Brook Pond) have more alkalinity than the average Maine lake (Kahl., 1995; Heath *et al.*, 1992). This dilute, poorly buffered nature of the water has led to the concern about potential effects of acidic deposition.

Lake Sediment Chemistry. Lake sediment records from The Bowl, Sargent Mountain Pond and Long Pond on Isle au Haut indicate that atmospheric deposition of elevated concentrations of trace metals has been occurring for over 150 years at Acadia (Kahl *et al.*, 1985; Norton and Kahl, 1987, 1991). Similar records from peat cores taken at the park corroborate this inference (Norton *et al*., 1997; Norton and Kahl, 1986; 1987). The presence of polluted precipitation 150 years ago suggests that anthropogenic contributions of mineral acids (from fossil fuel combustion) were probably present in precipitation in the mid-1800s as well. The chronology of these cores was determined using ^{210}Pb (Binford *et al.*, 1993), as part of a regional effort to determine the historical impacts and trends in acidic deposition.

Biological Data for Lakes and Ponds. Mack (1988) and Mack and Gibbs (1989) surveyed Long Pond, Sargent Mountain Pond, Aunt Betty Pond, and Eagle Lake for mayfly (*Ephemeroptera*) species. Myers (1931) surveyed rotifera in most Mount Desert Island lakes and ponds. Olday (1975) identified benthic macro-invertebrates (to genus only) in Long Pond and Echo Lake. According to Snell and Persoone (1989, cited in Greene *et al.*, 1992), rotifers can be conveniently and quickly used to determine freshwater toxicity.

Mercury. An issue discovered at Acadia in the mid-1990s is high mercury concentrations in fish. Results from a statewide study by DEP, IF&W and the University of Maine in 1993 have revealed mercury contamination in fish

from Maine lakes, including some lakes at Acadia (Table 2G). Brook trout (*Salvelinus fontinalis*) from Bubble Pond had a mean mercury content higher than the statewide background mercury content for this species. In Seal Cove and Hodgdon ponds, specimens of chain pickerel (*Esox niger*), white perch (*Morone americana*), and smallmouth bass (*Micropterus dolomieu*) exceeded the FDA limit of 1 part per million wet weight. The high mercury levels, especially in bass, are a health hazard to humans as well as to fish and wildlife predators. These data were instrumental in a proposal which led to the establishment of a pair of gauged watersheds in 1998 (Kahl *et al*., 1998) to study the biogeochemistry of mercury, as well as other issues (section 3.1).

Table 2-G. Mercury Content of Fish Sampled in Acadia (Source: Terry Haines, USGS BRD).

Name	Fish Species	Length (cm)	Hg (µg/g wet)*
Bubble Pond	Brook trout	27.4	0.22
	Brook trout	18.1	0.19
Hodgdon Pond	Smallmouth bass	47.3	3.40
	Smallmouth bass	47.8	2.80
	Smallmouth bass	32.9	0.81
	Smallmouth bass	33.4	0.78

*equals parts per million

The major source of mercury in lakes appears to be deposition from the atmosphere. Mercury bioconcentrates in the food chain. Fish mercury content appears to be higher in softwater lakes such as those at Acadia, although the controls on mercury bioavailability are not understood. The State of Maine issued a statewide public health advisory in May 1994, warning pregnant women, nursing mothers, women who may become pregnant, and children less than eight years of age not to eat fish from lakes and ponds in Maine, including those in Acadia. In 1994, the park began to notify visitors about mercury contamination of fish in the park.

Bacteria. Summer bacterial water monitoring of Acadia recreational swim beaches was conducted bi-monthly in 1993 at Echo Lake, Long Pond, Lake Wood and Sand Beach as part of a joint National Park Service/League of Towns lake monitoring program. Results in 1993 were within Maine water quality standards, but bacterial levels were higher than expected. In 1994 the National Park Service initiated weekly sampling of the freshwater swimming areas at Echo Lake and Lake Wood, the marine waters at Sand Beach and the brackish lagoon behind Sand Beach (Breen, 1995). Freshwater samples were analyzed for Escherichia coli and marine and estuarine samples were analyzed for enterococci bacteria. Findings in 1994 exceeded Maine Department of Human Services (MDHS) and EPA standards at Sand Beach Lagoon in late August and in early September immediately following heavy rains, but returned to acceptable levels within a week.

2.6 GROUNDWATER

Groundwater exists in surficial and bedrock geologic units (Hansen, 1980). On MDI, surficial units consist of Pleistocene and Holocene-age deposits of glacial and glaciomarine origin. They include unconsolidated deposits, till, glaciofluvial deposits, end moraines, marine deposits and alluvium. Water availability is typically low in the surficial units in the park with the possible exceptions of an end moraine at the south end of Long Pond and the glaciofluvial deposit south of Jordan Pond where induced infiltration may be sufficient for a public water supply. Water yields from wells installed in till on Mount Desert Island are generally low, 0-10 gallons per minute (Hansen, 1980). Local glacial deposits of sands and gravels are of limited use as aquifers (due their small size).

Water in bedrock exists within fractures, joints and faults, and the rate of discharge from bedrock wells varies with the size and complexity of the fracture system. Tests on 160 Mount Desert Island wells in crystalline bedrock revealed a mean yield of 10 gallons/minute and a range of 0.5-100 gallons/minute (Hansen, 1980). For practical purposes, most usable groundwater on Mount Desert Island is found in bedrock fractures.

Groundwater Chemistry. Much less is known about the groundwaters than the surface waters of Acadia. In many upland regions of the park, groundwater in surficial materials only exists ephemerally as pore water in shallow soils. In the valleys, a wider variety of thicker tills were deposited via glacial transport. In many of these valleys, deposits

of Presumpscot Formation (glaciomarine silts) cap deposits of coarser till. The poorly permeable Presumpscot formation affects both groundwater and surface water flow by locally inhibiting percolation into groundwater, and increasing the rate of surface runoff.

Hansen (1980) characterized Mount Desert Island groundwater as 'soft', with water quality generally good and of sufficient quality for domestic use. Groundwater can leach iron and manganese out of bedrock, a process which occurs beneath some wetlands and peat deposits or in stagnant fractures. Groundwater chemistry data exist for well tests conducted by the Maine Department of Transportation (MDOT) and the MDHS.

High concentrations of radon in groundwater from Mount Desert Island pose a potential concern to human health. Radon is a radioactive gas naturally present in most groundwater in Maine. It enters homes by degassing from groundwater, or by degassing into basements from soils and bedrock. Exposure to radon can cause lung cancer or cancer in the digestive tract. Radon data are summarized in Table 2H (Hess, unpublished data, 1993). The U.S. EPA has recommended that public water supplies contain no more than 300 pCi/l (picocuries per liter). The U.S. Geological Survey estimates that water containing 10,000 pCi/l contributes one pCi/L to indoor air where it can pose a risk to human health (USGS, 1992).

Fresh groundwater lies over salt water in costal areas. Excessive withdrawal of fresh water will cause salt water to infiltrate bedrock fractures. Development of the coastline outside of the park and increased fresh water demands on Mount Desert Island as a whole, can cause a degradation of potable water in the fractured bedrock.

Table 2H. Radon in MDI Wells (from Hess, unpub., 1993) All measurements in picocuries per liter.

Town	# Observations	Low	High	Mean
Bar Harbor	34	692	29,700	4,105
Mount Desert	46	317	34,866	12,979
Southwest Harbor	6	1,100	5,600	2,618
Tremont	6	1,200	8,600	3,403

2.7 WETLANDS

Wetlands form the transition between terrestrial and aquatic environments. The wetlands of Acadia are diverse and contribute significantly to the health, productivity, and uniqueness of the region (Figure 8; Table 2I). Wetlands have a special role in maintaining biodiversity because they provide habitat for a wide range of species. Biodiversity is most easily understood at the species level, but it also includes the diversity of genes found within species and the diversity of ecosystems that species comprise (Calhoun *et al.*, 1994). More than half of Maine's state-listed rare plants are found in wetland habitats, and at least one rare plant is found in each Acadia wetland type. Issues and recommendations for wetlands management are included in section 3.3.

The National Wetlands Inventory (NWI) has recently updated its wetland mapping in the Acadia region (Calhoun *et al.*, 1994). The NWI classifies wetlands for the purposes of regulation, habitat evaluation, inventory and management. To be defined as wetland, areas must be periodically saturated with water or covered by shallow water during the growing season. Wetlands may also have a substrate that consists of undrained hydric soil (soil that remains moist enough to develop anaerobic conditions) or they may support hydrophytic vegetation, at least periodically (Cowardin *et al.*, 1979). Permanently flooded deepwater areas are not classified as wetlands.

Acadia wetlands span all five of the ecological systems recognized by the NWI (Table 2J). Marine aquatic beds, intertidal shellfish flats, salt marshes, freshwater marshes, forested wetlands, and peatlands are all present, adding contrast and definition to the otherwise rugged landscape. Descriptions of each of the major types of wetland communities found in Acadia and lists of characteristic plants are provided in Calhoun *et al.* (1994).

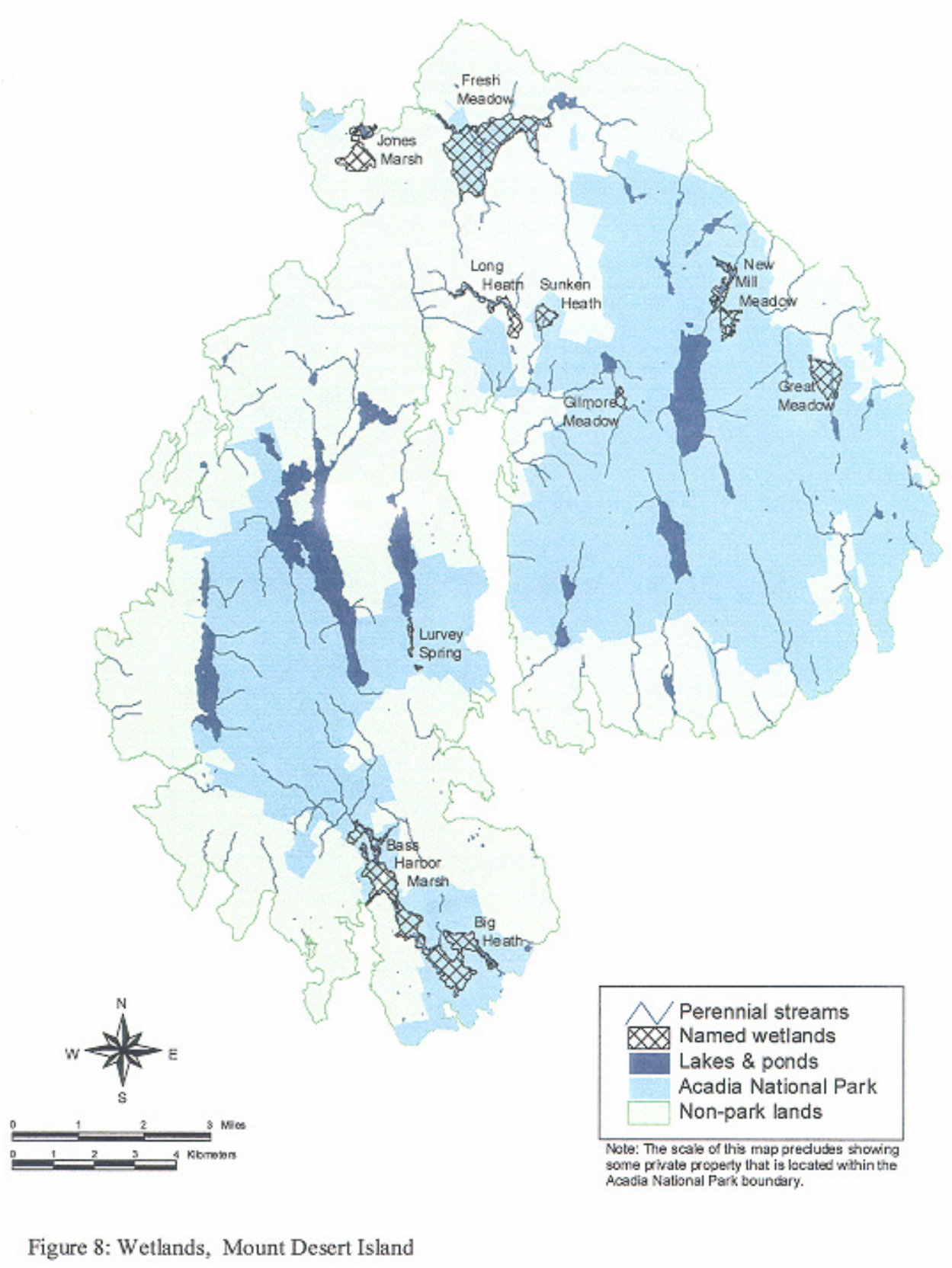

Figure 8: Wetlands, Mount Desert Island

Table 2I. Named Wetlands of Acadia National Park. Wetland areas are taken from digital (GIS) National Wetlands Inventory maps (Calhoun et al 1994). Polygons were selected by contiguousness and hydrological connection with streams. Bass Harbor Marsh area includes the open water within Rout 102. Bass Harbor Marsh and Big Heath were divided at Adams Bridge.

Wetland	Size (ha/ac) - entire wetland	% within park
Jones Marsh	51.3/126.7	0
Fresh Meadow	220.6/544.8	95
New Mill Meadow	44.0/108.8	100
Great Meadow	46.6/115.32	100
Gilmore Meadow	8.4/20.8	100
Long Heath	35.3/87.1	0
Lurvey Spring	6.2/15.3	100
Big Heath	138.9/343.1	97
Bass Harbor Marsh	80.4/197.6	100
Sunken Heath	20.4/50.5	100

Table 2J. Wetland Systems in Acadia National Park (classification after Cowardin *et al.*, 1979; figures from Acadia National Park NWI database)

			No. of Units
Marine[2]	Aquatic Bed	38	
	Rocky Shore	75	
	Unconsolidated Bottom/Shore	5	
	Subtotal	118	525
Estuarine[3]	Aquatic Bed	18	
	Emergent	59	
	Rocky Shore	2	
	Unconsolidated Shore/Bottom	70	
	Subtotal	149	101
Riverine	Unconsolidated Bottom	3	
	Subtotal	3	
Lacustrine	Aquatic Bed	19	
	Unconsolidated Bottom	334	
	Subtotal	353	113
Palustrine	Aquatic Bed	11	
	Emergent	126	
	Forested	357	
	Scrub-shrub	485	
	Unconsolidated Bottom	68	
	Subtotal	1,047	963

[1] Within the Acadia National Park legislative boundary, not all lands are currently owned in fee by the National Park Service. While most of these wetlands are located in the park, much of the land in the watershed draining into the wetlands are outside the park boundary on private property.

[2] Wetland areas are taken from digital (GIS) National Wetlands Inventory maps (Calhoun et al. 1994) LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States.

Calhoun *et al*. (1994) calculated the total area occupied by each wetland system. The areas of Acadia's marine and estuarine wetlands rely on accurate delineation of park boundaries in intertidal zones, which are not available on the park GIS at this time (Table 2J).

According to the NWI, wetlands comprise over 10 percent of Acadia holdings and cover approximately 1,670 ha (4,175 acres). These figures include wetlands greater than 0.3 ha (.75 acres) and exclude the marine and riverine wetlands.

The predominant freshwater wetland system for Acadia is palustrine, which covers 1,047 ha (2618 acres). Palustrine wetlands are characterized by persistent vegetation such as sedge meadows, cattail marshes or wooded swamps and by definition include open water bodies less than 8 ha (20 acres). A large diversity of plant communities and overall species abundance occurs in palustrine wetlands owing to the wide range of settings within which these wetlands form. In Acadia, palustrine wetlands are dominated by scrub-shrub (dominated by high or low shrubs) and forested communities (dominated by evergreens or hardwoods or a mix) and the majority are under 0.5 ha (1 acre) in size.

By definition, lacustrine wetlands are associated with lakes that exceed 8 ha (20 acres) in size. Lacustrine wetlands consisting of floating aquatic plants and freshwater marshes make up 353 ha (872 acres) of the park. Lacustrine wetlands at the deeper, steep-sided lakes such as Eagle and Echo lakes are restricted to sheltered coves and shallow sections, but are fully developed at the shallow lakes such as Aunt Betty Pond, Round Pond, and the Tarn. Rare aquatic plants, including water awlwort (*Subularia aquatica L.*) and small purple bladderwort (*Utricularia resupinata*) are associated with Acadia lacustrine habitats.

Acadia marine and estuarine wetlands are further described in Section 2.8. In all, 525 marine and 101 estuarine wetland units have been mapped for Acadia and included in the NWI database, representing 118 ha. (295 acres) and 149 ha (373 acres), respectively (Calhoun *et al.*, 1994), although these areas are somewhat approximate due to the park's imprecise intertidal boundaries.

Peat deposits at Big Heath were examined by Norton (1987), Norton and Kahl (1986, 1987, 1991) and Norton *et al.* (1997) to evaluate accumulation rates of metals from atmospheric deposition. Norton and Kahl (1987) compared peat deposits at Big Heath with lake sediments from Sargent Mountain Pond on Mount Desert Island and Long Pond on Isle au Haut as long-term monitors for recording the chronology and magnitude of atmospheric deposition of trace metals. Based on these studies, accumulation rates for trace metals associated with fossil fuel combustion began to increase in the mid-1800s. Mercury accumulation began in the late 1800s. There is some indication from the sediment record that mercury deposition has declined in the last 20 to 30 years (Norton *et al*., 1997), although the reason for a decline is unclear.

Of great significance among the park's wetlands is the rare raised peatland landform, the Coastal Plateau Bog, which is characterized by unusual natural features of both local and continental significance. Limited in distribution to a narrow band of islands and headlands along the eastern coast of Maine to Canada's northeast provinces, this raised peatland type represents a unique climatic and biogeographical zone that is globally limited in extent. A description of this rare wetland type, its vulnerability to visitor impacts, and its reasons for being listed on the Maine Register of Critical Areas, is given in Worley (1980).

2.8 MARINE RESOURCES

The marine environment is an important part of the park setting. The cool ocean waters surrounding Acadia 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 and wildlife that are enjoyed by park visitors, 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 rely on the salt water resource for habitat and food. Acadia staff conduct interpretive activities on marine ecosystems but the National Park Service does not have any management authority in marine waters.

Marine Hydrology and Chemistry Data. Beyond the marine hydrology studies performed for the Somes Sound estuary (described under the Estuaries heading below) there is little research available on the marine waters surrounding Acadia. Limited data on temperature, salinity and conductivity have been documented for intertidal areas by Borei (1963), Hyler (1963) and Jones (1988) and for estuaries by Acadia National Park staff (National Park Service 1986) and others, including Doering *et al.* (1994) and Doering and Roman (1994).

