VITAL SIGNS MONITORING PLAN

Phase II Report

Northeast Temperate Network

October 2004









NATIONAL PARK SERVICE

EXECUTIVE SUMMARY

The National Park Service (NPS) initiated a new "Vital Signs" program in 1998 to develop comprehensive, long-term monitoring of ecological resources within U.S. national parks. Vital signs are indicators, and are defined as are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. This report documents the progress of the Northeastern Temperate Network in implementing the first two Phases of this program. In Phase 1, baseline inventories and analysis of threats provided information to build conceptual ecological models for four ecosystem groups – terrestrial, wetland, aquatic, and intertidal systems. In Phase 2, the core science team developed a list of more than 100 potential vital signs. This preliminary list was peer-reviewed to develop a final list of 23 high priority vital signs, with 104 associated potential measures. In Phase 3, protocols will be developed for groups of vital signs. To ensure that the final set of measured vital signs produce reliable inference within cost constraints of NETN, statistical power analyses and cost assessments will be an integral part of Phase 3. Because timely reporting and communication is a primary component of a successful monitoring program, we will incorporate standard summaries of statistical trends in vital signs measures after each implementation period. We will also develop a rating scheme to allow integration of vital signs into an overall ecological integrity rank for particular occurrences of an ecosystem. The ranks can be used as part of an "Ecological Integrity Scorecard" that provides an important communication tool for adaptive management, which requires that information be communicated in a way that informs management decisions and can be understood by a diverse audience.

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Greg Shriver is the Network Coordinator and Fred Dieffenbach is the biologist / data manager for the NETN. They, along with Don Faber-Langendoen, Geraldine Tierney, Pam Lombard, and James Gibbs form the core science team for the Phase II report. John Gunn is developing information on the Appalachian Trail. Ben Rubin and Shawn Carter assisted the team during earlier work on the Phase I report.

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Chapter 1 Introduction and Background

1.1 The NPS Vital Signs Program and the Northeast Temperate Network

Recognizing the need for comprehensive, long-term monitoring of ecological resources within the U.S. National Park System, the National Park Service (NPS) undertook a major new initiative in 1998 to develop a program for long-term monitoring of "Vital Signs," or indicators, of ecological integrity within the parks. Vital signs are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. This Inventory & Monitoring (I&M) program is being implemented within 270 parks, which have been grouped into 32 park networks, using a consistent framework and process.

The Northeast Temperate Network (NETN) consists of 10 parks in 7 states, plus the Appalachian Trail, which traverses the NETN region from Maine to Pennsylvania. The Appalachian Trail (APPA) is coordinating inventory and monitoring activities throughout its length (from Maine to Georgia) with the NETN, thus NETN will coordinate monitoring efforts with the four other networks that intersect with the APPA. The 11 "parks" within the NETN are grouped together based on their common ecological resources - northeastern temperate forests and the wetland and aquatic systems that accompany them.

As with other NPS networks, NETN seeks to identify and define appropriate vital signs of ecological integrity and to establish protocols for their measurement. NETN has focused on identifying indicators representing the diversity of ecological systems and anthropogenic stressors within parks at a range of ecological scales. The challenge is to identify a coherent set of indicators that cover the range of ecological resources and stressors found in the network, within the budgetary constraints of the program, and which can be meaningfully compared to indicators selected by other NPS networks and other monitoring programs. The NETN vital signs program must also provide effective communication tools that allow park managers and other audiences to interpret meaningful changes to park ecological integrity; in order to do so, NETN plans to employ an innovative ecological integrity ranking scheme described herein.

The overall process for developing the NPS vital signs program has been outlined by the NPS Vital Signs Program (http://science.nature.nps.gov/im/monitor/index.htm; see also Fancy 2004, Gross 2004). Briefly, the I&M Vital Signs Program incorporates a three-phase approach:

Phase 1 - define goals and objectives; begin the process of identifying, evaluating and synthesizing existing data; develop draft conceptual models; and complete other background work;

Phase 2 - prioritize and select vital signs and develop specific monitoring objectives for each park and the network; and,

Phase 3 - develop detailed plans to implement monitoring, including the development of sampling protocols, a statistical sampling design, a plan for data management and analysis, and expectations for reports and other presentation of results.