Oil and kerosene spills reported in marine waters in the Mount Desert Island area from 1953-1973 are listed in a report by Shenton (1973) and summarized in Greene *et al.* (1992). Contaminant concentrations were measured and ranked in Frenchman Bay and Penobscot Bay sediments by NOAA (1988). Current research is being sponsored by the National Park Service to examine toxic contaminants in the Frenchman and Blue Hill Bay areas in an attempt to explain low reproduction rates for bald eagles (National Park Service, 1995).

Biological Monitoring of Marine Resources. Fish in Frenchman Bay were tested for levels of DDT related compounds and PCB's by Adamson and Guarino (1972). Contaminant concentrations in Frenchman Bay bivalves were studied as part of the Mussel Watch Project (NOAA, 1987) but results for Frenchman Bay were not listed in the published report (Greene *et al.,* 1992). Procter's (1933) inventory of marine invertebrates (noting over 500 species in deepwater and intertidal stations in Frenchman and Blue Hill Bays) is considered the best inventory to date (Greene *et al.*, 1992). Hurst *et al.* (1979) measured trace metal contents in several intertidal species at the outlet of Salt Pond, on the western edge of Blue Hill Bay. Mast (1998) documented bioaccumulation of chlorinated organic contaminants (including dioxins) in eagles around MDI.

Marine Intertidal Areas. Acadia preserves public access to rocky headlands and intertidal bedrock areas which are generally scarce on the east coast of the United States. Rocky intertidal areas are technically classified as marine wetlands by the NWI, which identified 118 ha (291 acres) of marine wetlands in the park. Marine wetlands are distinguished from estuarine wetlands by their exposure to high energy wave action. They make up the characteristically rugged shoreline of Acadia in the form of rock headlands, tidepools and cobble beaches.

Descriptions of Acadia marine macroalgae communities associated with marine wetland communities can be found in Calhoun *et al.* (1994). An ecological characterization of intertidal resources and macrofauna is contained in Cammen and Larsen (1992). An inventory of Acadia tidal zone invertebrates is lacking and thus does not meet minimum National Park Service Level I requirements. Partial biological inventories of intertidal areas have been conducted for Otter Cliffs (Johnson, 1915), Anemone Cave (Jones, 1988), and Schoodic Peninsula (Doggett *et al.*, 1978). High species diversity is found where wave energy is high, slopes are gentle, and the bedrock surface is heterogeneous with abundant crevices and tidepools. The intertidal area at Schoodic Peninsula in the park is listed as a Maine Critical Area for its high diversity of intertidal macroinvertebrates which include 27 species, some of them considered noteworthy (Doggett *et al.*, 1978).

Intertidal bedrock areas of high species diversity can be disturbed or destroyed by over-collecting and excessive foot traffic. Overlapping jurisdiction for intertidal areas (Section 2.11) and lack of clarity over park boundaries complicate management of marine and estuarine resources.

Estuaries. Estuarine waters constitute the transition zone between the freshwater and the marine environment. Acadia estuarine wetlands consist of intertidal mud flats, coarse gravel shores, salt marshes, and aquatic beds in coves or embayments, sheltered from high energy waves of the open ocean. The high tidal range at Acadia (over 3 m./10 ft.) has helped to create an extensive system of mud flats that are of great ecological and economic importance to the region (Calhoun *et al.*, 1994).

Although estuarine waters are outside park boundaries, the National Park Service has sponsored water quality research on Somes Sound (Doering and Roman, 1994) and Bass Harbor Marsh (Doering *et al.*, 1994). A large part of the watershed for both estuaries is contained within the park. Both estuaries receive freshwater from private and park lands.

Somes Sound is classified as a fjord-type estuary because of its long (8 km/5 mi) and narrow (1 km/.6 mi) configuration, deep basins (40-50 m (130-160 ft) deep), and relatively shallow sill (10-12 m/33-40 ft) deep) near Northeast Harbor (Doering and Roman, 1994). Prior research conducted on Somes Sound includes water chemistry studies by Ketchum and Cass (1986) and hydrology studies by Folger *et al.* (1972).

Bass Harbor Marsh is a 22 hectare (54 acre) marsh-dominated estuarine system with a main creek that meanders for 3 km (2 mi). A study of water quality and habitat of the marsh ecosystem were initiated by the National Park Service in response to concerns about decreasing brook trout populations, increasing macroalgae biomass, and the knowledge of nitrogen leaching from a landfill in the headwaters outside of the park boundary. The researchers' findings and management alternatives for Somes Sound and Bass Harbor Marsh are summarized in section 3.3.

2.9 AQUATIC AND RIPARIAN RESOURCES AND HABITATS

Fisheries. This plan does not attempt to addresses fisheries resources of Acadia in detail. Fish resources and management will be most appropriately handled in a separate fisheries management plan as recommended in section 3.2. A baseline inventory on Acadia fish is underway in a 3-year study by J. Moring at the University of Maine. Fish surveys conducted between 1946 and 1984 (referenced by Greene *et al.*, 1992) documented 24 fish species in Mount Desert Island lakes and ponds. Although the presence or absence of non-game fish were recorded (Table 2K) these surveys have focused on game fish in selected lakes. As a result, a comprehensive inventory of all species present and the abundance and distribution in all waters located within or adjacent to park boundaries does not exist.

Table 2K. Freshwater Fish of Mount Desert Island (from Greene et al, 1992)

Alewife[a]	*Alosa pseudoharengus*
American eel	*Anguilla rostrata*
Banded killifish	*Fundulus diaphanus*
Brook trout[a]	*Salvelinus fontinalis*
Brook stickleback[b]	*Culea inconstans*
Brown bullhead	*Ameiurus nebulosus*
Brown trout	*Salmo trutta*
Chain pickerel	*Esox niger*
Common shiner	*Luxilus cornutus*
Fallfish	*Semotilus corporalis*
Fourspine stickleback	*Apeltes quadracus*
Golden shiner	*Notemigonus crysoleucas*
Lake trout	*Salvelinus namaycush*
Landlocked (Atlantic) salmon	*Salmo salar*
Ninespined stickleback	*Pungitius pungitius*
Northern redbelly dace	*Phoxinus eos*
Pumpkinseed	*Lepomis gibbosus*
Rainbow smelt	*Osmerus mordax*
Redbreast sunfish	*Lepomis auritus*
Smallmouth bass	*Micropterus dolomieu*
Threespine stickleback	*Gasterosteus aculeatus*
White perch	*Morone americana*
White sucker	*Catostomus commersoni*
Yellow perch	*Perca flavescens*

[a] Landlocked as well as anadromous runs.
[b] Identification in early records, not confirmed.

There is even less information available for fish in smaller ponds or streams. Greene *et al.* (1992) found no fish data for Schoodic Peninsula or for other park owned islands. A large marsh on Schoodic may contain fish, but no fisheries information is known to exist. In Long Pond on Isle au Haut, seven species were documented in 1984, but at least three of those were stocked or introduced.

Fish stocking records are also available for 17 Acadia lakes and ponds for the period of 1937 to the present from the IF&W (Table 2L). The year in which stocking began varies from water body to water body. From year to year, the water bodies stocked also vary. Stocking is known to have been done on some ponds by private citizens since the

1890s. Of species currently stocked, only brook trout are native to Mount Desert Island (John Moring, U. Maine, 1994, pers. comm.).

2L. History of Fish Stocking in Mount Desert Island Lakes and Ponds (from Inland Fisheries & Wildlife)

Pond	Species Stocked	Year Begun	Recent Stocking
Aunt Betty	Brook trout (*Salvelinus fontinalis*)	1985	
Breakneck (lower)	Brook trout	1964	1998
Breakneck (upper)	Brook trout	1964	1998
Bubble	Brook trout	1937	1997
	Brown trout+		
Eagle Lake	Atlantic salmon (*Salmo salar*)	1971	1998
	Brook trout		1998
Echo Lake*	Atlantic salmon	1938	1998
	Brook trout		1998
Hadlock (lower)	Brown trout (*Salmo trutta*)	1938	1998
	Brook trout		1998
Hadlock (upper)	Brook trout	1959	1997
	Splake✧		
Halfmoon	Brook trout	1962	1998
Hodgdon	None		
Jordan	Atlantic salmon	1937	1998
	Lake trout (togue)	1961	
	Mysis shrimp (*Mysis relicta*)	mid-1970's	
Lake Wood	Brook trout	1970	1998
Long (Great)	Atlantic salmon	1938	1998
Round	Brook trout	1986	1998
Seal Cove	Brown trout	1938	1998
The Tarn	Brook trout	1984	1998
Witch Hole	Brook trout	1964	1998

* In 1956, Echo Lake was chemically treated to restore brook trout.
\+ Brown Trout may be introduced by IF&W in the future.
✧ Splake may be introduced by IF&W in the future.

In addition to the lack of a baseline fisheries inventory, no comprehensive inventory has been conducted to characterize fish habitats. Such work would address the location and condition of spawning areas and temporal variation in plankton and invertebrate populations and water quality conditions in lakes and streams. In addition, there is a lack of knowledge on the genetic integrity of native fish stocks such as brook trout.

Anecdotally, streams in the park were "*teeming with trout*" 50 years ago (Dennis Smith, Trout Unlimited, and Leslie Smith, former IF&W staff, pers. comm., 1994), a condition that does not describe the present condition. Historic population levels are unknown, but were undoubtedly higher than those of today (John Moring, University of Maine, pers. comm., 1995). A major cause includes overfishing (Ron Brokaw, IF&W, pers. comm., 1999). Other possible causes for the decline in fisheries may include the effects of atmospheric deposition on water chemistry (section 3.1) and habitat changes caused by beaver.

The impact of recreational fishing management on native fishes is not well understood. Keith Havey (1980) of IF&W in Bangor studied the relationships between stocking rate and growth and yield of landlocked salmon in Long Pond. When stocking was increased to provide better angler success, growth and yield decreased, apparently due to near elimination of forage species. Havey and Locke (1980) found that angler success during the ice-fishing season caught virtually all brook trout stocked in Eagle Lake the previous fall, although the stocking program around 1980 provided 1.5 year old fish that were 10 to 14 inches in length. Present stocking is with 5 to 7 inch fingerlings (Ron Brokaw, IF&W, pers. comm, 1999).

Flora. Calhoun *et al.* (1994) provided a description of the major wetland plant communities for Acadia along with a list of wetland plants recorded in the park. Rare plants are associated with every type of wetland in the park Documented and historic records of rare vascular plants of Acadia National Park and Mount Desert Island have been compiled by Greene (1990) who provided information on the occurrence, habitat and status of each species. A variety of state-listed plant species of concern are found in park wetlands along with an extremely rare aquatic plant. Prototype quillwort (*Isoetes prototypus*) is present at Acadia as the first and only known occurrence of this aquatic plant in the United States (Brunton and Britton, 1993). The discovery of this species at Acadia stimulated recent National Park Service efforts to conduct an inventory of aquatic vegetation in the park (Linda Gregory, Acadia National Park, pers. comm. 1995).

Shore and aquatic vegetation are among the components of the aquatic-terrestrial ecosystems that are most vulnerable to recreational impacts. Steeply sloping stream and lakeshores are prone to erosion and moist soils have great potential for vegetation damage and soil compaction. Intensive use of the shoreline for angling, swimming, walking and boat launching can lead to complete vegetation loss. Some of the plants that can tolerate wave action from boats cannot tolerate mechanical damage by treading (Liddle and Scorgie, 1980).

Certain exotic plants threaten the integrity of park ecosystems. The principal non-native species of concern in park wetlands are purple loosestrife (*Lythrum salicaria*) and buckthorns (*Frangula alnus* and *Rhamnus catharticus*). An integrated purple loosestrife management program has been employed since 1988 which includes early detection, herbicide treatment, wetland monitoring and public education (section 3.3). The program was scientifically peer reviewed in 1996 and recommendations were made to monitor long-term wetland community composition, including other exotic species (Hiebert et al, 1997). Control efforts are ongoing and permanent transects have been established to evaluate control actions and monitor long-term wetland community compositions (National Park Service, 1995).

Fauna (other than fish). Beaver (*Castor canadensis*) exert a significant influence on the wetland and stream hydrology of Acadia. Mount Desert Island beaver were trapped out before the park's founding, but were reintroduced shortly after the park was established. Examples of wetlands maintained by beaver are at Canon Brook, Gilmore Meadow, and the wetland east of the Precipice (Calhoun *et al.*, 1994). Measurements of water level fluctuations of active and inactive beaver flowages on Mount Desert Island by Dubuc *et al.* (1988) revealed more stable water levels in wetlands used by beaver. Watersheds burned by the 1947 fire provide the most desirable food sources and habitat for beaver. A decline in the number of active beaver colonies within the burned area in the early 1990s was a cause for concern. However, populations have grown considerably over the past few years as trapping pressure has declined due to a drop in prices for beaver pelts.

Surveys of river otter on Mount Desert Island from 1985-1987 confirmed their presence in over half of the island's watersheds. Dubuc *et al*. (1988) characterized otter habitat on Mount Desert Island and developed a predictive model of otter occurrence. Watersheds regularly used by otter are inhabited by beaver, contain longer streams, and have more complex and highly configured shorelines (calculated by dividing the perimeter of the water body by total area.

Fresh and estuarine wetlands provide nesting sites for a variety of waterfowl and shorebirds that also rely on Acadia fresh and marine waters for forage and rest during migration. The annual Maine Audubon loon count has documented common loon (*Gavia immer*) individuals, pairs, nests and chicks on Mount Desert Island lakes since the survey began on MDI in 1983. However, there appear to be fewer loons on Mount Desert Island lakes compared to other lakes in Hancock County. Loon pairs at Acadia also have low rates of reproductive success. The reasons for this are unknown, but could be related to habitat characteristics (such as an absence of freshwater islands), disturbances (Ruth Sergeson, Hancock County Loon Coord., Maine Audubon, pers. comm., 1995) or toxic chemicals in the environment which have been shown to bioaccumulate in birds of the MDI vicinity (Mast, 1998).

Up-to-date inventories are lacking for most groups of freshwater invertebrates at Acadia. Although invertebrates are not presently recognized on Maine's endangered species list, Maine has several varieties of freshwater mussels that would qualify for listing (Tom Hodgman, pers. comm., 1995). Maine has 11 species of freshwater mussels, of which four are rare. At the state level, the tidewater mucket (*leptodea ochracea*, historically referred to as L*ampsilis*

ochracea), and squawfoot (*Strophitus ungulata*) are candidates for endangered and threatened status, respectively (Beth Schwartz, MIF&W, pers. comm., 1995). Freshwater mussel species have not been inventoried within the park at this time and the presence of these rare freshwater mussel species is unknown.

During the first half of this century, Mount Desert Island insects were thoroughly inventoried in over 27 seasons of field work by Johnson (1927) and Procter (1933, 1938, 1946). A data set of this kind is unique in North America, has potential for comparisons with contemporary fauna, and may be useful in assessing perturbations such as climate change (Greene *et al.*, 1992). Subsequent inventories of Mount Desert Island insects are described in Greene *et al.* (1992).

Research conducted at Mount Desert Island on insects associated with freshwater habitats documents distributions of mayflies (*Ephemerida*) by Mack (1988) and Mack and Gibbs (1989). The former includes data for Isle au Haut.

The distribution of dragonflies and damselflies (*Odonata*) on MDI are summarized by White (1989). Mayflies (*Baetis sp., Ephemerella funeralis*, and other *Ephemerella sp*.) are especially sensitive to low pH (Andersen, 1984; Haines 1981; Gibbs pers. comm. in Greene *et al.*, 1992). Duck Brook and Stanley Brook were found to have the most diverse mayfly population of streams sampled on Mount Desert Island (Mack 1988). Aquatic insects at Long Pond on Isle au Haut (then called Turner's Lake) were included in an inventory conducted in the early 20's (Bishop and Clarke, 1923).

Mount Desert Island freshwater rotifers were thoroughly inventoried in a decade of field work by Myers from 1922-1931. Myers' research documents the distribution and abundance of 449 species of rotifera, of which 63 were new at that time. Two streams (Duck Brook and Northeast Creek) and almost every lake and pond on Mount Desert Island were studied, with Witch Hole Pond and Aunt Betty Pond being the most frequently mentioned in Myers' publications (Myers, 1931, 1933a,b, 1934a,b,c,d).

Aquatic insect community composition can indicate the health of an ecosystem, provide a warning system and show the relative intensity of pollution problems. Greene *et al.* (1992) recommend a program to monitor mayflies sensitive to low pH and water quality. Another recommendation by Greene *et al.* (1992) is an inventory of insect fauna in the park designed for comparison to Johnson and Procter's baseline data.

Acadia amphibians and reptiles have been partially inventoried, and the park maintains a species list for public information. Data for these groups do not meet minimal Level I National Park Service Inventory and Monitoring requirements (National Park Service, 1995). Coman (1987) summarized herptile and amphibian field observations and reports for Acadia. Recent National Park Service inventories of small park-owned islands have documented amphibians and reptiles (Mittelhauser *et al.*, 1996). Limited inventories of Acadia amphibia have been undertaken by Manville (1938, 1939) and Davis (1958). Little is known about the amphibian populations living in Acadia or their sensitivity to factors such as acidification. Research on the potential impacts of acidification on breeding and larval mortality have not been completed. Amphibians can be very useful for monitoring aquatic community health in efforts that are linked with air and water resource monitoring. An amphibian inventory and monitoring project is listed as a high priority in the Acadia Resource Management Plan (National Park Service, 1995).

Federally Threatened or Endangered Species. Two federally endangered species inhabit Acadia, the bald eagle (*Haliaeetus leucocephalus*) and the peregrine falcon (*Falco peregrinus*). Bald eagles are found throughout the park. Fifteen traditional bald eagle nesting territories exist within the park with approximately seven of these being used during the last ten years. All of the nesting territories are associated with freshwater and estuarine wetlands, including Bass Harbor Marsh, Northeast Creek and Somes Sound on Mount Desert Island.

Peregrine falcons were reintroduced to Acadia in 1984-1986 and a pair began nesting successfully at the Precipice in 1991. At least three pairs nested in the park in 2000. Wetlands lying directly east of the Precipice provide a close source of foraging habitat for the fledgling peregrines. Peregrine falcons are federally and state listed as an endangered species.

2.10 CONSUMPTIVE AND NON-CONSUMPTIVE USES OF WATER RESOURCES

Park water resources are subject to withdrawals for domestic and commercial use (consumptive) as well as recreational activities and assimilation of wastewater (non-consumptive). Withdrawals of surface water serve Bar Harbor, Seal Harbor, Northeast Harbor and Southwest Harbor, and wells within the park serve park visitors and park staff. Protection of drinking water supplies in Eagle Lake and Jordan Pond was part of the motivation for early land purchases which led to the park's establishment (Dorr, 1942). At current levels, withdrawals have not caused any known ecological problems, and supplies and quality easily meet current standards for their uses. For example, the Bar Harbor Water Company withdrew almost 1.3 million cubic meters (350 million gallons) from Eagle Lake in 1993. This represents approximately 5% of Eagle Lake's total volume of 22.4 million cubic meters, some of which would have run-off anyway if not withdrawn by the water company.

Boating, fishing and swimming have historically been popular activities on Acadia lakes and ponds. Boating is still common on the Great Ponds that provide convenient boating access (Long Pond, Eagle Lake, Seal Cove Pond, Echo Lake, Jordan Pond). Some restrictions apply (Table 2M).

Table 2M. Recreational Uses and Restrictions for Acadia Lakes and Ponds (current as of New Great Ponds Legislation passed in 1997).

	Official Boat Landing	
Pond	(Public or Private)	Recreation Restrictions
Aunt Betty	No	Closed to visitors.
Breakneck (lower	No	
Breakneck (upper)	No	
Bubble	No	Same as Eagle Lake No motors.
Eagle Lake	Yes	Bar Harbor water supply No Swimming. No windsurfing. No boating near water intake. Maximum 10 HP engine for boats
Echo Lake	Yes	Maximum 10 HP engine for boats
Hadlock (lower)	Yes	Northeast Harbor water supply Maximum 10 HP engine for boats. No Swimming. Boat ramp & most of pond closed to protect water intake.
Hadlock (upper)	No	Same as Lower Hadlock No ramps.
Halfmoon	No	
Hodgdon	No	
Jordan	Yes	Seal Harbor water supply. No Swimming. No Boating near intake. Maximum 10 HP engine for boats.
Lake Wood	No	Closed to motors.
Long (Great)	Yes	Southwest Harbor water supply. No Swimming Zone near intake.
Round	No (OK for hand-carried boats)	
Seal Cove	No	
The Tarn	No (OK for hand-carried boats)	
Witch Hole	No	Closed to motors.

Fishing is popular at all of the Great Ponds except Aunt Betty Pond and Lake Wood. Anglers also frequent many of the parks smaller ponds. Ice fishing is becoming more popular statewide (Kevin Boyle, Dept of Resource Economics and Policy, University of Maine, pers. comm., 1995) and is thought to account for an increasing portion of the harvest within Acadia as well (Len Bobinchock, pers. comm., 1994). Fishing activities are regulated by IF&W.

The park maintains swimming beaches at Echo Lake and Sand Beach and recognizes a beach at Lake Wood.

Aesthetic appreciation of park water resources can also be considered a non-consumptive use. The aesthetic qualities of water resources are important components of people's enjoyment of Acadia. Protection of aesthetic values is an important element of National Park Service resource management programs (National Park Service-77). A formal 'viewshed' analysis has not been conducted in the park, but authors of early guide books considered Acadia's lakes to be some of Mount Desert Island's most attractive features (Newlin, 1989). The park has recently undertaken to re-establish historic scenic vistas from selected carriage roads.

2.11 LEGAL RELATIONSHIPS AND RESPONSIBILITIES

Management jurisdiction for Acadia water resources is complicated and shared by many organizations. This issue is described and discussed in detail in the section on recreational use and management of surface waters (Section 3.2) as it relates to Great Ponds.

Examination of deed references reveals that the park owns lands to low water for more than half of its fee area (Table 2N). Thus the park controls a significant amount of intertidal areas. This is contrary to a common misconception that intertidal areas are outside of the park. Some of the areas specified in the deeds where jurisdiction clearly extends to low tide include the west half of Bar Island in Bar Harbor, the shoreline from Otter Cove to Hunter's Brook, Somes Sound by Norumbega, Flying, and Acadia Mountains, and the shoreline from Seawall Picnic area to Bass Harbor Head. Park ownership excludes the intertidal area and ends at the high water mark in only three areas: Oak Hill Cliff near Schooner Head Overlook, Seawall Pond, and the Pretty Marsh Picnic Area. The remaining shoreline areas in the park have coastal boundaries that are unspecified in the deed reference descriptions on file. Examination of the actual deeds in the Hancock County office may help to clarify where they extend to low or high water (Mike Blaney, Acadia National Park, pers. comm., 1994).

Table 2N. Park Ownership of Intertidal Areas (from Acadia National Park files)

Park boundaries clearly deeded to the low tide line
Bar Island (western half), Bar Harbor Otter Cove to Hunter's Brook Somes Sound (shoreline adjacent to Norumbega, Flying, and Acadia Mountains) Seawall Picnic Area to Bass Harbor Head
Park boundaries clearly deeded to end at high tide
Oak Hill Cliff near Schooner Head Overlook, Bar Harbor Seawall Pond Pretty Marsh Picnic Areas
Park boundaries requiring deed inspection and/or clarification of intertidal ownership
All remaining shoreline areas in Acadia National Park

2.12 ARTIFICIAL HYDROLOGIC CONTROL STRUCTURES

There are many small artificial dams and dam-like structures located at streams and lakes within Acadia (Figure 6; for a partial list, see Table 2O). Many of these are associated with maintenance of water levels at lakes used for drinking water supplies. Park maintenance files list 9 dams in the park, located at Storm Beach, Bubble Pond, Eagle

Lake, the Tarn, Jordan Pond, Upper Hadlock, Lower Hadlock, Long Pond and Mill Field Reservoir. Most of the dams raise water levels 1 to 3 m. (less than 10 ft) and have been in place for decades. The original purpose and impact of these dams on park resources is often unknown.

Table 2O. Water Bodies affected by Dams -partial list
(from Acadia National Park Maintenance files, 1995)

Water Bodies	
Bubble Pond	The Tarn
Eagle Lake	Long Pond
Jordan Pond	Storm Beach
Upper Hadlock Pond	Mill Field Reservoir
Lower Hadlock Pond	

2.13 THREATS TO WATER RESOURCES

The water resources of Acadia are threatened by local point and non-point sources of pollution as well as ecological factors such as the introduction of non-native fish and plant species, recreational use, atmospheric deposition, and climate change.

There are no point sources which discharge upstream of, or directly to, freshwaters within park boundaries. However, at least eight point sources on Mount Desert Island discharge treated wastewater to marine and estuarine waters in close proximity to park boundaries: Bar Harbor (3), Otter Creek, Northeast Harbor, Somesville, Seal Harbor and Southwest Harbor (Table 2P). These discharges contribute to shellfish flat closures over most of the southern and eastern sides of Mount Desert Island and may affect aquatic ecosystems. Park operations affect these discharges by contributing influent to the Otter Creek plant. Several smaller shellfish areas on the west side of Mount Desert Island are closed as the result of nonpoint sources.

Runge *et al.* (1991) investigated the applicability of a non-point source pollutant loading model for Acadia National Park. Potential nonpoint sources of pollution within or in close proximity to park boundaries include roads, road ditches, trails, unstable shorelines, on-site wastewater systems, landfills, the atmosphere and developed areas including construction sites, parking lots, buildings and petroleum storage facilities. Atmospheric deposition is addressed separately in this report.

The park maintains two campgrounds, 138 miles of paved and unpaved roads, 130 miles of hiking trails, 16 parking lots and 25 on-site wastewater systems. Nonpoint problems are often observed during wet weather which can generate overland flows to surface water and infiltration to groundwater.

IF&W maintains a fish stocking program on 17 lakes and ponds within and adjacent to park boundaries. Stocked species vary by lake or pond, but Sunapee trout, lake trout, landlocked salmon, brook trout, brown trout, rainbow trout and smallmouth bass have been stocked at various times over the past 58 years. Ecological impacts on native fishes have not been studied.

Changes in annual patterns of temperature and precipitation can affect water quality, water body volumes, sea level and the composition of aquatic communities. Current variability is considered to be well within historical records, although sea level is known to be rising at the rate of several millimeters per year (Lyles *et al.*, 1988; Kelley *et al.*, 1995). It is not possible to know if Acadia's climate will change in the forseeable future, or in what manner.

Table 2P. Licensed Point Source Discharges Adjacent to the Park (Source: U.S. Region I Wastewater Licensing Division. Information Summary for Selected Waste Water Treatment Facilities near the Acadia National Park[1]

Facility	Permitted Discharge Parameters	Receiving Water
Bar Harbor Wastewater Plant Ledgelawn Ave., Bar Harbor, ME 04609 Type of Operation: Sewerage Systems Status: operating (3 pipes) NPDES Permit # ME0101214 Discharge Volume: No Data	Pipe 1) CHLORINE, TOTAL RESIDUAL, SOLIDS, SETTLEABLE PH, COLIFORM, FECAL GENERAL, LC50S TAT 48HR ACU MENIDIA, SOLIDS, TOTAL SUSPENDED, LC50 STAT 48HR ACU MYSID.BAHIA, BOD,5-DAY (20DEG.C), FLOW IN CONDUIT OR THRU TREATMENT PLANT, SOLIDS, SUSPENDED PERCENT REMOVAL, BOD,5-DAY PERCENT REMOVAL Pipe 2) FLOW, IN CONDUIT OR THRU TREATMENT PLANT, PH, SOLIDS, TOTAL SUSPENDED, SOLIDS, SETTLEABLE, CHLORINE, TOTAL RESIDUAL, BOD, 5-DAY (20DEG.C) COLIFORM, FECAL GENERAL BOD, 5-DAY PERCENT REMOVAL SOLIDS, SUSPENDED PERCENT REMOVAL Pipe 3) FLOW, IN CONDUIT OR THRU TREATMENT PLANT, COLIFORM, FECAL GENERAL, CHLORINE, TOTAL RESIDUAL, BOD, 5-DAY (20DEG.C), BOD, 5-DAY PERCENT REMOVAL, SOLIDS, SUSPENDED PERCENT REMOVAL, SOLIDS, TOTAL SUSPENDED PH, SOLIDS, SETTLEABLE	Frenchman Bay Atlantic Ocean
Town of Mount Desert[2] Sinclair Road, Northeast Harbor 04662 Type of Operation: Sewerage Systems Status: Operating NPDES Permit # ME 0101346 Discharge Volume: No Data		Somes Sound Tidewaters of Mt. Desert Class SB
Town of Mount Desert Northeast Harbor Discharge Volume: 0.330 mgd*	BOD, 5-DAY (20 DEG.C), PH, TOXICITY TEST LC50 STAT 48 HR ACU MENIDIA BOD, 5-DAY PERCENT REMOVAL, TOXICITY TEXT LC50 STAT 48HR ACU MYSID BAHIA, FLOW, IN CONDUIT OR THRU TREATMENT PLANT, CHLORINE, TOTAL RESIDUAL, SOLIDS, TOTAL SUSPENDED, SOLIDS, SUSPENDED PERCENT REMOVAL, COLIFORM, FECAL GENERAL, SOLIDS, SETTLEABLE	
Town of Mount Desert Otter Creek Discharge Volume: 0.130 mgd*	BOD, 5-DAY (20 DEG. C), SOLIDS, SUSPENDED PERCENT REMOVAL, TOXICITY TEST LC50 STAT 48 HR ACU MENIDIA, CHLORINE, TOTAL RESIDUAL, SOLIDS, TOTAL SUSPENDED, SOLIDS, SETTLEABLE, TOXICITY TEST LC50 STAT 48HR ACU MYSID BAHIA, COLIFORM, FECAL GENERAL, FLOW, IN CONDUIT OR THRU TREATMENT PLANT, BOD, 5-DAY PERCENT REMOVAL, PH	
Town of Mount Desert Seal Harbor Discharge Volume: 0.150 mgd*	FLOW, IN CONDUIT OR THRU TREATMENT PLANT, SOLIDS, TOTAL SUSPENDED, BOD, 5-DAY (20 DEG.C), COLIFORM, FECAL GENERAL, BOD, 5-DAY PERCENT REMOVAL, FLOW, IN CONDUIT OR THRU TREATMENT PLANT, SOLIDS, SETTLEABLE, COLIFORM, FECAL GENERAL, CHLORINE, TOTAL RESIDUAL, SOLIDS, TOTAL SUSPENDED, PH, BOD, 5-DAY (20 DEG. C), CHLORINE, TOTAL RESIDUAL, SOLIDS, SETLEABLE, PH, BOD, 5-DAY PERCENT REMOVAL, SOLIDS, SUSPENDED PERCENT REMOVAL, SOLIDS, SUSPENDED PERCENT REMOVAL	

Town of Mount Desert Somesville Disharge Volume: .080 mgd*	COLIFORM, FECAL GENERAL, SOLIDS, TOTAL SUSPENDED, CHLORINE, TOTAL RESIDUAL, FLOW, IN CONDUIT OR THRU TREATMENT PLANT, BOD, 5-DAY PERCENT REMOVAL PH, SOLIDS, SUSPENDED PERCENT REMOVAL, SOLIDS, SETTLEABLE, BOD, 5-DAY (20 DEG. C)	
Southwest Harbor Waste Water Treatment Facility 5 Apple Lane, Southeast Harbor, Me 04679 Type of Operation: Sewerage Systems Status: Operating NPDES Permit # ME0100641 Discharge Volume: No Data	BOD, 5-DAY (20 DEG. C), PH, SOLIDS, TOTAL SUSPENDED SOLIDS, SETTLEABLE, FLOW, IN CONDUIT OR THRU TREATMENT PLANT, CHLORINE, TOTAL RESIDUAL COLIFORM, FECAL GENERAL, BOD, 5-DAY PERCENT REMOVAL SOLIDS, SUSPENDED PERCENT REMOVAL, LC50 STAT 48 HR ACU MYSID. BAHIA, LC50 STAT 48 HR ACU MENIDIA, NOEL STAT 1 HR FERT. CHR ARBACIA, NOEL STATRE 7DAY CHR MENIDIA	Atlantic Ocean

1 Query results from U.S. Environmental Protection Agency Permit Compliance System database. Results based on data extracted on 14-DEC-97 Query executed on 22-JAN-98. Copies of current (1997) NPDGS permits can be obtained from: Douglas M. Corb, Mail Code CME, Maine Office of Ecosystem Protection, Boston, MA 02203-2211, tele: (617) 565-4433.

2 Apparently, Seal Harbor, Someville, and Other Creek facilities are covered under the Town of Mount Desert discharge permit.

* Influent Flow only.

CHAPTER 3. ISSUES AND MANAGEMENT RECOMMENDATIONS

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Steve Kahl *University of Maine*
Nick Houtman *University of Maine*
Mark Flora *National Park Service, Water Resources Division*
Charles Roman *U.S. Geological Survey, Biological Resources Division*
Bob Breen *Acadia National Park*

INTRODUCTION

The water resources of Acadia National Park are perceived by the public to be among the cleanest, most pristine waters in Maine. However, these waters are not problem-free. The issues include the 'invisible' impacts caused by acid rain and mercury, eutrophication caused by excessive nutrients from human activities, aquatic ecosystem degradation due to introductions of non-native species, recreational use conflicts, and protection of public health from pathogens at swimming beaches or in public water supplies. Moreover, the water resources of Acadia encompass more than the exceptionally clear waters that the casual visitor enjoys. These resources include colored bog waters in sharp contrast to the clear water of Jordan Pond, estuarine environments near expanding residential development, and groundwater that is increasing needed for serving the public and local residents. These issues, and the diversity of water resources, create the need for a comprehensive management strategy.

This chapter discusses management needs that arise from the hydrology, environmental setting, geographic location, and use patterns of the park. Building upon the description of the water resources and legal issues outlined in the previous chapters, we examine specific issues affecting water resources at Acadia National Park. For each issue, management actions are identified to protect drinking water supplies and the ecological, aesthetic, and recreational values of park water resources. Specific recommendations focus on documenting and clarifying threats, monitoring vital signs, mitigating and/or restoring degraded conditions, cooperating with others, and educating park visitors and neighbors about issues and solutions to problems. Table 3.0 summarizes the recommended management actions of this plan for the following issues:

Section 3.1 Atmospheric deposition and climate change p. 3-7
Section 3.2 Recreational use and management of surface waters p. 3-13
Section 3.3 Wetland and estuarine/marine environments p. 3-21
Section 3.4 Watershed management issues p. 3-26
Section 3.5 Protection of public health p. 3-32

THE PLANNING VERSUS IMPLEMENTATION PROCESS

Resource planning and management are on-going processes that are never finished. This Water Resources Management Plan for Acadia National Park reflects the dynamic nature of planning for management because *several of the recommendations were successfully implemented while the plan was in preparation*. This remarkable result occurred in part because the key people involved in management and research were also the authors of the plan. This rapid success in achieving some of the plan's goals is included in the sections that follow, reflecting the existence of the water resource issue, and the timely implementation of the recommendation.

Table 3.0A Overview of issues, management alternatives, and recommended actions contained in Chapter 3.

Section 3.1: Atmospheric Deposition and Climate Change

Statement of Problem	Recommended Actions
Most surface waters at Acadia National Park are poorly buffered, low nutrient (oligotrophic), and thus potentially vulnerable to acidification. Based on years of data on fog chemistry, abundant ozone and mercury advisories, and 15 years of NADP precipitation chemistry, we know that Acadia National Park is located in the exhaust pipe of the urban northeast and industrial Ohio River Valley. Deposition of atmospherically transported metals and organic compounds of anthropogenic origin may be higher in Acadia National Park surface waters and their watersheds than anywhere else in northern New England. The effects of climate change (predicted to be most severe in mid latitudes where Acadia National Park resides) may also influence aquatic ecosystem function in the park. There is a general lack of knowledge about the functioning of Acadia's watersheds to fully predict ecosystem impacts of episodic acidification, climate change, and/or deposition of toxic substances.	**Continue Existing Program and Enhanced Lake and Watershed Monitoring and Assessment.** The data on atmospheric inputs currently collected by the park is essential to monitoring the long-term status and trends relating to acidifying substances and mercury entering park ecosystems. The impacts of these substances will be assessed through the following additional monitoring and research activities: establishing a long-term paired watershed study focused on nitrogen and mercury biogeochemistry; inventories of organic contaminants with likely atmospheric sources, implementing a peer-reviewed enhanced lake monitoring program.

Table 3.0A continued. **Section 3.2: Recreational Use and Management of Surface Waters**

Statement of Problem	Recommended Actions
Protection of natural resources and visitor experiences on Great Ponds in Acadia National Park is complicated because the National Park Service, State of Maine and local water companies all have a special interest and/or responsibility for their management. Under state law, the public has a right to fish, fowl, and navigate on all Great Ponds regardless of ownership. Although prohibited in Acadia National Park and contrary to National Park Service policies, state law permits hunting and trapping on Great Ponds within the park. The National Park Service believes that these activities are inappropriate and conflict with the purposes for which the park was established. Fisheries management on Great Ponds at Acadia National Park has emphasized enhancement of sport fish production using hatchery reared non-native and native species. The National Park Service believe that greater attention is needed to conserve native fish species and protect native aquatic ecosystem integrity, and provide quality and diversity in recreational fishing opportunities. Given increasing, demands for outdoor recreation at the park, the National Park Service desires that all surface uses of waters be consistent with the purposes for which the park was established. Given current authorities, the State of Maine cannot resolve or manage user conflicts, noise and boat speed problems on Great Ponds at Acadia National Park	**Cooperative Management.** The National Park Service is committed to work collaboratively to ensure that water based recreation and natural resource management at Acadia National Park is consistent with the purposes for which the park was established. This will be accomplished through the following activities. 1. Establish formal cooperative agreement with the Maine Department of Inland Fisheries and Wildlife. 2. Pursue state legislation or other alternatives to prohibit hunting and trapping on Great Ponds in the park. 3. Develop a cooperative fisheries management plan. 4. Conduct a park-wide aquatic ecosystem inventory. 5. Protect visitor experiences on Great Ponds by actively working with state to develop appropriate regulations that recognize and protect the special qualities of the Great Ponds at Acadia National Park.