Herein we present here our progress on Phases I and II of this program.

1.2 Purpose

1.2.1 Justification for Integrated Natural Resource Monitoring

Knowing the condition of natural resources within national parks is fundamental to NPS's ability to manage park resources "unimpaired for the enjoyment of future generations." National Park managers are confronted with increasingly complex and challenging issues that require a broad-based understanding of the status and trends of park resources. For years, managers and scientists have sought a way to characterize and determine trends in the condition of parks and other protected areas in order to assess the efficacy of management practices and restoration efforts, and to provide early warning of impending threats. The challenge of protecting and managing a park's natural resources requires a multi-agency, ecosystem approach because most parks are open systems, with many threats, such as air and water pollution and invasive species, originating outside of park boundaries. Moreover, an ecosystem approach is needed because no single spatial or temporal scale is appropriate for all system components and processes. The appropriate scale for understanding and effectively managing a resource might range spatially from site-specific to regional, and might vary temporally from sub-annual to decadal or more. In some cases a regional, national or international effort may be required to understand and manage the resource. National parks are part of larger ecosystems and must be managed in that context.

Natural resource monitoring provides site-specific information needed to identify and understand changes in complex, variable, and imperfectly understood natural systems and to provide insight into whether observed changes are within natural levels of variability or indicate undesirable human influence. Thus, monitoring provides a basis for identifying and understanding *meaningful change* in natural systems characterized by complexity, variability, and non-linear responses. Monitoring results can be used to identify threatened or impaired resources and initiate or change management practices. Understanding the dynamic nature of park ecosystems and the consequences of human activities is essential for management decision-making designed to maintain, enhance, or restore the ecological integrity of park ecosystems and to avoid, minimize, or mitigate ecological threats to these systems (Roman and Barrett 1999).

The intent of the NPS monitoring program is to track a subset of park resources and processes, representing significant indicators of ecological condition; these indicators are called "vital signs." These indicators must be a useful subset of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations," including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on these resources. By choosing a meaningful subset of ecological resources, NPS recognizes that tracking everything is neither possible nor desirable. In situations where natural areas have been so highly altered that physical and biological processes no longer operate (e.g., control of fires or floods in developed areas), information obtained through monitoring can help managers understand how to develop the most effective approach to restoration or, in cases where restoration is impossible, ecologically sound management. The broad-based, scientifically

sound information obtained through natural resource monitoring will have multiple applications for management decision-making, research, education, and promoting public understanding of park resources.

1.2.2 Legislation, Policy and Guidance

National Park managers are directed by federal law and National Park Service policies and guidance to know the status and trends in the condition of natural resources under their stewardship in order to fulfill the NPS mission of conserving parks unimpaired. The mission of the National Park Service (National Park Service Organic Act, 1916) is:

"...to promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified by such means and measures as conform to the fundamental purposes of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life 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".

Congress strengthened the National Park Service's protective function, and provided language important to recent decisions about resource impairment, when it amended the Organic Act in 1978 to state that *"the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established…"*.

More recently, the National Parks Omnibus Management Act of 1998 established the framework for fully integrating natural resource monitoring and other science activities into the management processes of the National Park System. The Act charges the Secretary of the Interior to "*continually improve the ability of the National Park Service to provide state-of-the-art management, protection, and interpretation of and research on the resources of the National Park System*", and to *"… assure the full and proper utilization of the results of scientific studies for park management decisions*." Section 5934 of the Act requires the Secretary of the Interior to develop a program of "*inventory and monitoring of National Park System resources to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources*."

Congress reinforced the message of the National Parks Omnibus Management Act of 1998 in its text of the FY 2000 Appropriations bill:

"The Committee applauds the Service for recognizing that the preservation of the diverse natural elements and the great scenic beauty of America's national parks and other units should be as high a priority in the Service as providing visitor services. A major part of protecting those resources is knowing what they are, where they are, how they interact with their environment and what condition they are in. This involves a serious commitment from the leadership of the National Park Service to insist that the superintendents carry out a systematic, consistent, professional inventory and monitoring program, along with other scientific activities, that is regularly updated to ensure that the Service makes sound resource decisions based on sound scientific data."

The 2001 NPS Management Policies updated previous policy and specifically directed the Service to inventory and monitor natural systems:

"Natural systems in the national park system, and the human influences upon them, will be monitored to detect change. The Service will use the results of monitoring and research to understand the detected change and to develop appropriate management actions".

Box 1:
Statutes that provide legal direction for expending funds to determine the condition of natural resources in parks and specifically guide the natural resource management of network parks:

- Taylor Grazing Act 1934;
- Fish and Wildlife Coordination Acts, 1958 and 1980;
- Wilderness Act 1964;
- National Historic Preservation Act 1966;
- National Environmental Policy Act of 1969;
- Clean Water Act 1972, amended 1977, 1987;
- Endangered Species Act 1973, amended 1982;
- Migratory Bird Treaty Act, 1974;
- Forest and Rangeland Renewable Resources Planning Acts of 1974 and 1976;
- Mining in the Parks Act 1976;
- American Indian Religious Freedom Act 1978;
- Archaeological Resources Protection Act 1979;
- Federal Cave Resources Protection Act 1988

Further, "The Service will:

- Identify, acquire, and interpret needed inventory, monitoring, and research, including applicable traditional knowledge, to obtain information and data that will help park managers accomplish park management objectives provided for in law and planning documents;
- Define, assemble, and synthesize comprehensive baseline inventory data describing the natural resources under its stewardship, and identify the processes that influence those resources;
- Use qualitative and quantitative techniques to monitor key aspects of resources and processes at regular intervals;
- Analyze the resulting information to detect or predict changes, including interrelationships with visitor carrying capacities, that may require management intervention, and to provide reference points for comparison with other environments and time frames;
- Use the resulting information to maintain-and, where necessary, restore-the integrity of natural systems" (2001 NPS Management Policies).

These are among the many additional statutes that provide legal direction for expending funds to determine the condition of natural resources in parks and specifically guide the natural resource management of network parks (See Box 1).

1.3 Monitoring Goals and Strategies

1.3.1 Role of Monitoring

Monitoring is a central component of natural resource stewardship in the National Park Service, and in conjunction with natural resource inventories and research, provides the information needed for effective, science-based managerial decision-making and resource protection (Figure 1.1). The NPS strategy to institutionalize inventory and monitoring throughout the agency is based on a framework that consists of several key components; (a) completion of 12 basic

resource inventories upon which monitoring efforts can be based, (http://science.nature.nps.gov/im/inventories.htm) (b) a network of 11 experimental or "prototype" long-term ecological monitoring programs initiated in 1992 to evaluate alternative monitoring designs and strategies, and (c) implementation of operational monitoring of critical parameters (i.e. "vital signs") in 270 parks with significant natural resources that have been grouped into 32 networks linked by geography and shared natural resource characteristics. NETN is one of these 32 networks.

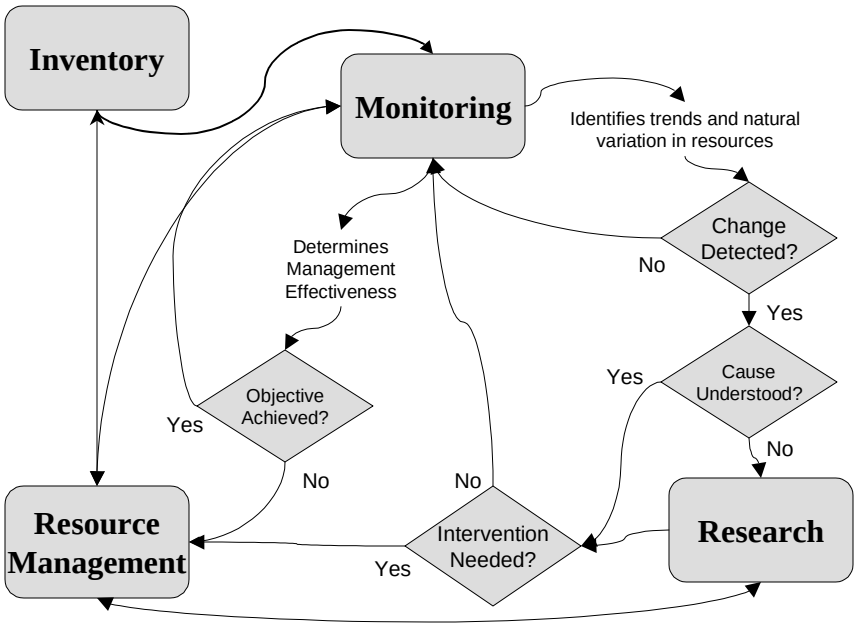


Figure 1.1. *Relationships between monitoring, inventories, research, and natural resource management activities in national parks.*