Table 3.0A continued. Section 3.3: Wetland and Estuarine/Marine Environments

Statement of Problem	Recommended Actions
Wetland comprise more than 10% of Acadia National Park. The National Park Service is concerned about maintaining the functional quality of park wetlands. Recent studies in Bass Harbor suggest that this estuary may be tending toward eutrophied conditions. Park wetlands are also threatened by non-native plant species. At present, the park only manages purple loosestrife, but many other invasive species inhabit park wetlands. Given the intense commercial boat traffic along the Acadia National Park coastline (fishing and tanker), there is a potential for oil spills. At present the park has only a limited ability to effectively assess the ecological impact to park wetlands following such an event. Increasing visitation to sensitive wetland habitats also threatens resources through trampling vegetation and illegal animal and plant collecting.	**Initiate Comprehensive Monitoring and Research, and Manage Visitor Impacts.** Based on recommendations identified in baseline studies at Bass Harbor Marsh, Somes Sound, Northeast Creek and Anemone Cave, a long-term integrated monitoring program of park estuaries and intertidal areas will be developed and implemented as funding becomes available. Non-native wetland plants will be ranked according to their threat to park resources, and efforts will be made to manage and monitor those that pose the greatest risk. Wetlands with dikes, ditches, or other human -made structures will be evaluated to assess hydrologic effects. Sites that are significantly altered will be considered for restoration. Efforts will be made to enhance visitor education about wetland values, fragility, and appropriate ways to visit these communities without causing lasting disturbances.

Table 3.0A continued. **Section 3.4: Watershed Management Issues**

Statement of Problem	Recommended Actions
Management and protection of water resources at Acadia National Park is complicated because only a portion of the major drainage systems on Mount Desert Island are located within the park. Activities taking place outside the park can significantly impact waters in the park. In addition, park visitor facilities are extensive and if not properly designed and managed may also contribute to nonpoint source pollution. Inadequate disposal of wastewater is one of the biggest local threats to park water quality. Surface runoff from roads and trails can also be a potential problem.	**Continue Existing Programs and Cooperate with Other Island Communities to Protect Water Quality.** The park has adopted a set of guiding principles that are now routinely used when designing new or upgraded sewage treatment facilities to minimize nutrient and bacteriological loading of sensitive waters. The park will also continue to apply good management practices to address other nonpoint sources of pollution using waterbars, protecting riparian buffers, restoring disturbed areas, and other methods in trail and road maintenance. The park, working in collaboration with the Mount Desert Island League of Towns, Friends of Acadia, and others, will participate in the formation of lake associations if they are desired by shoreline property owners.

Table 3.0A continued. **Section 3.5: Protection of Public Health**

Statement of Problem	Recommended Actions
As a public water supplier, the park is required to comply with the 1986 amendments to the Safe Drinking Water Act as well as to National Park Service public health guidelines. As part of these requirements, the park routinely monitors for a range of chemical, bacterial, and radiological contaminants of its drinking water systems. Groundwater is the water source for park headquarters, visitor facilities, and staff housing. Four municipal water supply systems withdraw water from lakes within or adjacent to the park. The towns of Bar Harbor, Seal Harbor, and Northeast Harbor currently have exemptions from filtration requirements for lakes serving as public water supplies within the park. In order to maintain these exemptions, close cooperation in watershed management activities between the park and municipalities is required. This requires the National Park Service to properly maintain septic systems, to prohibit the routine use of pesticides in the park, and to enforce camping restrictions within the affected watershed. The park has two designated swimming beaches and several other locations where swimming occurs. Ensuring that visitors have a safe swimming environment free of bacterial contamination is an essential park management objective.	**Continue Existing Programs and Enhance Public Awareness About Public Water Supplies.** Funding has recently been made available to Acadia National Park for the purpose of rehabilitating and upgrading most of the water supply systems within the park. Once the repairs and improvements are completed, all public and non-public potable water supply systems in the park will meet or exceed all current state and federal standards. Routinely required monitoring will assure that all park water supplies are safe. Given that there are limited sources for bacteria around public swimming beaches and that monitoring between 1993-1995 detected only low levels, annual monitoring is not warranted. Future bacteriological monitoring will be conducted seasonally over a 2-3 year period every decade. The National Park Service will continue to collaborate with local water companies to ensure maximum protection for public drinking water supplies. In addition, the park will work with the water companies, towns, and others to increase public attention and awareness about water quality issues and ways to protect public drinking water supplies.

Section 3.1 ATMOSPHERIC DEPOSITION AND CLIMATE CHANGE

Steve Kahl, University of Maine

INTRODUCTION

The 1990 Water Resources Scoping Report for Acadia National Park (National Park Service, 1991a) identified atmospheric deposition as one of the key areas of concern for water resources at Acadia. Subsequent discussions with natural resource specialists, focus groups, as well as responses to the public questionnaire during the information gathering phase of the plan, indicated that acidic deposition was indeed viewed as a potential threat by both the scientific community and the public. We use the term 'atmospheric deposition' to mean more than just 'acid rain'. In fact, there are many pollutants of environmental concern that have significant sources from the atmosphere, including trace metals and classes of organic substances such as pesticides, PAHs, dioxins, and PCBs.

Climate change is a related issue of concern expressed by both scientists and residents of Mount Desert Island during the information gathering phase of preparing this document. In this section, we include discussion of management actions relating to atmospheric deposition *and* climate change because they are interrelated, ecosystem-scale issues for which data collection requirements are similar and overlapping. The rationale for the linkage between atmospheric deposition and climate change is that both threats potentially affect park resources over a time frame of years to decades. Both are 'non-point' sources of change, potentially affecting a broad variety of resources. Both may ultimately influence water resources by impacting soils, water, and forest resources. In addition, the climatic and hydrogeochemical data required for long-term monitoring and research on potential ecosystem-level effects of both atmospheric deposition and climate change are similar, and these data are collected with the same methods. Thus, the recommended management actions address both issues.

STATEMENT OF THE PROBLEM

Most of the surface waters at Acadia National Park are poorly buffered with low productivity, and thus potentially vulnerable to acidification. Modern baseline chemistry is largely limited to data collected in the 1980s by Kahl and co-workers (Kahl *et al.*, 1993; Heath *et al.*, 1992; Kahl *et al*., 1985), and a repeat survey in 1995 (Kahl, 1996). Long term trends in chronic acidity status and other issues related to atmospheric deposition cannot be discerned with these limited data. Changes in climate, if any, may superimpose chemical or hydrologic ecosystem perturbations on watersheds already stressed by acidic deposition. Monitoring such changes requires long-term consistent data collection.

In addition to deposition of acidifying substances, many other contaminants at Acadia National Park have an atmospheric source. This source for contamination is the main threat to the park environment, because parklands typically occupy the upland headwaters of Mount Desert Island. Runoff is unlikely to be the mechanism of contamination for toxic substances. The contaminant for which we have the most data is mercury (Hg), a main subject of the paired-calibrated watershed research underway since 1998. The source for Hg is global long-range transport, plus local sources that are upwind of the park in eastern Maine (Maine Department of Environmental Protection, 1998).

We know that atmospheric deposition is responsible for high levels of certain trace metals and sediments (Norton *et al*., 1998; Norton and Kahl, 1987; Kahl *et al.*, 1985). We also know that polluted air masses move across the Gulf of Maine from the eastern seaboard, depositing contaminants along the coast of Maine. We suspect that atmospheric deposition of highly toxic substances such as dioxins, PCBs may be important at Acadia National Park, but we presently have no data (see recommendation 3.1.2d). These substances are known to be carcinogens at very low concentrations. They may also be endocrine disrupters with significant potential for reproductive consequences in many species.

Acadia National Park resource managers need to determine to what extent atmospheric deposition is adversely impacting park water resources, and what the trends are for these impacts. Basic knowledge about the functioning of watershed scale ecosystems is necessary to anticipate the ramifications of these potential changes. Present or future biological impacts from episodic acidification or deposition of toxic substances such as mercury are poorly understood. Because of the droughty thin soils, small changes in precipitation and temperature could lead to severe impacts on aquatic biota or even terrestrial ecosystems. The need exists for research and monitoring on the related issues of climate change and atmospheric deposition of acidifying or toxic substances.

In the broadest sense, the issue of global climate change is of direct relevance to water resource management. Climate change is a matter of great uncertainty, but many atmospheric circulation models suggest that the mid latitudes (around 45° north and south latitude) may experience the largest changes in temperature and rainfall patterns. Acadia National Park is located between approximately 44° 10' and 44° 30' north latitude. Climate change could affect aquatic ecosystem function as well as affecting forest ecosystem integrity, including water balances, nutrient cycling, and forest succession. All of these factors directly impact water resources in the park. Acadia National Park is also located at the transition between northern hardwood forests of southern New England, and the boreal spruce-fir of northern Maine, Quebec, and maritime Canada (McMahon, 1990). This location makes it especially likely that the natural resources at Acadia National Park will be substantially affected by changes in climate if they occur.

In the next several decades, atmospheric deposition and possibly climate change will continue to influence Acadia National Park water resources. An emerging issue is that of base cation depletion in northeastern soils (Liken *et al*., 1996). Recent studies (Watt *et al*., 2000; Kahl, 1999; Stoddard *et al*., 1999) have shown that base cations are declining faster than sulfate concentrations in surface waters of the northeastern North America. This discrepancy is preventing recovery in pH and alkalinity in surface waters. However, the implications for forest nutrient status (e.g. Likens *et al*; 1996) are substantial. The decline in base cations may be climate-related (Kahl, 1999; Stoddard *et al*., 1999), and will be one of the issues of major interest in the new calibrated watersheds at Acadia.

Nitrogen loss from forested catchments is an important issue for continued research (Aber *et al.*, 1998; 1989; Kahl *et al.*, 1993b). Potential changes in nutrient cycling may be due to changes in the chemistry of precipitation, changes in local climate, other unrecognized factors, or a combination of several factors. Whatever the cause, this nutrient loss has *direct* implications for fresh water quality, and for the N-limited estuarine waters around Mount Desert Island. The *indirect* implications of N export from forested ecosystems may be changes in soil chemistry and forest health, with resulting changes in water retention. An additional problem is the possibility of increased episodic acidity associated with increasing nitrate export to surface waters.

At present, there is no evidence for either an increase in leaching of nitrogen from Acadia National Park watersheds, or of chronic acidification of surface waters. However, some watersheds, including the Upper Hadlock watershed under study as part of new watershed research, have substantial nitrogen loss in stream water. The lack of regular data collection yields an inability to forecast long-term watershed changes due to changes in climate, atmospheric chemistry, visitor usage, local land use, or other regional changes that are not yet recognized. Moreover, the potential for estuarine eutrophication due to N flux from terrestrial watersheds has had increasing attention in recent years (Doering and Roman, 1994).

MANAGEMENT OBJECTIVES

Acadia National Park management objectives for these issues are:

1) Maintaining high water quality to protect public health, maintain ecosystem integrity, and preserve the existing high water quality.

2) Promoting and conducting inventories, monitoring, and research necessary to understand and detect trends, and if necessary, developing mitigation strategies for addressing potential effects of acidic atmospheric

deposition, point source and non-point source contamination, climate change and other influences upon park water resources.

RECOMMENDATIONS

3.1.1: Continuation of existing programs in atmospheric deposition and baseline lake monitoring.

Currently, Acadia National Park maintains a meteorological, air quality and wet deposition monitoring station at McFarland Hill. In addition to being an important site within the National Atmospheric Deposition Program (NADP) nationwide monitoring network, this station provides essential baseline information on precipitation chemistry, mercury deposition, ozone and atmospheric particulates. The continuation of this data collection will be essential in determining long term status and trends for both precipitation chemistry and air quality. These data will serve as a reference for future monitoring and research on the effects of these human-made influences on sensitive park resources.

Over the past several years, Acadia National Park has also instituted a summer limnological monitoring program in partnership with the University of Maine Water Research Institute. The program monitors for basic physical and chemical water quality parameters designed primarily to address eutrophication and should be continued. However, this program does not address the scope of stated management objectives in this section that relate to the other potential issues for waters in the park. Additional research and monitoring are therefore also recommended below.

3.1.2: Development of enhanced long-term monitoring and research program.

The data on atmospheric inputs currently collected by the park is essential to monitoring the long-term status and trends relating to acidifying substances and Hg entering the park ecosystem from the atmosphere. However, these data are inadequate for assessing the long-term impact of these inputs. Consequently, the present activity (recommendation 3.1.1) is necessary but not sufficient to meet the management objective of maintaining ecosystem integrity and preserving the existing high water quality. Therefore, this recommendation proposes a sustainable, long-term monitoring program capable of providing an adequate level of impact assessment for freshwater aquatic resources.

Research and monitoring may document actual impairment of water uses, which would be violations under section 303d of the Clean Water Act. This violation could require development of Total maximum Daily Load for non-point source pollutants if so listed by Maine DEP. A TMDL requirement could result in a requirement to address atmospheric loading of polluntants ranging from acids to mercury.

Implementation of some of the components of this recommendation have already begun through the efforts of Acadia National Park natural resource staff and cooperators from the University of Maine. This group has:

- convened a workshop in 1997 of local and regional experts to evaluate options and assist with the design of a long term monitoring program;
- drafted a monitoring protocol for lakes which will be subjected to external peer review and comment in 2000;
- begun field testing in 1997 of the recommended protocol;
- resulted in funding of three proposals to develop a pair of calibrated watersheds focused on N and Hg biogeochemistry; and
- begun monitoring for UV-B; and dry atmospheric deposition as part of National Dry Deposition Network (NDDN).

In addition, the following future educational activities are also recommended: training park staff in field and laboratory techniques and data management protocols; and developing education programs and displays based on long-term monitoring data would help better inform local residents and visitors about the issues of atmospheric deposition and climate change.

Recommendation 3.1.2a: Long-term monitoring and research in paired, calibrated watersheds

This effort is designed to provide an enhanced understanding of fundamental watershed ecosystem status and function, and a baseline reference against which future chemical and hydrologic trends can be compared. The implementation of this option has already begun, with EPA funding (Kahl *et al*., 1998) and USGS funding (Kahl et al., 1999) to the University of Maine and co-workers at Acadia National Park and the USGS for a paired-watershed field design.

These projects have established two calibrated watersheds in dissimilar forested catchments for the purposes of:

a) determining trends in seasonal and annual elemental mass balances;
b) examining in detail the chemistry and ranges of episodic acidification of potential biological significance; and,
c) serving as a long-term monitoring baseline for other related research on air quality, precipitation chemistry, water quality and quantity, aquatic biota, forestry, and non-point source pollution.

One study watershed is in an area burned in the 1947 fire (the Cadillac Brook watershed), and one in an unburned area (the Hadlock Brook watershed) area. These areas differ markedly in vegetation age, species composition, and soil chemistry (especially forest floor development and organic horizon composition). Therefore, each area will respond differently to changes in climate and to the effects of atmospheric deposition. Neither of these catchments has anthropogenic development; thus, they serve as references for trends in analytes related to non-point source pollution, affected only by atmospheric deposition and climate.

The routine ecological data will include: temperature, color, conductance, closed cell (field) pH, air-equilibrated pH, acid neutralizing capacity (ANC), calcium, magnesium, potassium, sodium, ammonium, silica, total aluminum, dissolved inorganic carbon, dissolved organic carbon, total nitrogen, total phosphorus, chloride, nitrate, and sulfate. In addition, a calibrated watershed presents the opportunity to study the biogeochemical cycling, ecological magnification and bioaccumulation of mercury and other chemicals of environmental toxicity. Few such studies are known to be underway in eastern North America for toxics such as mercury or dioxins, both of which have significant sources from atmospheric deposition. For example, sufficient data exist for mercury in fish and sediments to establish that the issue of significant concern at Acadia National Park. The next logical step is to examine the processes that control mercury mobility and bioaccumulation in watersheds with different characteristics.

This approach will provide the most complete assessment of ecosystem function, chemical weathering, dry deposition, water chemistry, episodic acidification, and rates of change. Therefore, data from calibrated watersheds offer the best potential for recognizing problems and determining trends before the impact is significant. The myriad of uses of data from sites such as the Bear Brook (ME) and Hubbard Brook (NH) watersheds is testimony to the usefulness of these types of data. Such projects provide the infrastructure and background data that attracts additional research dollars from other sources, thus multiplying the benefits to the National Park Service beyond the actual investment in National Park Service dollars. The drawbacks often cited for this type of project are the cost and the long-term commitment, although the long-term commitment should be viewed as an advantage, not a drawback.

Recommendation 3.1.2b: Seasonal sampling of lakes

This approach would sample selected lakes during summer stratification and during spring and fall overturn, for a baseline chemistry against which future data can be compared. Using the locations from prior surveys (Kahl, 1996; Heath *et al.*, 1992; Kahl *et al.*, 1985), the lakes would include those entirely within park boundaries, or bounded by the park. Summer sampling would be included for selected lakes in the 1992-93 summer eutrophication survey (Reeb, 1992). The spring overturn period will yield information on the nature and magnitude of spring acidification in lakes. Long-term data from this period will provide insight into any trends. Lakes are most homogeneous in October and November, during isothermal overturn. This fall 'index' period (Linthurst *et al.*, 1986) provides the most representative and cost-effective opportunity to assess the baseflow chemistry of lakes.

Recommended routine data include: temperature, dissolved oxygen on selected sites (summer stratification only), secchi transparency, color, conductance, closed cell (field) pH, air-equilibrated pH, acid neutralizing capacity (ANC), calcium, magnesium, potassium, sodium, ammonium, silica, total aluminum, dissolved inorganic carbon, dissolved organic carbon, total nitrogen, total phosphorus, chlorophyll, turbidity, total suspended solids, chloride, nitrate, and sulfate. Data on chlorophyll, total P, and total N would provide baseline information on non-point pollution, and on nutrient cycling in forested ecosystems.

Recommendation 3.1.2c: Monitoring of benthic invertebrates and zooplankton communities

An alternative to chemical monitoring is biomonitoring using changes in benthic invertebrate and/or zooplankton community structure. Such monitoring assumes that sensitive aquatic species integrate the environmental conditions to which they are subjected. An environmental stress is reflected in altered population distributions, although the casual factor may not always be apparent from this type of monitoring even when ecosystem impairment is indicated. This type of monitoring offers the advantage of collecting fewer samples per year, per site, than traditional chemical monitoring. This option is being investigated in cooperation with Maine Department of Environmental Protection, utilizing Maine Department of Environmental Protection methods and standardized data analyses procedures on a selected subset of Acadia National Park streams. A pilot benthic macroinvertebrate project was conducted in 1997 on four park streams. These results will be reviewed and analyzed, and at least one additional year of monitoring is anticipated.