1.3.2 Service-wide Vital Signs Monitoring Goals

Servicewide Goals for Vital Signs Monitoring for the National Park Service are as follows:

- Determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources;
- Provide early warning of abnormal conditions and impairment of selected resources to help develop effective mitigation measures and reduce costs of management;
- Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments;
- Provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment;
- Provide a means of measuring progress towards performance goals.

These general goals will be supplemented by specific goals for the Northeast Temperate Network (see section 1.6 below), after the basic park natural and cultural resources and management issues have been presented.

1.3.3 The Three-Phase Process for the I&M Monitoring Program

During the initial planning for park vital signs monitoring, it became clear that a "one size fits all" approach to monitoring would not be effective within NPS due to the tremendous variability among parks in ecological conditions, sizes, and management capabilities. To develop an effective and cost-efficient monitoring program that addresses the information needs of each park and integrates across other park operations like interpretation and maintenance, parks need the flexibility to allow existing programs, funding,and staff to be combined with new I & M program. Partnerships with federal and state agencies and adjacent landowners are necessary to effectively understand and manage resources and threats that extend beyond park boundaries, and these partnerships will vary across the national park system. For example, parks in the Pacific Northwest will need to select indicators and methodologies that are consistent with the Northwest Forest Plan, whereas parks in South Florida, in conjuction with the U.S. Army Corps of Engineers, South Florida Water Management District, and other partners, may select a completely different set of indicators and sampling protocols appropriate to restoration of the everglades ecosystem.

The complicated task of developing a network monitoring program requires an initial investment in planning and design to guarantee that monitoring meets the most critical information needs of each park, and produces scientifically credible results that are clearly understood and accepted by scientists, policy makers, and the public, and that are readily accessible to managers and researchers. These front-end investments also ensure that monitoring will build upon existing information and understanding of park ecosystems and make maximum use of leveraging and partnerships with other agencies and academia.

The NPS has established a 3-phase planning and design process for the I & M program. *Phase 1* involves defining network goals and objectives; identifying and synthesizing existing data; developing conceptual ecological models of park resources; and completing other background work. *Phase 2* involves prioritizing and selecting vital signs using a process of scientific peer review. *Phase 3* involves the development of specific sampling protocols, a statistical sampling design, a plan for data management and analysis, and a plan for reporting monitoring results. After completion of each Phase, each network reports their progress for NPS review within a structured report (such as this report). The timeline for accomplishing these phases within NETN is presented in Table 1.1.

We used a standard process to begin Phase 1 of the development of long-term ecological monitoring within NETN (Figure 1.2). We began with a series of brainstorming sessions, questionnaires, meetings and scoping workshops (Table 1.2) to identify: (1) focal resources and ecological processes important within NETN parks, (2) key stressors or agents of change known or suspected to be acting upon NETN ecological resources; and (3) key elements and processes representing ecological integrity within these ecological resources. Conceptual models were then developed to help organize and communicate this information, and identify cause and effect relationships between stressors and response variables (see Chapter 2).

Table 1.1. *Timeline for the Northeast Temperate Network to complete the 3-phase planning and design process for developing a monitoring program.*

ACTIVITY	FY01 Oct-Mar	FY01 Apr-Sep	FY02 Oct-Mar	FY02 Apr-Sep	FY03 Oct-Mar	FY03 Apr-Sep	FY04 Oct-Mar	FY04 Apr-Sep	FY05 Oct-Mar	FY05 Apr-Sep
Data gathering,										
Inventories to										
Scoping										
Conceptual										
Indicator										
Protocol										
Monitoring Plan Due Dates Phase 1, 2, 3						Phase 1 Oct. 03		Phase 2 Oct. 04		Phase 3 Dec. 05

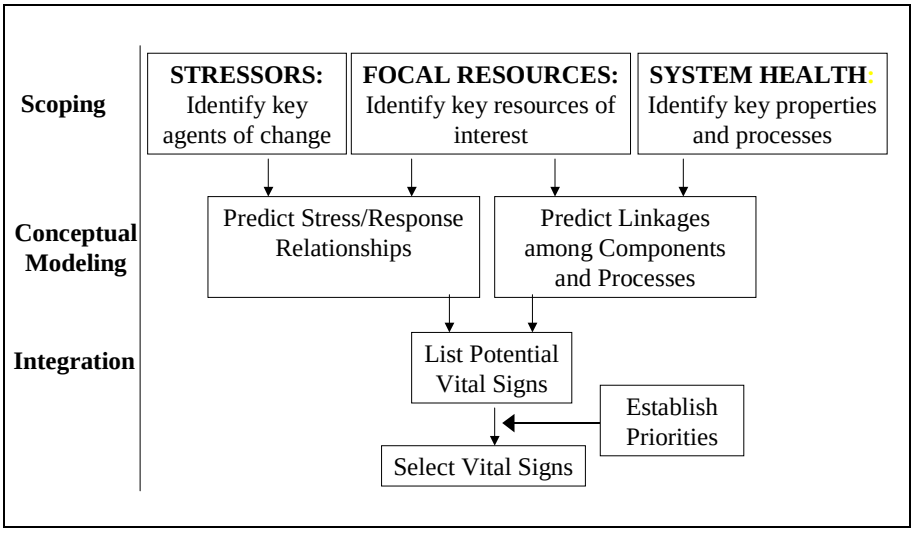


Figure 1.2. *The basic approach to identifying and selecting vital signs for integrated monitoring of park resources (source: Kurt Jenkins, USGS Olympic Field Station).*

Table 1.2. *Workshops/meetings held to implement the monitoring program in the Northeast Temperate Network, 2000-2004.*

PHASE	MILESTONES	DATES
Phase 1	Assessing Natural Resources	
	Identify Priorities for Inventory Needs	May 2001- Dec. 2003
	Identify Significant Resources, Prioritize Management Issues, Identify Monitoring Needs for each park.	August 2003
	Developing Program Resources	
	First NETN Board meeting to review program and charter	December 2002
	Create Core Science Team	December 2002
	Park-based scoping meetings	January – May 2003
	Phase I Plan	
	Phase I draft review – Acadia NP (conceptual models)	October 2003
	Complete Phase I Report	October 2003
Phase II	Phase II Plan	
	Technical Committee Planning Meeting	November 2003
	Vital Signs Selection Workshop	May 2004
	Technical Committee / Parks Review Workshop	August 2004
	Submit Phase II Report	October 2004
Phase III	(to be developed)	

1.3.4 An Integrated Approach to Monitoring

A key initial decision in designing a monitoring program is balancing the need to monitor for current management issues against the need to detect future, perhaps unforeseen threats to park ecosystems. Many have enumerated advantages and disadvantages of these two approaches (Woodley 1993, Noon 2002). Our ability to predict ecosystem response to changes in various system drivers and stressors is limited by our incomplete understanding of ecological systems and processes. A monitoring program that only focuses on well-known threat/response relationships will not provide the long-term information and understanding necessary to address unanticipated, high-priority issues that will arise in the future.

Alternatively, monitoring key ecological properties and processes indicative of ecosystem integrity will allow detection of change in response to unforeseen or uncharacterized stressors and perhaps provide early warning of unacceptable change. Ecological integrity can be defined as "the maintenance of ... structure, species composition, and the rate of ecological processes and functions within the bounds of normal disturbance regimes" (Lindenmayer and Franklin 2002). This concept builds on earlier definitions of biological integrity, defined as the capacity to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats of the

region (Karr et al. 1986); ecological integrity is a broader concept which incorporates aspects of abiotic condition such as air or water quality.