Recommendation 3.1.2d: Inventory of metals and organic toxic substances

Due to the lack of data on contaminants such as dioxins and PCBs, the first step in examining these substances will be an inventory of selected ecosystem components. These substances are typically too low in concentration to monitor in precipitation or surface waters. Thus, the costs for inventory and monitoring are high due to the expense of the analyses, but are one-time or periodic costs rather than on-going. The inventories for these substances are conducted on soils and sediments to identify if the problem exists. If an issue is determined to exist, a realistic research program on biota can be designed based on the inventory. Implementation of this recommendation in the existing calibrated watersheds would be cost-effective and provide key baseline information for future research.

MANAGEMENT ACTIONS CONSIDERED BUT NOT RECOMMENDED

Chemical monitoring of selected streams

A 1982-84 stream water quality survey provided a general characterization of stream chemistry in 23 streams and brooks within Acadia National Park by collecting at most a dozen samples per year. However, this approach is not be practical or cost-effective for monitoring flowing waters on a long term basis. If data on a broad sampling of streams are desired, dozens of samples per stream per year are required, over a range of seasonal and hydrologic conditions. Instead, it is more appropriate to collect this information on one or two well characterized streams that are assumed to be 'representative', using the watershed-based monitoring already in place. Results from this type of work can be generalized for the general population of streams and brooks.

Monitoring for bioaccumulation of metals or toxics

One of the issues listed in the 1990 Water Resources Scoping Report for Acadia National Park was the potential bioaccumulation of metals or toxics in invertebrates or fish (National Park Service, 1991a). Since the Scoping Report was written, new information has been gathered on the issue of mercury in Maine. We know that older specimens of certain fish species bioaccumulate Hg to concentrations that are considered to be above safe limits for routine human consumption (T. Haines, pers. comm.). Work by T. Haines, S. Norton, and S. Kahl at the University of Maine has gathered information from lake sediments in the park to determine the historical trends in Hg deposition, and by inference, to determine how much Hg may be naturally present in the local environment. The next step is to determine how watershed chemical and physical characteristics affect the cycling, speciation,and ultimately the bioaccumulation of Hg. This type of research is ideally suited to build upon data collection activities that will be part of the calibrated watersheds. The proposals funded in 1998 and 1999 will expand the scope of Hg process-level research at the watershed-scale.

Alternative methods for measuring dry deposition.

Park staff requested that an evaluation of the issue of dry deposition be included in this Water Resources Management Plan. The new monitoring site at McFarland Hill includes dry deposition monitoring as part of the National Dry Deposition Network (NDDN). This station in the national network generates data comparable to other sites. We do not believe that additional effort is warranted for dry deposition, for three reasons. First, there is little agreement in the scientific community on the methods for measuring dry deposition. Measurements of dry deposition are generally in substantial disagreement with other measures such as watershed mass balances (Rustad *et al*., 1994). Second, the amount of dry deposition is reflected in stream and lake chemistry, and by elemental mass balances from calibrated watersheds. Although there are other input and recycling terms in a mass balance equation for a watershed, estimates of dry deposition for some elements are possible by difference when wet deposition and stream solute flux are well characterized. Third, a calibrated watershed may include measurements of throughfall chemistry as part of an associated research project. Throughfall is wet deposition after it passes through the leaf canopy. Estimates of dry deposition on throughfall data are possible for some elements, by difference with wet deposition.

Liming of low pH lakes or streams.

There is no justification for adding limestone to increase pH in any park waters. Although these are naturally oligotrophic, poorly buffered waters with low Ca concentrations, few have low pH. $CaC0_3$ amendments to surface waters, regardless of pH, would be gross pollution of these low Ca waters at Acadia National Park and would be seriously deleterious to extant populations or organisms that are adapted to living in these waters. The two acidic lakes in the park (Sargent Mountain Pond and Duck Pond) are function ecosytems in equilibrium with their pH. Duck Pond in particular is naturally acidic, and thus liming would drastically alter the natural biotic communities in the pond and its watershed.

Section 3.2 RECREATIONAL USE AND MANAGEMENT OF SURFACE WATERS

David Manski, Acadia National Park
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INTRODUCTION

The National Park Service, State of Maine, and local towns and water companies all have a special interest and responsibility for management of water resources at Acadia National Park . These multiple jurisdictions complicate the protection of natural resources and the visitor experience. The Great Ponds in the park offer particular management challenges, because each of these entities has distinct authorities and sometimes conflicting management objectives.

Great Ponds are defined in Maine Statutes as an inland body of water which in its natural state has a surface area in excess of 10 acres (4 ha) or any impoundment with an area greater than 30 acres (12 ha) (Title 38, Chapter 3, 1973, c. 608 Article 1-A, subsection 381). Nine Great Ponds are located completely within the legislative boundary of the park and five other Great Ponds border park lands (Table 2F).

National Park Service responsibilities for all waters within the boundaries at Acadia National Park (including Great Ponds) focus on protecting water quality, aquatic ecosystem integrity, public drinking water supplies, and visitor experiences. Authorities for resource stewardship, visitor management and safeguarding public health at the park are based upon National Park Service enabling legislation (National Park Service Organic Act, 16 USC 1) and policies (National Park Service, 1988), federal regulations (36 CFR Parts 1-99), and Acadia legislative history and mandates. In 1986, boundary legislation (Public Law 99-420) was enacted that defined a permanent park boundary in order "*to protect and conserve the land and **water** resources*"(our emphasis) of Acadia National Park.

Local interest in protecting park water resources is reflected in the unique history of the park. Strong public interest in watershed preservation on Mount Desert Island was one of the main purposes for the establishment of the Hancock County Trustees of Public Reservations in 1901. This group of dedicated individuals acquired private lands that were ultimately donated in 1916 to the federal government for the establishment of Sieur de Monts National Monument (later, Lafayette National Park and in 1929, Acadia National Park).

Under state law, the public has the right to fish and fowl on Great Ponds. The Maine Department of Inland Fisheries and Wildlife (Inland Fisheries &Wildlife) is the agency responsible for fish and wildlife management and the regulation of public use on Great Ponds. At Acadia National Park, Inland Fisheries & Wildlife has historically managed fisheries and recreational fishing. They stock native and non-native fish in Great Ponds and other smaller water bodies for the purpose of enhancing sport fish production and recreational fishing opportunities. The IF&W also manages hunting and trapping on the Great Ponds.

Because Great Ponds are public property owned and controlled by the State of Maine, the state may also authorize diversion of Great Pond water for public use (American Woolen v. Kennebec Water District, 66A. 316, 317 [1906]). Under this authority, the state can authorize municipal water companies to remove water from Great Ponds (Camden v. Town of Hope, 543 Aa.2d 827, 829 [1988]). The state and local governments can also enact various surface-use ordinances and statutes to protect water supplies (22 MRSA 2641 et. seq; 12 MRSA 7801; 38 MRSA 1841). In addition to complying with these statutes, water companies must comply with the Federal Safe Drinking Water Act (42 U.S.C. § 300g *et al.* and its regulations, 40 CFR 140 et seq.), which established national minimum water quality standards and requirements for the protection of public drinking water. The state, through the Department of Human Services, is responsible for implementing the Safe Drinking Water Act (U.S.C. § 300g-2).

On Mount Dessert Island, six of the 14 Great Ponds serve as public water supplies for four Mount Desert Island communities. In order to comply with federal and state safe drinking water laws, town and private water companies institute restrictions for the surface-use of these six Great Ponds.

Three main issues relate to recreational use and management of freshwaters to the Great Ponds at Acadia National Park. These are:

1) hunting and trapping,
2) fisheries management,
3) water based recreation.

The National Park Service considers that hunting and trapping are inconsistent with the purposes for which the park was established, that priority attention be given to the acquisition of baseline fisheries data and conservation of native fish species and genotypes, and that water-based recreation be compatible with traditional and contemplative park visitor activities. The following sections of Chapter 3.2 address these issues.

STATEMENT OF PROBLEM

Hunting and Trapping

National Park Service policies intend to provide the public with opportunities to enjoy natural environments that are minimally influenced by human actions. Management emphasis is on minimizing human impacts on native animal populations (National Park Service, 1988). The mission at Acadia National Park is to protect and preserve outstanding scenic, natural, scientific and cultural values and provide opportunities for non-consumptive resource-based recreation and education (National Park Service, 1992). National Park Service policies state that public hunting and trapping within national parks is prohibited unless specifically authorized by federal law (National Park Service, 1988).

No authorization for hunting and trapping is included in any federal legislation pertaining to Acadia National Park. However, hunting and trapping occurs at the Great Ponds within the park based on the Colonial Ordinances which grant 'fishing' and 'fowling' rights on Great Ponds. Inland Fisheries &Wildlife has managed hunting and trapping on Great Ponds within the park with little communication with park staff. The park has issued as many as a dozen permits a year to transport firearms and traps across park property to reach Great Ponds (Norm Dodge, personal communication, 1995). Permits have been issued for access to Witch Hole Pond, Aunt Betty Pond, Eagle Lake, Jordan Pond, and Lake Wood. Only a few of the permits each year have actually been used by hunters and trappers. The small number of permits issued each year, and the even fewer number of permits used, implies that harvests are likely not impacting wildlife populations and suggests that these activities are not in high demand.

Management concerns over hunting and trapping at Acadia National Park focus on visitor safety, visitor experience, and aesthetics. Many of the Great Ponds where hunting occurs are located immediately adjacent to the park's historic carriage roads and hiking trails. These ponds offer some of the most spectacular scenery in the park. With nearly 3 million people visiting Acadia National Park each year, some of these individuals invariably come into contact with hunters. While no one is known to have been injured, visitors may perceive a safety threat from individuals observed transporting firearms or hunting at Great Ponds in the park. More importantly, firearms, traps, and/or harvested wildlife within park boundaries are inconsistent with the usual visitor experience in a national park. Visitors to Acadia National Park believe they are recreating in a nature preserve in which wildlife are protected from hunting and trapping. Park staff believe that hunting and trapping are inappropriate on Great Ponds at Acadia National Park.

Fisheries Management

Unlike hunting and trapping, recreational fishing is permitted in units of the National Park System except where specifically prohibited by legislation and when it does not interfere with the functions of natural aquatic ecosystems or riparian zones (National Park Service, 1988). Management and protection of native species and aquatic communities, while providing the recreational angler with a quality fishing experience, is the focus of National Park Service recreational fisheries program. Specifically, the National Park Service seeks to preserve and/or restore natural aquatic habitats, and the natural abundance, age, and size distribution of native aquatic species. Policies also

strive to preserve the natural behavior and diversity, genetic variability, and ecological integrity of fish populations. The National Park Service also works to support and enhance recreational fishing opportunities when ever possible, while conserving and protecting fisheries resources and related aquatic and terrestrial ecosystems (National Park Service, 1992).

Freshwater recreational fishing is permitted at Acadia National Park. Inland Fisheries &Wildlife regulates and manages freshwater fishing on Great Ponds in the park. The agency establishes regulations on seasons, fish length and daily catch, and method of taking. In addition, state fisheries biologists conduct periodic creel surveys, trap-nettings, and gill nettings to determine relationships between landlocked salmon, togue, brook trout with forage species like smelt, and landlocked alewifes (Ron Brokaw, Maine Department of Inland Fish and Wildlife, personal communication, 1994). The state relies primarily on annual stockings of hatchery reared native and non-native fish to lakes and ponds in the park (including non-Great Ponds) to enhance sport fish production. IF&W biologists have manipulated prey species as a management tool to enhance populations of game fish, often without the knowledge of Acadia National Park staff. The extent of National Park Service participation in these activities is to occasionally open locked gates for state biologists to gain access to a pond or lake. The National Park Service also makes available several public parking areas and boat ramps to enable visitors to access the water.

With the exception of supporting ongoing research on the accumulation of mercury in the park aquatic environment (see below), the National Park Service is not directly engaged in any fishery management programs at Acadia National Park. Until recently, this was in part due to the lack of National Park Service staff with time for involvement in fishery management issues. Although the State of Maine has been the lead agency for fisheries management, the National Park Service has a strong interest in, and mandated responsibility for, the protection of these aquatic resources and management of recreational activities at the park. The National Park Service is therefore interested in becoming more involved in fisheries management issues at Acadia National Park. In particular, the goal is to focus greater attention on the conservation of native fish species and aquatic communities in park waters consistent with National Park Service policies. The National Park Service desires to collaborate with the IF&W to conserve native fish species and aquatic communities, protect ecosystem integrity, and provide quality and diversity in recreational fishing opportunities at Acadia National Park.

Another concern to the National Park Service is the lack of baseline information on the distributions, species composition, habitat affiliations and relative abundance of all fish populations at Acadia National Park. While IF&W has historical data for most of the harvested species, there is a lack of information on non-game fish, native sea-run brook trout and other anadromous and catadromous species. Such information is necessary to manage fisheries in a manner that will preserve and protect native aquatic ecosystems. Baseline data are essential to identify and evaluate potential effects of acid deposition, cultural eutrophication, human harvest, introductions of non-native species and other factors. A lack of historical data and the existence of more than a century of human impact complicate the task of characterizing modern impacts on aquatic ecosystems. Water quality impacts related to atmospheric deposition are described in section 3.1, but other ecosystem-scale impacts in the park have not been studied.

Another concern to the National Park Service focuses on the potential ecological and public health problems associated with mercury contamination in the aquatic environment at Acadia National Park. Results from a 1993 statewide study of mercury levels in fish, revealed that smallmouth bass sampled from Hodgdon Pond at Acadia contained the highest levels of mercury found in the study (3.4and 2.8 parts per million; Terry Haines, Biological Resources Division, U.S. Geological Survey, personal communication, 1994). The elevated mercury levels found in fish throughout the state prompted the Department of Human Services to issue a health advisory recommending that pregnant women, nursing mothers and children under 8 years old should not eat fish from Maine lakes. The present advisory also suggests other limits for consumption for segments of the population.

Based on the preliminary results at Acadia National Park, the National Park Service and National Biological Survey funded research in 1995 to better understand the severity and extent of mercury contamination in aquatic habitats at the park. Research has been completed to document the levels of mercury contamination in park fish, evaluate the presence of mercury in the aquatic food chain, assess the magnitude of mercury deposition from the atmosphere and evaluate the historical deposition patterns in park lakes (Burgess, 1977). A related study was funded by the

University of Maine Water Research Institute to evaluate the historical pattern of mercury deposition by evaluating additional lake sediment cores in Maine.

Recreation

Water-oriented recreation is an important part of the public recreation of Acadia National Park. Park lakes and ponds offer outstanding recreational opportunities for visitors to explore, swim, boat, and fish. These water resources provide an extraordinary scenic backdrop to the exposed rocky mountain summits and glacially carved valleys. Lakes also offer the visitor a quiet alternative to the more heavily congested tourist destinations such as Cadillac Mountain, Sand Beach, or Thunder Hole.

Park visitation has increased dramatically in the past decade and now approximates three million visitors annually. The length of the primary visitor season has doubled from 11 summer weeks to a 22-week summer/fall season. More park visitors are seeking backcountry areas, which include the park's many lakes and ponds. Active management of park users has now become a necessity in order to protect natural resources and to ensure that visitors continue to have opportunities for high quality recreational experiences. The National Park Service is specifically concerned that expanding visitation to the park's freshwater lakes and ponds could result in shoreline erosion and vegetation trampling, degradation of water quality, increased noise, and/or conflicts among different users recreating on or near the water.

There is substantial concern about the issue of crowding at Acadia National Park by visitors and residents of Mount Desert Island (Manning, 1987). One-quarter of summer visitors sampled and over one-third of residents indicate they generally found the park too crowded (Manning, 1987). This opinion was much more prevalent among repeat visitors and residents than among first-time visitors. More than half of Acadia's visitors are repeat visitors and most of them return frequently. The perception of crowding was substantially higher among those who participated in activities such as camping and hiking. While many visitors enjoy social interaction, the study indicated an expectation among those seeking solitude that was not being satisfied.

The National Park Service has authority to regulate visitor activities and to enforce federal regulations that protect natural, cultural, scenic and recreational resources within the park. The National Park Service oversees visitor activities on lands surrounding Great Ponds, but has not attempted to regulate surface water activities. Until 1998, the Commissioner of IF&W had rule making authority (12 MRSA 7792) to regulate waterbased recreation on Great Ponds *only* for safety reasons. The agency had no ability to institute regulations at Great Ponds to resolve natural resource management concerns, aesthetic problems, noise, or user conflicts. New state legislation passed in 1998 provides for a process by which municipalities can recommend surface water regulations to address these issues.

Six of the Great Ponds at Acadia National Park serve as public water supplies for four Mount Desert Island communities. The water utilities that supply drinking water have the authority to restrict access and surface-uses on these water bodies (22 MRSA 2642) in order to comply with Maine Department of Human Services requirements and the 1986 Amendments to the Safe Drinking Water Act. Currently, specific town and state regulations are in effect on the Great Ponds in Acadia to protect public water supplies. While these regulations clearly limit present recreational activities on these ponds, water companies and towns likely will not have the authority to resolve noise, aesthetic and some crowding and environmental problems that could develop in the future.

The lack of rules and clear authority to establish appropriate regulations to manage user conflicts, noise, and boat speed has been a significant public policy issue for the State of Maine. Increasing citizen complaints and expressions of concern about existing social and environmental problems at many Great Ponds in the state resulted in the Governor establishing a task force to address these issues. The Great Ponds Task Force submitted a report to the legislature in 1997 based on extensive public input, including comments from the National Park Service. Their report recommended actions to protect the special qualities of the Great Ponds at Acadia National Park. The legislature in 1998 included landmark regulations that included the prohibition ofinternal combustion engines at five park Great Ponds and limited horsepower on two others. The National Park Service and the non-profit Friends of Acadia, worked closely with local communities, state representatives, and the legislature to facilitate these new regulations. With this legislation and horsepower restrictions already in place on other park waters, Acadia

National Park became the first park unit in the National Park System to ban personal watercraft ('jet-skis') on lakes within the park. This milestone was achieved through state rather than federal action.

Personal watercraft are presently still allowed on lakes bordering the park (e.g. Long Pond on Mount Desert Island, and Long Pond on Isle au Haut). The new law permits towns to petition IF&W to regulate or ban these craft. All Mount Desert Island towns are considering such action as of 1998. The National Park Service desires that all surface uses of waters be consistent with the purposes for which the park was established. Water-based recreation on Great Ponds within and adjacent to the park should be compatible with other non-consumptive activities that park visitors engage in such as hiking, biking, photography, bird watching, sailing and canoeing. Given that other public and private entities also have legitimate interests in these waters bordering the park, there are inherent challenges to meet these National Park Service recreation objectives.

MANAGEMENT OBJECTIVES

Acadia National Park management objectives are to:

1) Seek appropriate designations around park waters to protect wildlife from hunting and trapping to ensure visitor safety, minimize public confusion concerning permitted activities and promote outdoor recreation experiences consistent with the mission of the National Park Service;
2) Foster fisheries management activities that restore and perpetuate, to the greatest degree practicable, natural assemblages of indigenous fish species and aquatic communities;
3) Work cooperatively with the Department of Inland Fisheries and Wildlife and local groups to provide quality fishing experiences;
4) Maintain high water quality of all park waters in order to protect public health and maintain ecosystem integrity;
5) Promote scientifically-based watershed management activities and visitor education, and institute visitor use regulations for all park waters that are public water supplies to meet federal and state safe drinking water standards, and,
6) Cooperate with state and town officials to regulate water-based recreation to foster visitor safety, minimize conflicts among user groups, and provide for a spectrum of recreational opportunities (including uncrowded visitor experiences).

RECOMMENDATIONS

The National Park Service will work cooperatively with the State of Maine, interested organizations and private citizens to achieve the stated water resource management objectives for Acadia National Park. It is recommended that through meetings, negotiations and joint field activities, the National Park Service and the State of Maine would strive to resolve existing issues surrounding the management of Great Ponds at the park. Potential benefits include enhanced communications among parties, the identification of shared goals and objectives, durable and implementable agreements and the ongoing dialog about cooperative management issues and strategies. Cooperative management would also facilitate program cost sharing and increase efficiency by combining the limited resources of both the National Park Service and the State of Maine. The following approaches should enhance working relations among all parties interested in Acadia National Park water resources management.

3.2.1. Establish a formal cooperative agreement with the Maine Department of Inland Fisheries and Wildlife.

This action is designed to provide an overall framework for future cooperation and coordination between the National Park Service and the Department of Inland Fisheries and Wildlife for the management, protection, and study of fish and wildlife and their habitats at Acadia National Park. The scope of the agreement should cover all lands and waters within the legislative park boundary and identify agency roles and responsibilities to achieve

National Park Service and state objectives. There is a need for an agreement to serve as the master document guiding future specific cooperative activities such as beaver management and wild brook trout conservation, and aquatic contaminant research (working with the University of Maine). Such a plan would facilitate greater communication and collaboration between both agencies, and facilitate greater National Park Service involvement in the management of all waters and aquatic organisms at Acadia National Park. Greater cooperation with the Department of Inland Fisheries and Wildlife would result in enhanced natural resource stewardship at Acadia National Park.

3.2.2. Pursue state legislation for wildlife sanctuary designation.

The National Park Service would like to work with the Maine Department of Inland Fisheries and Wildlife to develop a strategy to close the Great Ponds at Acadia National Park to public hunting and trapping. This action is likely to be controversial with some interest groups, however it would have limited direct impacts as few people currently hunt and trap on Great Ponds in the park. Hunting and trapping are already prohibited on federal *lands* in the park. Creation of a wildlife sanctuary at Acadia National Park would alleviate long-standing National Park Service concerns over conflicts between wildlife harvesting and other more traditional non-consumptive park recreational activities. Specifically, visitor safety issues would be eliminated and all public activities at the park would be consistent with the purposes for which the park was established. In order for this action to occur, the Maine legislature would need to designate the Great Ponds at Acadia National Park as closed to hunting and trapping.

3.2.3. Develop a cooperative fisheries management plan.

This action would seek to address National Park Service objectives to maintain naturally functioning aquatic ecosystems, protect and perpetuate native aquatic species and natural habitats and provide for a diverse range of quality fishing experiences at Acadia National Park. A fisheries management plan for the park would be developed in collaboration with IF&W recreation groups and interested individuals. The plan would establish mutually agreeable long-term fish population and recreational fishing goals, identify research and monitoring needs, describe watershed specific management actions, and delineate roles and responsibilities for their implementation. The plan would address a number of key issues, including, but not limited to: status and conservation of native (indigenous) fish populations, role of stocking, promotion of recreational fishing experiences, public access, boating and fishing regulations, enforcement of park and state regulations, public education, and opportunities for collaborative funding of research, monitoring, management, and educational activities.

The National Park Service is interested in focusing future fisheries management on ecosystem concerns and on the preservation of the recreational fishing experience and not solely on fish harvest. However, the National Park Service recognizes that fish populations at the park have been managed and stocked since the beginning of this century and that a fisheries management plan focusing exclusively on native species conservation may not be appropriate for all waters in the park. Implementation of this action acknowledges that fish populations at Acadia National Park would be a shared resource to be co-managed by both agencies. It would allow the National Park Service to be more actively involved in fisheries management at the park, while providing for the continued active role by the Maine Department of Inland Fisheries and Wildlife.

3.2.4. Conduct an aquatic ecosystem inventory.

In collaboration with the Maine Department of Inland Fisheries and Wildlife, the National Park Service would identify and characterize the presence and condition of aquatic species populations in watersheds at Acadia National Park. Since the scope of such a task would be large, priorities would need to be established on water bodies, data types and level of detail. Information would be generated on such topics as primary and secondary productivity, macrophytes, invertebrates, fish populations and habitats, transport and partitioning of contaminants and human use. Past surveys and reports would be reviewed for information relevant to human impact and past management practices on the current status of fisheries and aquatic ecosystems. Interviews would be conducted and specific information gaps would be identified. Participation from external funding sources such as the USGS Biological Resources Division, US EPA, or private foundations would be solicited. This alternative would fill a significant

data void identified by park staff and Greene *et al.* (1992) and greatly assist in the preparation of a Fisheries Management Plan.

An issue related to an aquatic ecosystem inventory pertains to lake impoundments. There are several dams on lakes and streams (Table 2-0). These may be impeding fish migration or otherwise affecting aquatic biota and their distribution. As part of the aquatic ecosystem inventory, these dams should be evaluated for impact and necessity, with the understanding that many are serving useful purposes as part of the water supply system on Mount Desert Island.

3.2.5. Protect the natural visitor experience on Great Ponds

The National Park Service will actively work with local communities, Friends of Acadia, and the Maine Department of Inland Fisheries and Wildlife to develop appropriate management strategies that recognize the special qualities of the Great Ponds bordering Acadia National Park. The National Park Service desires that all surface uses of water be compatible with the purposes for which the park was established. Given the current lack of regulations on these water bodies other than for safety concerns, protection of visitor experiences and natural resources will continue to be limited. By cooperating to develop appropriate regulations, the National Park Service would be better able to prevent future social and environmental conflicts on these Great Ponds.

The National Park Service has already worked with local communities and the state on regulations that prohibit personal watercraft on all Great Ponds bordering Acadia National Park. The Great Pond rules passed in 1998 by the Maine legislature provide an opportunity for municipalities to develop recommendations to regulate personal watercraft use of local lakes and ponds. The National Park Service will work closely with those communities advocating for a ban on personal watercraft on lakes adjacent to the park and will assist in efforts to gain support of the proposed regulations by the Maine Department of Inland Fisheries and Wildlife.

MANAGEMENT ACTIONS CONSIDERED BUT NOT RECOMMENDED

No New Action

Under this alternative, no change in present management strategy would occur. The National Park Service would continue to allow hunters and trappers by permit to cross park lands with firearms and traps to access Great Ponds and wildlife harvesting would continue on Great Ponds within Acadia National Park. The National Park Service would not be directly engaged or involved in any fishery management programs at the park, including activities at non-Great Ponds. IF&W would continue to implement regulatory and stocking actions in the park, focusing primarily on enhancing fish production and harvest, and providing recreational fishing opportunities. The National Park Service would continue to have only a limited understanding of fish populations and aquatic ecology in the park and be hampered in meeting its conservation mandates. This alternative would continue to result in activities that are inconsistent with National Park Service policies and the purposes for which the park was established.

National Park Service Management of Surface Waters

Under this alternative, the National Park Service would unilaterally manage recreation and natural resources on all waters, including Great Ponds. The National Park Service could manage activities on Great Ponds based on its concurrent jurisdiction over all lands and waters within the boundary of Acadia National Park and Congressional regulatory authority under the Property Clause of the U.S. Constitution (personal communication, U.S. Department of Interior Regional Solicitor's opinion, March 4, 1994). Activities that are prohibited by federal law and inconsistent with National Park Service policy or with the purposes for the establishment of the park would be phased out, including hunting and trapping. The park would no longer provide permits to individuals to transport firearms and traps across Park Service property to access Great Ponds and would enforce federal regulations against wildlife harvesting. The National Park Service would take primary responsibility for fisheries management at the park and place a greater emphasis on conservation of native aquatic organisms and fishing experiences in a natural environment, rather than managing primarily to provide anglers with harvestable fish. This alternative would

accomplish most National Park Service water resource management goals for Acadia National Park; however, it would also negatively affect the park's existing relationship with the State of Maine. National Park Service actions to assert its management authority over the Great Ponds would also be highly controversial with some segments of the public and would likely be subject to litigation.

Section 3.3 WETLAND AND ESTUARINE/MARINE ENVIRONMENTS

Charles Roman, U.S. Geological Survey

INTRODUCTION

Freshwater and saltwater wetlands, intertidal and nearshore subtidal environments (e.g. eelgrass beds, tidal flats, rocky shores) are all integral components of the Acadia National Park landscape. More than 10% of the Acadia National Park land area is classified as wetland (Calhoun *et al.,* 1994). Because of their well-documented values and functions (Table 3.3A (Calhoun *et al., 1994*; Greeson *et al.,* 1979) wetland and estuarine/marine habitats are afforded considerable legislative protection at the federal (Rivers and Harbors Act of 1899, section 10; Clean Water Act of 1977, section 404) and state (Maine Natural Resources Protection Act of 1990) levels. The National Park Service has also published wetland protection guidelines for National Park units (National Park Service, 1998). Given this legislation and National Park Service guidelines, wetlands and estuarine/marine environments are, with few exceptions, protected from filling, dredging and other obliterating impacts. However, these environments generally remain sensitive to the more subtle, chronic, and long-term impacts that are not given priority consideration by existing regulatory measures. The kinds of issues that can be addressed in a Water Resources Management Plan toward effective protection of wetland and estuarine/marine habitats of Acadia National Park and vicinity include:

1) eutrophication
2) habitat restoration, including non-native species control
3) consumptive uses (e.g. overharvesting, aquaculture)
4) catastrophic events (e.g. oil spills)
5) visitor impacts and
6) atmospheric deposition of toxic contaminants

There is some evidence that estuarine ecosystems in the Gulf of Maine region are becoming more eutrophic, primarily in response to excess nutrient loading from non-point sources (Valiela *et al.,* 1992; Nixon, 1995; Dow and Braasch, 1996). At Mount Desert Island's Bass Harbor Marsh estuary, recent studies suggest that the system may be tending toward higher productivity (eutrophication) based on dense macroalgal growth, occurrence of benthic species that are indicative of nutrient enriched conditions, and high nitrogen inputs from freshwater tributaries (Doering *et al.,* 1994). Conversely, Doering and Roman (1994) report that nutrient loading to Somes Sound, a fjord-type estuary bisecting Mt. Desert Island, is low. The nutrient and chlorophyll concentrations, and dissolved oxygen indicate a relatively pristine system.

STATEMENT OF THE PROBLEM

Between 1780 and 1980 over 50% of the freshwater and estuarine wetlands of the lower forty-eight states were lost. During the same two century time frame 20% of Maine's wetlands were destroyed (Dahl, 1990). Given this extraordinary loss of habitat that provides such a diversity of ecological, economic and socio-cultural values, it is important to maintain the functional quality of remaining wetlands and restore degraded habitats. The National Research Council (1992) recommends a national strategy of restoration management for aquatic systems that will reestablish altered flooding and flow regimes to altered wetlands, reduce the delivery of sediments and contaminants to wetlands, and reintroduce native biota that has been lost. Further, National Park Service wetland guidelines call for restoration of wetlands as a management objective in Park Service Water Resource Management Plans and Natural Resource Management Plans. Altering both surface and groundwater hydrology has created a significant impact to some wetlands of the Acadia region (Calhoun *et al.,* 1994). Restoration of natural hydrologic regimes and concomitant enhancement of ecological functions can be effectively accomplished, as demonstrated elsewhere (e.g. Kusler and Kentula, 1990; Roman *et al.,* 1995).

Table 3.3A. List of Major Wetland Values

Flora and Fauna Values • Breeding habitat for reptiles and amphibians (vernal pools) • Fish and shellfish habitat • Waterfowl and other bird habitat • Mammal and other wildlife habitat Endangered species habitat (plant and animal)
Environmental Quality Values • Water quality maintenance • Pollution abatement • Sediment removal • Nutrient cycling Chemical and nutrient absorption • Aquatic productivity • Macroclimate regulator • World climate (ozone layer)
Socio-Economic Values • Flood control • Shoreline erosion control • Groundwater recharge • Water supply • Timber and other natural products • Energy source • Fish and shellfishing • Hunting and trapping • Recreation Aesthetics

Wetland restoration includes the control of non-native species, such as the highly competitive purple loosestrife (*Lythrum salicaria*), known to invade entire wetlands as monotypic stands thereby altering habitat functions (Thompson *et al.,* 1987). Since 1988, Acadia National Park has successfully implemented a purple loosestrife control program (Hiebert *et al.,* 1996). Other non-native plant and animal species (e.g. littorine snails in the marine environment) are also aggressive invaders, but information on ecosystem impacts is limited.

Commercial and recreational harvest of marine/estuarine species, such as soft-shelled clams (*Mya arenaria*) and bait worms (*Nereis virens*) from intertidal mudflats, and elvers (*Anguilla rostrata*) from tidal streams, is prevalent along the shores of Mount Desert Island and vicinity. The National Park Service has no regulatory or management jurisdiction over the harvest of these species beyond the park boundary. Given the close proximity of these often intense activities immediately adjacent to the park, the National Park Service is interested in working cooperatively with the Maine Department of Marine Resources to insure that these populations remain sustainable. An additional issue is that of vehicle and pedestrian access to harvest sites (often associated with park lands) that may be detrimental to non-target species and overall ecosystem structure and function.

Similarly, Acadia National Park maintains no jurisdictional authority over finfish or shellfish aquaculture activities in the nearshore zone, but park management remains committed to protecting marine habitats, especially those areas adjacent to park boundaries. Several issues have been identified in response to aquaculture activities, including

potential genetic interactions between cultured and wild stocks, spread of disease from cultured to wild fisheries, introduction of exotic species, benthic impacts from excess organic enrichment, and perhaps the most relevant to National Park Service management, multiple user conflicts including aesthetic issues, land use conflicts, and recreational users (Dow and Braasch 1996).

Estuarine and marine habitats of Acadia National Park have not experienced widespread catastrophic events, such as oil spills or toxic algal blooms that have caused massive mortalities of shellfish as was reported for Maquoit Bay in southern Maine (Heinig and Campbell, 1992). However, given the tanker traffic along the coast of downeast Maine, coupled with increasing development pressure, it is imperative that Acadia National Park be prepared to effectively assess resource damages following such events. A network of quantitative baseline data sets within various wetland, estuarine and marine habitats is clearly needed.

A final issue of relevance to wetland and estuarine/marine environments relates to increased visitation of wetland habitats and the extraordinary visitation pressure of Acadia National Park's rocky shoreline. These systems are sensitive to trampling and resource removal by visitors. A balance must be achieved by using pro-active education to assist resource protection.

MANAGEMENT OBJECTIVES

National Park Service management objectives focusing on these issues at Acadia National Park include:

1) Promoting and conduct inventory, monitoring, and research necessary to understand and detect trends, and if necessary, develop mitigation strategies for addressing potential effects of acidic atmospheric deposition, point source and non-point source contamination, climate change and other influences upon park water resources;
2) Preserving and/or restoring natural water flow regimes, to the degree practicable, to sustain freshwater discharge and perpetuate the natural function of wetland and estuary systems;
3) Maintaining high water quality to protect public health, maintain ecosystem integrity, and preserve the existing high water quality.

RECOMMENDATIONS

3.3.1. Initiate an Inventory, Monitoring and Research Program for wetland and estuarine ecosystems

The objectives of a wetland and estuarine/marine resources management and protection program are to develop a comprehensive inventory, monitoring, and research data base on the structure, function, and processes controlling these systems. This information will enable the National Park Service, state partners, and others to monitor habitat and environmental changes, to understand the factors causing changes, to define thresholds of change that are ecologically or environmentally meaningful, and perhaps most important, to anticipate detrimental impacts and initiate proactive resource management scenarios.

Recommendation 3.3.1a. Inventories.

Several major wetland and estuarine/marine systems or system types within Acadia National Park have no baseline environmental information available. Comprehensive inventories of vegetation, biota, water chemistry, and controlling processes have been started within the last year for the Northeast Creek system, Big Heath, Fresh Meadow, Anemone Cave, and Somes Sound, to name a few. Regarding habitat types, the intertidal and nearshore subtidal marine rocky intertidal habitats and eelgrass beds associated with the park shoreline require further study in order to develop effective monitoringprograms. Similarly, quantitative assessments of lake and pond littoral communities (vegetation, invertebrates, fishes) are necessary, especially given the sensitivity of these environments to nutrient enrichment, atmospheric deposition, and visitor impacts.

Upon completion of an inventory for a particular system or habitat type, the information will be available to develop scientifically-based long-term monitoring protocols. A monitoring program for Bass Harbor Marsh has been outlined following a three year study (Doering *et al.,* 1994), although specific protocols for the program have not been developed. At a minimum, wetland and estuarine/marine habitat monitoring programs should explicitly identify monitoring objectives, select monitoring variables that will be sensitive to natural and human-induced threats, and identify thresholds of change when management action should be implemented. Recommendations identified in recently completed studies of Bass Harbor Marsh and Somes Sound and from research now ongoing at Northeast Creek and Anemone Cave should be integrated into a comprehensive long-term monitoring program.

Recommendation 3.3.1b. Non-native species control.

The Acadia National Park Purple Loosestrife Management Program has been ongoing since 1988. A recent scientific review concluded that the program has been successful in controlling the spread of this aggressive non-native plant within freshwater wetland habitats (Hiebert *et al.* 1996). To further enhance the program, these additional recommendations were made:

1) reduce source populations outside the park and identify and monitor corridors of dispersal
2) experiment with biological control agents, both within park boundaries and adjacent to the park
3) if experiments are successful, pursue more widespread biological control
4) expand the public education program to a regional level
5) determine the impact of other invasive non-native plant species on park habitat structure and function

In addition to Purple Loosestrife and other non-native plants, efforts should be made to identify non-native fauna that pose a threat to the structure and function of wetland, aquatic and estuarine/marine habitats. After identification, literature review and research efforts will be necessary to assess the population, community and ecosystem-level threats imposed by the invasive species, and if appropriate, adopt a management strategy.

Recommendation 3.3.1c. Hydrology

Maintaining natural hydrologic flow is a fundamental requirement toward sustaining natural functions of wetland environments. Bridges, causeways, dikes, and other structures that traverse wetlands often restrict or impede the natural hydrologic regime. Impacts associated with altered surface and groundwater hydrology include vegetation changes, altered faunal communities, and changes in water chemistry (Kusler and Kentula, 1990; Roman *et al.,* 1995). Employing the wetland GIS database in conjunction with field visits, wetlands throughout Acadia National Park should be systematically surveyed to identify sites with structures that can potentially alter wetland hydrology. Based on consistent and scientifically-based criteria, sites warranting restoration should be selected and options for restoration evaluated.

3.3.2. Management of Visitor Impacts and Expansion of Public Education Opportunities

Wetland, aquatic, marine and estuarine habitats at Acadia National Park represent a major aspect of the visitor experience. Opportunities to visit these habitats and learn of their values and functions should be encouraged, while minimizing visitor impacts. Boardwalks through select wetlands, coupled with self-guided and Ranger-guided environmental interpretation, should be constructed. For example, Big Heath currently has an extensive network of visitor-made trails extending into the wetland from the Wonderland and Ship Harbor parking areas. A boardwalk to allow vistas of this extensive wetland would alleviate the problem of unwanted trail creation, while also serving an essential educational role.

A systematic survey of park wetland and estuarine/marine habitats in the vicinity of trails, parking areas, and carriage roads should be conducted to identify wetland habitats with extensive networks of visitor-created trails. If necessary, appropriate management actions should be implemented (e.g., boardwalk construction or discourage access).

MANAGEMENT ACTIONS CONSIDERED BUT NOT RECOMMENDED

No New Action

Over the past several years Acadia National Park has made excellent progress toward developing a comprehensive long-term monitoring, inventory and research program focused on wetland, estuarine and marine environments. Wetlands and deepwater habitats have been mapped by the US Fish and Wildlife Service's National Wetlands Inventory, digital map files are available on the park's GIS, and a report is available that describes and details the values of these systems (Calhoun *et al.,* 1994). An ecological inventory and assessment of water quality issues at Bass Harbor Marsh has been completed (Zubricki, 1992; Doering *et al,*. 1994; Farris, 1996). A water quality assessment of Somes Sound and watershed nutrient inputs is complete (Doering and Roman 1994), with ongoing investigations of primary productivity -- an initial response variable to increased nutrient loading. Cammen and Larson (1992) established baseline monitoring stations for long-term monitoring of intertidal marine benthic invertebrates. Greene et al. (in press) recently completed an inventory of the aquatic macroflora of Acadia's lake and pond shorelines (Greene, in press). Finally, a management program to control the spread of the non-native purple loosestrife has been in place since 1988 (Hiebert *et al.,* 1996). A new study (Kahl *et al*., 1997) is underway to develop a pair of gauged watersheds in forested catchments at Acadia National Park. One of the goals of this project will be to periodically monitor the nutrient loading to several estuaries of Mount Desert Island, to determine potential trends in estuarine eutrophication. Additionally, research at NE Creek has been started to establish baseline water quality data about this estuary.

These studies and management activities provide an excellent baseline for the recommendations above. Monitoring, management and research recommendations set-forth by these previous efforts need to be carefully considered and implemented when appropriate. Moreover, investigations of other wetland and marine habitats is required to acquire a comprehensive understanding of the processes controlling these ecosystems and the human-induced impacts that pose immediate or chronic threats to system structure and function.

Section 3.4 WATERSHED MANAGEMENT ISSUES

Mark Flora, National Park Service Water Resources Division
David Manski, Acadia National Park
Nick Houtman, University of Maine

INTRODUCTION

National Park Service policy seeks to restore, maintain, or enhance the quality of all surface and ground waters within parks consistent with the Clean Water Act and other applicable federal, state and local laws and regulations (National Park Service, 1988). The quality of water originating in parks is to be maintained in its natural condition free from pollutants generated by human activity, by providing adequate sewage treatment facilities, regulating human use, and minimizing contamination by toxic substances. In addition, the National Park Service works to protect the condition of park water resources originating outside of the park through cooperative efforts at the watershed level with local, state, and federal agencies responsible for their management.

In response to a water issues questionnaire circulated as part of this Water Resource Management Plan planning process, 94% of the responders felt that nonpoint source pollution was an important issue at Acadia National Park. Furthermore, the Acadia National Park Water Resources Scoping Report (National Park Service, 1991a) identified two major concerns relevant to point source and nonpoint source relating to land-use activities on Mount Desert Island: 1) nutrient enrichment and contamination by pathogens associated with inadequate septic systems and "over-board" discharges, and 2) reduced infiltration capacity and increased erosion/sedimentation potential from development activities.

STATEMENT OF THE PROBLEM

The management and protection of water resources within Acadia National Park is complicated by the fact that only a portion of the major drainage systems on Mount Desert Island are completely within the boundary of Acadia National Park. The Town of Mount Desert shares responsibility for land use with the park around most of Somes Sound, Echo Lake, Long Pond, Lower Hadlock Pond and Little Long Pond as well as streams draining to those water bodies. The Town of Southwest Harbor contains a small portion of the Long Pond/Somes Pond watershed, but relies exclusively on Long Pond for it's municipal public water supply. The Bass Harbor watershed lies within the Towns of Southwest Harbor and Tremont, as well as within the park. The watersheds of Seal Cove Pond and Hodgdon Pond includes land both in the Town of Tremont and Acadia National Park.

With the exception of Hamilton Pond, great ponds within the Town of Bar Harbor are located entirely within the park. However, activities within the Eagle Lake/Bubble Pond sub-basins are of interest the Town of Bar Harbor, as these ponds provide the town's municipal drinking water supply. In addition, the municipal drinking water supply for Mount Desert is derived from Jordan Pond and Lower Hadlock Pond, both of whose watersheds are contained within the park. Appropriate protection of these resources require that the park develop a cooperative and effective watershed management strategy with the local towns.

Park operations and development

The operation of facilities and infrastructure necessary to serve almost 3 million visitors annually is extensive and, if not properly designed and managed may contribute to nonpoint source pollution. These activities include: the operation of two campgrounds, various visitor facilities, a maintenance yard/vehicle maintenance shop and approximately 136 buildings; the maintenance and operation of numerous wastewater treatment systems; the maintenance and repair of numerous roads, bridges, and parking lots, as well as implementing an extensive program of carriage road rehabilitation and vista clearing, and; managing trail erosion and problems associated with inadequate toilet facilities at popular trail heads and backcountry locations.

Wastewater management

Of the watershed management issues listed above, the one most likely to contribute to a degradation of water quality within Acadia National Park is the inadequate disposal of wastewater. Wastewater disposal on Mount Desert Island is often problematic due to the preponderance of thin and generally poorly developed soils. The Towns of Bar Harbor, Mount Desert and Southwest Harbor all operate wastewater treatment plants which discharge treated sewage effluent to surrounding marine waters. However, much of the island is dependent upon individual septic systems, which sometimes include overboard discharge of untreated sewage from septic tanks directly into local marine waters.

Early sewage treatment systems within Acadia National Park, where they existed at all, were often primary treatment (septic tanks or Imhoff tanks) followed by discharge into receiving streams. Improved systems such as the package plant at the McFarland Hill Job Corps Center (Park Administrative Headquarters), the sand filter system at Cadillac Mountain, and several septic tank/drain field systems were constructed in the 1950s and 1960s. With growing environmental awareness and the passage of the Clean Water Act, a new generation of treatment systems were constructed in the park during the 1970s and early 1980s (Table 3.4A). Starting with the park's cooperative construction of the Otter Creek sewage treatment plant in 1969, a series of secondary treatment systems were constructed into the early 1980s. These systems included tank/sand mound systems, sand filters, and secondary biological treatment. This construction generally brought the park into compliance with Clean Water Act requirements.

Another round of construction occurred in the 1990s, due to increased visitation, the deterioration of existing systems, and increased concern about the effects of nutrients on receiving waters. Sewage systems were replaced at the Bear Brook Picnic Area (1993) and Cadillac Mountain (1994). At present, work is being initiated to connect the Hulls Cove Visitor Center to the Hulls Cove municipal system, to rehabilitate the Seawall Campground sewage system, to replace the sewage system at Wildwood Stables and to construct new vault toilet or composting toilet systems at 15 popular trail heads and/or visitor sites on Mount Desert Island and Isle au Haut. Future plans call for the future rehabilitation of the sewage systems at Echo Lake, Sieur de Monts, Harden Farm Apartments, Thompson Island, and McFarland Hill.

These projects have been designed with an increased environmental awareness of the deleterious effects of nutrient loading to area waters. For example, increased nitrogen discharge to marine coastal waters is now recognized to be a cause of coastal algal blooms as well as stimulating the growth of epiphytic algae on submerged aquatic plants. This has led to eelgrass declines in other areas along the New England coast. Similarly, phosphorus discharge into fresh surface and groundwaters can stimulate the growth of algae and aquatic weeds in freshwater lakes and ponds, diminishing water clarity, and sometimes leading to oxygen depletion in the lake.

Other non-point sources of pollution

While the development and operation of appropriate wastewater disposal systems is the biggest local threat to water quality, other nonpoint sources of pollution may also be a concern. Impacts may arise from poorly planned residential and/or commercial development, pesticide application, application of road salts near sensitive resources, improper disposal of hazardous materials and/or household wastes, leaking underground storage tanks, and poor road and trail design and maintenance. In coastal waters, food sanitation regulations require that intertidal areas be closed to shellfish harvesting inclose proximity to wastewater discharges. Discharges of treated sewage from the municipal wastewater treatment plants and about 98 permitted overboard dischargers have caused large areas of the intertidal waters of Mount Desert Island to be closed to shellfishing.

The Maine Department of Environmental Protection has identified several additional nonpoint source pollution-related concerns throughout the state (Maine Department of Environmental Protection, 1998). Several of these potential sources should be considered when planning and implementing park operations and development. These include: 1) maintenance of adequate vegetated buffer strips adjacent to ponds, lakes, and streams; 2) adequate

Table 3.4A. Recent History of Wastewater Management Facilities Development in Acadia National Park.

Year	Location	Activity
1969	Blackwoods Campground	connected to Otter Creek sewage treatment plant
1976	Cadillac Mountain Visitor Center	rehabilitation of sand filter
1977	Seawall Campground	construction of septic tank/sand filter system with chlorinated "overboard" discharge
late 1970s	Thunder Hole	abandon rostrum due to inadequate sewage treatment
1981	Jordan Pond House	connect to Seal Harbor sewage treatment plant
1982	McFarland Hill Headquarters	constructed sand mound system
1982	Sieur de Monts	constructed sand mound system
1982	Thompson Island	constructed sand mound system
1992	Cadillac Mountain	abandon sand filter system (commence hauling untreated sewage to municipal treatment plants)
1993	Bear Brook Picnic Area	abandon rostrum facility due to faulty sub-surface treatment system; constructed replacement peat bed system and new rostrum building
1994	Cadillac Mountain	constructed peat bed system
1998	Hull's Cove Visitor Center	plan to connect to Hulls Cove municipal treatment plants (extended aeration secondary treatment with "overboard" discharge)
1999	Seawall Campground	plan rehabilitation of sand filter system (convert to recirculating sand filter with subsurface disposal
1999	15 Trail heads/Pull Offs	plan construction of vault or composting toilets
1999	Wildwood Stables	plan construction of replacement subsurface system
Future Needs	Echo Lake, Sieur de Monts, Harden Farm, Thompson Island, McFarland Hill	Planned rehabilitation of existing systems

management of stormwater runoff from parking areas and roads; 3) appropriate erosion and sediment control measures when undertaking facility and road construction activities; 4) properly managing landscaped areas within pond and lake shoreline zones; 5) control of excessive erosion and sediment runoff from unpaved fire roads and carriage paths and heavily utilized trails; and 6) identification of areas within the watershed which are excessively contribute to nonpoint source pollution.

While none of the potential nonpoint sources listed above are known to be significant sources within Acadia National Park, prudent management would dictate that the National Park Service be aware of these potential sources, and perhaps conduct appropriate surveys of possible problem areas, where warranted. The maintenance of adequately vegetated buffer strips adjacent to the shores of streams, ponds and lakes are particularly important for protecting water quality (Maine Department of Environmental Protection, 1998). Even modestly sized riparian buffers have been shown to significantly reduce the amount of nutrients and other contaminants entering adjacent waters, as well as providing stream shading, which is important in the survival of cold water fish species.

Stormwater runoff can be a particular problem in densely developed areas where a high percentage of the land surface is impervious. In these areas, the runoff is typically contaminated with elevated concentrations of sediments, nutrients, heavy metals, hydrocarbons, and in some cases pathogens. Runoff from heavily used roads and large parking areas could potentially be a source of nonpoint source pollutants if they are situated in such a manner that they drain directly into sensitive waters. In addition, inadequately designed or maintained roadside ditches have been found to be a major cause of excessive sedimentation in other areas throughout the State of Maine (Maine Department of Environmental Protection, 1998). Stormwater runoff from lawns and landscaped areas (of which there are only a few within the park) can also be a significant source of phosphorus, particularly if they receive an excessive use of fertilizers containing phosphorus.

Unpaved roads can contribute significant amounts of phosphorus and sediments to adjacent streams and ponds, as can heavily and/or improperly used trails. While these types of roads exist within the park, they are thought to present few problems. Drainage from carriage paths in particular will require maintenance to minimize runoff of sediments to surface waters. However, they may constitute problems in other parts of the watersheds that are not within the park boundary, such at Long Pond in Southwest Harbor. A preliminary study found that impacts to water quality in Long Pond may be occurring from development on steep slopes with thin soils, eroding trails, private camp roads and steep driveways draining toward the pond, private septic systems (especially those built prior to 1974), and residential landscaping activities (Hancock County Planning Commission, 1993).

Other non point source water quality impacts have been documented from the now closed Worcester Landfill in the Town of Southwest Harbor (Hansen , 1980; Gerber *et al*., 1989; Soukup and Mitchell, 1981; Doering *et al*., 1995).

MANAGEMENT OBJECTIVES

National Park Service management objectives focusing on these issues at Acadia National Park include:

1) Maintaining high water quality to protect public health, maintain ecosystem integrity, and preserve the existing pristine high water quality;
2) Developing inventory, monitoring, and research activities necessary to understand and detect trends, and if necessary, develop mitigation strategies for addressing potential effects of acidic atmospheric deposition, point source and non-point source contamination, climate change and other influences upon park water resources;
3) Promoting scientifically-based watershed management activities and visitor education, and instituting appropriate visitor use regulations for all lakes that are public water supplies in order to meet federal and state safe drinking water standards;
4) Providing park visitors with high quality potable water while assuring that park operations and development do not adversely affect park water resources or water-dependent environments;
5) Cooperating with local and state planning and regulatory agencies in developing watershed-wide strategies that respect local municipal needs to provide drinking water while recognizing National Park Service obligations to prevent adverse impacts on water-dependent resources within and adjacent to the park, and;
6) Promoting public awareness and education of local water resources, water quality protection, and water conservation as well as the potential for human impacts upon these resources.

RECOMMENDATIONS

3.4.1. Continuation of existing program with collaborative protection efforts facilitated by the park

The National Park Service will continue to strive to protect park waters from septic and waste system discharge to the greatest degree practicable. The park recognizes that the following locations are considered to be especially vulnerable to waste water discharge: Bass Harbor Marsh, Northeast Creek/Fresh Meadow Marsh, Somes Sound,

marine shellfishing areas, public water systems, and public swimming beaches. All new or rehabilitated sewage treatment system projects within the park will continue to be developed according to the following guidelines:

1) projects will comply with applicable federal, state, and local regulations, as well as with National Park Service policy;
2) projects will be designed in a manner that will minimize nitrogen discharge into coastal waters (this may include setbacks of septic leach fields of up to 200 m);
3) projects will be designed in such a manner that will minimize phosphorus discharge into fresh surface and ground waters. This may also require appropriate setbacks of septic leach fields from nearby streams, lakes, ponds, and wetland resources, and
4) projects will be designed so as to minimize the discharge of bacteria and pathogens into coastal marine and freshwater systems, especially in those areas supporting public water supplies, public swimming beaches, and marine shellfish harvesting areas. These strategies will protect park waters from nutrient and bacterial contamination.

Park maintenance practices will continue to be carried out to the greatest extent possible in accordance with National Park Service policies, guidelines and existing federal and state environmental compliance procedures. The park will attempt to mitigate known nonpoint source pollution sources occurring on park lands by using waterbars, protecting riparian buffers, revegetating disturbed areas, and other sensible methods in trail construction and road maintenance. The practice of allowing stormwater runoff from buildings and parking lots to infiltrate soils adjacent to these areas will also be continued. In addition, the park will remain responsive to non-point source impacts that occur on adjacent lands and waters, support efforts to protect park and local drinking water supplies, and continue to interact and collaborate with local officials and state agencies on water resource issues to the extent they are known.

The park will also continue to apply good management practices to address other nonpoint source pollution. At present watershed-based nonpoint source issues are not thought to be problems for most park waters. The ecological and public health impacts of non-point source pollution will be evaluated through the implementation of comprehensive and long-term monitoring strategies recommended in the chapters focusing on atmospheric deposition and climate change (3.1), wetlands and estuarine/marine environments (3.3), and public health (3.5).

Protection of those waters having multiple jurisdictions will be most effective when undertaken in a collaborative environment. Therefore, the National Park Service, working in collaboration with the Mount Desert Island League of Towns, Friends of Acadia and others, will actively participate in the formation of local lake watershed associations if they are desired by shoreline property owners. Water quality problems often stem in large part from human activities which are sometimes difficult to recognize and address. The lake associations could serve as an important forum in which to increase awareness and understanding of actions designed to protect water quality. The National Park Service could also use information gained from these forums to help develop specific educational programs geared toward local schools and park visitors that would enhance protection of these shared waters.

MANAGEMENT ACTIONS CONSIDERED BUT NOT RECOMMENDED

Utilize Best Available Technology (BATs) when implementing Best Management Practices (BMPs) to Protect Ambient Water Quality

Given the need to protect the existing high quality of park waters, the multi-jurisdictional nature of watersheds, the implementation of design and development needs as outlined in the general management plan (National Park Service, 1992), and the potential for continued development surrounding the park, this alternative proposes extending practices currently ongoing at the park.with the following practice:

All new park rehabilitation or development projects would include a cost/benefit analysis considering the use of Best Available Technology (BAT) when selecting BMPs to protect water resources. The use of BATs as they become

known should better protect water resources; however, higher costs are usually associated with their use. Thus, cost/benefit analysis of BATs, as well as an evaluation of the full range of BMPs would allow the manager to make informed decisions balancing project costs vs resource protection when selecting the preferred alternative for the development of visitor and operational facilities, roads, parking lots, on-site wastewater systems, and other applications. Assistance in obtaining up-to-date information on BAT/BMP technology can be obtained from contacts with the state and federal agencies.

Additional costs incurred in implementing this alternative would be related to the evaluation of BATs and BMPs associated largely with infrastructural development projects. These should be included in the initial planning stages of developmental proposals, and costs associated with the implementation of desired BATs/BMPs considered as part of the construction funding needs. Closer cooperation with local towns, the state, and other interested parties in the identification and assessment of existing nonpoint source problems could require some re-programming of current park staff priorities and additional technical assistance and possibly project funding.

Section 3.5 PROTECTION OF PUBLIC HEALTH

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INTRODUCTION

National Park Service Management Policies state that public health and safety are primary concerns in the management of activities within the National Park System (National Park Service, 1988). Visitors to Acadia National Park, as well as residents of Mount Desert Island, require a safe and adequate water supply for domestic and commercial use. In addition, water-based recreational activities such as fishing, swimming, and shellfishing are dependent upon good water quality. This section includes a discussion of management alternatives pertaining to the protection of public health including: 1) National Park Service compliance with the Safe Drinking Water Act for park-based water supplies; 2) the cooperative protection of municipal water supplies; 3) water quality monitoring at public swimming beaches.

The Acadia National Park Water Resources Scoping Report (National Park Service, 1991a) also suggested that the presence of radon-222 and *Giardia* were other potential public health-related issues. However, both issues appear to be relatively minor concerns, which can be adequately addressed on a case-by-case basis as part of the park's compliance with the National Park Service Public Health Management Guideline (National Park Service, 1993) and the Safe Drinking Water Act.

STATEMENT OF THE PROBLEM

Park-based water supplies

As a public water supplier, Acadia National Park is required to comply with the 1986 amendments to the Safe Drinking Water Act (SDWA) as well as to National Park Service Public Health Management Guidelines (National Park Service-83) pertaining to the management of water supply systems (National Park Service, 1993). The SDWA is administered by the Maine Department of Human Services and applies to all public water suppliers defined as those systems serving 25 or more individuals or having more than 15 service connections. In addition, the National Park Service requires regular monitoring for a range of chemical, bacterial and radiological contaminants. The State of Maine also requires annual testing for coliform bacteria, nitrate and nitrite. Acadia National Park does not depend upon surface water for any of its drinking water systems. Groundwater is the water source for park headquarters, visitor facilities (including campgrounds), and staff housing. Funding has recently been made available to Acadia National Park for the purpose of rehabilitating and upgrading most of the water supply systems within the park (Table 3.5A).

With the exception of the McFarland Hill supply, the Maine Department of Human Services regulates all non-residential potable water supplies in the park as “public transient non-community water systems”. These systems, which serve more than 25 persons per day (though generally not the same persons on a regular basis), are required by the state to be tested annually for nitrate and bacteria (Mary Corr, Maine Department of Human Services, personal communication, 1994). National Park Service PublicHealth Management Guidelines (National Park Service, 1993) requires more frequent monitoring for a larger range of constituents including total coliform bacteria, residual chlorine, turbidity, primary and secondary SDWA contaminants, pesticides, herbicides, volatile organic compounds and radionuclides (National Park Service, 1993). The McFarland Hill system, which serves park headquarters is classified as a "public non-transient non-community water system" which is defined as regularly serving at least 25 of the same persons for more than six months per year, and must therefore be monitored on a more frequent basis for the types of constituents listed above.

Table 3.5A. Potable Water Supply Rehabilitation and Improvement Recommendations
(adapted from Connors *et al.*, 1998)

WATER SUPPLY	DESIGN SOLUTION
Abbe Museum	Provide well head improvement recommendations to
Bear Brook	Well head improvements
Blackwoods Winter System (New Well)	add batch chlorination
Blackwoods Winter System (Old Well)	Replace with new well
Brown Mountain Gatehouse	Well head improvements
Cadillac Mountain Well #1/Well #2	Improve plumbing, add disinfection
Dermott House	Well head improvements
Echo Lake	Well head improvements
Fabbri Picnic	Well head improvements, replace water line, add
Frazier Point	Well head improvements, treat turbidity, add disinfection
Isle au Haut Campground	Improvements delayed to later phase
Isle au Haut Ranger Station	Improvements delayed to later phase
Isleford	Well head improvements, add disinfection
Jordan Pond Dorm	Well head improvements, add disinfection
Jordan Pond Gatehouse (backyard)	Well head improvements
Jordan Pond Gatehouse (basement)	Abandon well
Jordan Pond House (backyard)	add disinfection
Jordan Pond House (parking lot)	Well head improvements, add disinfection
McFarland Hill (Well #1)	Well head improvements, add disinfection
McFarland Hill (Well #2)	Well head improvements, distribution system
Pretty Marsh (not in current use)	Well head improvements
Sand Beach Residence	Well head improvements, add yard hydrant
Schoodic Point Ranger Station	Well head improvements
Schoodic Point (not in current use)	Rehab building, cap well
Seawall Maintenance Building	Abandon well
Seawall Winter System	Well head improvements, rehab building
Seawall Monitoring Well	Well head improvements
Sieur de Monts	Well head improvements, add disinfection
Sieur de Monts Spring	Disconnect piping from spring to other system
Somes Sound House	Well head improvements, replace pitless unit
Sunset House	Well head improvements
Sunset House Historical Well (not currently used)	Install lockable metal cover over well
Thompson Island Picnic Area	add disinfection
Thompson Island Information Center	Well head improvements, add disinfection
Thompson Island (unused well)	Abandon well
Thunder Hole (unused well)	Well head improvements

Municipal water supplies

The link between water quality and the area's health and economy was recognized in the early 1900s when residents and summer visitors acted to protect water quality in Eagle Lake and Jordan Pond (Dorr, 1942). Their actions led eventually to the establishment of Acadia National Park. Today, four municipal water supply systems withdraw water from lakes and ponds within or adjacent to the park, including Eagle Lake, Jordan Pond, Lower Hadlock Pond, and Long Pond. Acadia National Park encompasses the entire watersheds of Eagle Lake and Jordan Pond. Watershed protection responsibilities for Lower Hadlock Pond (water supply for Northeast Harbor) and Long Pond (water supply for Southwest Harbor) is shared among the park and the Towns of Northeast Harbor, Mount Desert, and Southwest Harbor .

The Towns of Bar Harbor, Seal Harbor, and Northeast Harbor currently have exemptions from filtration requirements under the Safe Drinking Water Act for the municipal water supplied from Eagle Lake, Jordan Pond, and Lower Hadlock Pond, respectively. In order to maintain these exemptions, close cooperation in watershed management activities between Acadia National Park and the municipalities will be required. The water companies have signed memoranda of understanding (MOUs) with the park outlining the shared responsibilities for watershed management. These MOUs call upon the park to properly maintain septic systems, to ban the routine use of pesticides within park boundaries, and to enforce camping restrictions within the affected watersheds. In turn, the local municipalities have taken actionsto restrict swimming and to limit boating activities and the use of motorized vehicles on the ice. The municipal water companies also maintain signs that identify the ponds as potable water supplies in which swimming is prohibited. Primary enforcement responsibilities for these regulations rest with the Bar Harbor and Mount Desert Police, though Acadia National Park enforcement personnel are sometimes called upon to assist with the enforcement of these regulations.

Since large portions of the Long Pond watershed are outside of the park, the Town of Southwest Harbor has found it more difficult to maintain its filtration requirement exemption. The town constructed a filtration plant along the south shore of Long Pond. In addition, the Seal Harbor Water Company has recently constructed an ozone treatment plant to disinfect its water supply, which originates in Jordan Pond.

In order to minimize risks associated with petroleum compounds, municipal water suppliers have established protection zones around water intakes. In Jordan Pond, the Seal Harbor Water Company has marked the intake protection zone with buoys, an action which has drawn criticism from park visitors who object to the intrusion in one of the most aesthetic settings in the park.

Water quality at swimming beaches

Water-based recreational activities such as swimming and wading both depend upon and can affect water quality. The Department of Human Services has promulgated water quality standards based upon U.S. Environmental Protection Agency guidelines for bacterial contamination at swimming beaches. These standards are based the incidence of gastrointestinal illness among swimmers who swim in contaminated waters. At present, there is no required program for beach water quality monitoring in Maine.

Acadia National Park has two designated swimming beaches, and several undesignated areas where swimming occurs. From 1993-1995, the park conducted monitoring for *Escherichia coli (E. coli)* and enterococcus bacteria at both the designated swimming beaches at Echo Lake and Sand Beach, and non-designated swimming areas including Lake Wood and the Sand Beach Lagoon (Breen, 1995). The purpose of this monitoring was to determine baseline bacterial levels at the most popular park swimming areas and to assure a safe swimming environment.

Results from this three-year monitoring effort indicated that bacterial densities exceeded the state standard at only one site (the undesignated swimming area in the Sand Beach Lagoon) only on rare occasions following a heavy rain event (Breen, 1995). This lagoon area where swimming occurs is shallow and ephemeral, often breached by tidal action during the summer. It is likely that the short-term exceedances of the bacterial standard reflect natural conditions although a precise cause and effect relationship has not been determined. In every instance where

exceedances were noted, bacterial levels returned to background levels within the re-sampling period (approximately one week).

Bacterial levels at the two designated swimming beaches (Echo Lake and Sand Beach) and the undesignated swimming beach at Lake Wood were well below state standards on all dates sampled. Due both to the lack of potential bacterial sources and the low bacterial levels detected, the monitoring program was discontinued in 1996 pending program review and consultation with the U.S. Public Health Service.

MANAGEMENT OBJECTIVES

National Park Service management objectives focusing on these issues at Acadia National Park include:

1) Maintaining high water quality to protect public health, maintain ecosystem integrity, and preserve the existing pristine high water quality;
2) Promoting scientifically-based watershed management activities and visitor education, and instituting appropriate visitor use regulations for all lakes that are public water supplies in order to meet federal and state safe drinking water standards;
3) Providing park visitors with high quality potable water while assuring that park operations and development do not adversely affect park water resources or water-dependent environments;
4) Cooperating with local and state planning and regulatory agencies in developing watershed-wide strategies that respect local municipal needs to provide drinking water while recognizing National Park Service obligations to prevent adverse impacts on water-dependent resources within and adjacent to the park, and;
5) Promoting public awareness and education of local water resources, water quality protection, and water conservation as well as the potential for human impacts upon these resources.

RECOMMENDATIONS

3.5.1. Continuation of existing program with enhanced cooperative education facilitated by the park

Given that there are limited sources for bacteria around swimming beaches in the park, bacteriological monitoring will continue to be conducted seasonally over a 2-3 year period every decade to compare with levels recorded in the mid 1990's. Unless there is a reason to believe a new source of potential contamination is present, future monitoring at this interval will protect public health interests.

Funding has recently been made available to Acadia National Park for the purpose of rehabilitating and upgrading most of the water supply systems within the park (Table 3.5A). Once the repairs and improvements recommended in the recent design analysis (Connors *et al.*, 1998) are completed, all public and non-public potable water supplies systems within the park will meet or exceed all current state and federal standards. Routinely required monitoring will assure that all park potable supplies are safe and adequate.

The National Park Service will also continue to protect town water supplies by meeting its responsibilities identified in existing formal agreements with local water companies. Issues needing resolution would continue to be addressed on a case by case basis.

In addition, the park will work with local water companies, towns, and others to increase public attention and awareness about water quality issues and ways to protect public drinking water supplies. Possible actions could include collaborating to host a Mount Desert Island Water conference, creating interpretive brochures, and developing specific lesson plans for inclusion in the park's environmental education programs.

MANAGEMENT ACTIONS CONSIDERED BUT NOT RECOMMENDED

Institute Annual Swimming Beach Water Quality Monitoring

Under this alternative, park staff would conduct bacterial monitoring at all designated and undesignated swimming beaches each season. This action would result in annual health assessments of the status of park swimming waters, but would also be the most costly. Monitoring to date has suggested that problems are minimal at swimming beaches. Moreover, test results are not possible to obtain quickly enough to make a difference for isolated bacterial events. Park staff believe that the recommendation to continue more limited testing is the proper choice at this time.

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APPENDIX A. Summary of Public Comments on Draft Acadia National Park Water Resources Management Plan

INTRODUCTION

In June 1999, The National Park Service sent over 140 copies of the draft plan to non-governmental organizations, federal and state agencies, local town officials and libraries, Native American tribes in Maine, faculty at College of the Atlantic and University of Maine, elected Maine State and Federal representatives, and private individuals. The Acadia National Park Advisory Commission also had an opportunity to review the draft plan. In addition, a copy of the draft plan was available on the Internet (at the Acadia National Park home page) for review and downloading. The public comment period was open about six weeks until July 23, 1999.

A total of 19 comments from individuals and organizations were received. One of the individual respondents submitted two different comment letters that outlined similar concerns; one was delivered directly to the park and the other was sent via the office of Senator Susan Collins to National Park Service headquarters in Washington. Eleven respondents and the Acadia National Park Advisory Commission supported the plan's recommendations. Three respondents opposed the plan's recommendations. Four other individuals only provided editorial comments and did not take a position on the plan's preferred alternatives.

All letters written in opposition to the plan were exclusively focused on hunting, trapping, and fisheries issues on Great Ponds in the park. These letters, however, gave opposite reasons for not supporting the plan's recommendations. Two respondents opposed the proposed recommendation to prohibit recreational hunting and trapping on Great Ponds in the park. One of these individuals also indicated opposition to the proposed recommendation for National Park Service participation in the management of fisheries at the park. In contrast, the other opposing respondent disagreed with the park's proposal to cooperate with the State of Maine. Instead, their letter stated that the National Park Service should have exclusive management within all areas of the park, including Great Ponds, and should prohibit hunting, trapping, and stocking of non-native fish species.

One of the respondents who supported the plan's recommendations also advocated for National Park Service management control on Great Ponds under certain circumstances. They stated that if situations developed where the natural integrity of water resources in the park were being compromised due to conflicting National Park Service and State of Maine management objectives, then ultimately the National Park Service should have the primary responsibility to ensure protection of these resources.

Summary of Public Comments Supporting Plan Recommendations

- Dr. Edward Dunham, Trustee, Mount Desert Water District. Supported plan and provided editorial comments.

- Ron Jordan, Mount Desert Water District. Supported plan and provided editorial comments.

- George Lapointe, Commissioner, Maine Department of Marine Resources. Supported plan and committed to continued collaboration with the National Park Service. No recommended changes.

- Lawrence Buck, Appalachian Mountain Club. Supported plan. Indicated that the plan's discussion of jurisdiction was handled "intelligently and sensitively". Also commented that maps in the plan do not adequately indicate that there is private property located within the park boundary.

- Paul Hunt, Drinking Water Program, Maine Department of Human Services. Supported plan and provided editorial comments. Suggested that the plan would benefit from inclusion of map showing the locations of wells and intakes in and around the park. Offered to assist in production of this map. Specifically mentioned support for recommendation to enhance cooperative protection efforts in watersheds containing public water supplies.

- Pam Person, Coalition for Sensible Energy. Supported plan. Her comments were limited to section in the plan on atmospheric deposition and climate change. Recommended expansion of monitoring and research activities at the park to other pollutants (PCBs and Dioxins). Also urged the allocation of resources to ensure that data are analyzed and reported in a timely and understandable manner so they can be used in local, state, and federal policy arenas.

- Jean Marshall, Planner, Town of Southwest Harbor. Supported plan and indicated recommendations will assist the town in carrying out its own goals.

- Gary Friedmann, Chair, Bar Harbor Conservation Commission. Conservation Commission passed resolution in support of plan recommendations, with particular interest in eliminating hunting and trapping in the park and cooperative efforts between the National Park Service and Maine Department of Inland Fisheries and Wildlife to protect and perpetuate native aquatic species and natural habitats. Also stated desire to work with the park to protect the town's natural resources.

- Steve Perrin, Bar Harbor resident. Supported the plan. Provided comments on his rationale for opposition to hunting and stocking of non-native fish and on removing dams on lakes that effectively block fish passage in the park.

- W. Kent Olson, President, Friends of Acadia. Supported all recommendations in the plan with the following caveat. If the integrity of water resources in the park was compromised because of conflicting management objectives between the National Park Service and other entities, then the National Park Service should have the ultimate responsibility for ensuring the protection of these resources.

- Matthew Horton, Bar Harbor resident (also Bar Harbor Town Council Member). Supported recommendations for cooperation between the National Park Service and the Maine Department of Inland Fisheries and Wildlife on fisheries management issues. Also indicated no objection to prohibiting hunting in the park. Mr. Horton, however, did voice concerns over National Park Service objections to the State proposal to introduce non-native splake and brown trout into two ponds at the park in 1999 (this issue was not specifically addressed in the plan). He also stated opposition to any increased regulation over use of motor boats on great ponds (also not specifically proposed in the plan). Mr. Horton also included in his letter some general comments expressed to him by local sportsmen about their concerns over greater National Park Service involvement in fisheries management at the park and the plan's proposal to prohibit hunting in the park. He indicated that his constituents have said to him that they feel that this represents another erosion of their rights to lawfully harvest game.

- Acadia National Park Advisory Commission. Approved (11-1) the following motion at their 9/13/99 meeting: "The Advisory Commission commends the thoroughness of the report and supports the direction of the scientific effort. As to the jurisdictional issue, the Commission recommends Acadia National Park focus primarily on the objectives listed in the plan by cooperating with the Maine Dept. of Inland Fisheries & Wildlife, Alternative C, as listed on pages 3-18 and 3-19."

<u>Summary of Public Comments Opposing Plan Recommendations</u>

- Terry Savage, Bar Harbor resident. Submitted two letters; one directly to the park and the other to Senator Susan Collins, which was forwarded to National Park Service headquarters in Washington, D. C. Mr. Savage stated that the "No Action" alternative in the chapter titled "Recreational Use and Management of Surface Waters" should be the National Park Service recommended position. He indicated that the Maine Department of Inland Fisheries and Wildlife has been doing an excellent job and that management does not need to be changed. Claimed that there is no federal legislation granting the National Park Service authority over Great Ponds in the park. He stated that the founders of the park (Dorr, Eliot, Stebbins, and Hancock County Trustees of Public Reservations) never intended for the public to lose recreational rights.

- Ted Perkins, Maine Trappers Association. Opposed plan's recommendation to close the park to trapping.

- Eileen Woodford, Northeast Regional Director, National Parks and Conservation Association. Supported all plan recommendations, except for those in the chapter titled " Recreational Use and Management of Surface Waters". Stated that the recommendation to cooperate with the Maine Department of Inland Fisheries and Wildlife would not guarantee the termination of current management practices that are contrary to National Park Service management policies and the Organic Act. Argued for the National Park Service to have sole jurisdiction over all park waters.

Summary of Public Comments Neither Supporting or Opposing Plan Recommendations

- Ron Brokaw, Regional Fisheries Biologist, Maine Department of Inland Fish and Wildlife. Focused comments exclusively on correcting errors in chapters 1 and 2 relative to historic and current department management practices.

- Gary Rosenlieb, Hydrologist, NPS Water Resource Division. Provided editorial comments.

- Steve Norton, Geologist at the University of Maine. Provided editorial comments.

- Donald Soctomah, Passamaquoddy Tribal Representative to the Maine State House. Expressed concerns over lack of reference to Native American use of the park in the plan, even though they have used the area for "thousands of years and some continue to use the area for traditional uses". Asks that future Native American cultural uses of the wetland areas of the park not be precluded. No specific position taken on the plan's recommendations.