NETN seeks to combine these two complementary approaches, by selecting a suite of indicators that measure both known stressors and ecological integrity (Figure 1.3). This approach is consistent with that advocated by the I&M program, which stresses that Vital Signs include: 1) physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources; 2) known or hypothesized effects of stressors; and 3) or elements that have important human values.

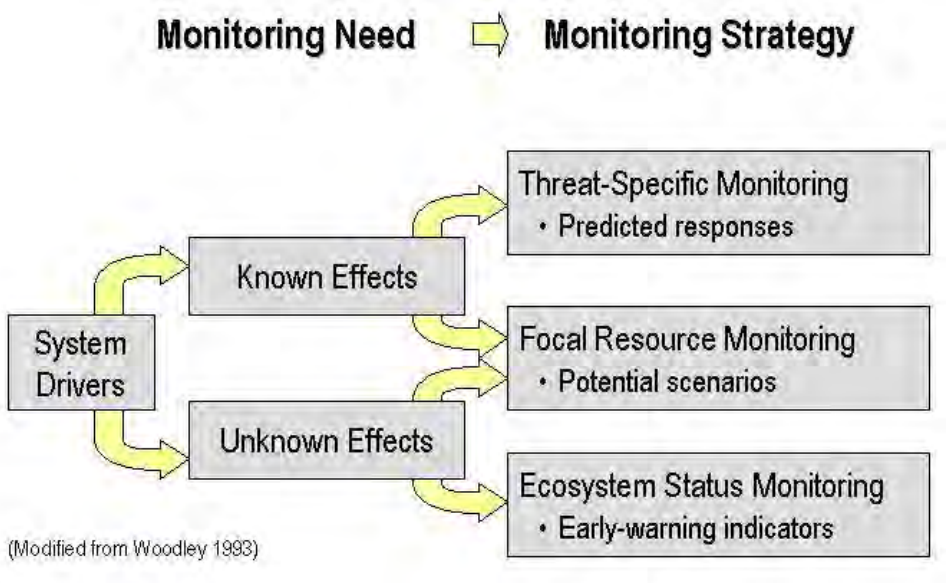


Figure 1.3. *Conceptual approach for selecting monitoring indicators.*

Moreover, an integrated monitoring program should yield information at multiple spatial and temporal scales, across major disciplines, and that is useful across program boundaries. NETN seeks to develop a program that incorporates the following aspects of integration:

Ecological Integration involves considering the ecological linkages among system drivers and the components, structures, and functions of ecosystems when selecting monitoring indicators. An effective ecosystem monitoring strategy will employ a suite of individual measurements that collectively monitor the integrity of the entire ecosystem. One approach for effective ecological integration is to select indicators at various hierarchical levels of ecological organization (e.g., landscape, community, population, genetic; see (Noss 1990).

Spatial Integration involves establishing linkages of measurements made at different spatial scales. It requires understanding of scalar ecological processes, the collocation of measurements of comparably scaled monitoring indicators, and the design of statistical sampling frameworks that permit the extrapolation and interpolation of scalar data.

Temporal Integration involves establishing linkages between measurements made at various temporal scales. It will be necessary to determine a meaningful timeline for sampling different indicators while considering characteristics of temporal variation in these indicators. For

example, sampling changes in the structure of a forest overstory (e.g., size class distribution) may require much less frequent sampling than that required to detect changes in the composition or density of herbaceous groundcover. Temporal integration requires nesting the more frequent and, often, more intensive sampling within the context of less frequent sampling.

Programmatic Integration involves the coordination and communication of monitoring activities within and among parks, among divisions of the NPS Natural Resource Program Center, and among the NPS and other agencies, to promote broad participation in monitoring and use of the resulting information. At the park or network level, involving a park's law enforcement, maintenance, and interpretative staff in monitoring activities and reporting results in a clear, concise format, creates a well-informed park staff, improved potential for informing the public, greater acceptance of monitoring results in the decision-making process, and therefore, wider support for vital signs monitoring. The systems approach to monitoring planning and design requires a coordinated effort by the NRPC divisions of Air Resources, Biological Resource Management, Geologic Resources, Natural Resource Information, and Water Resources to provide guidance, technical support and funding to the networks. Finally, there is a need for the NPS to coordinate monitoring planning, design and implementation with other agencies to promote sharing of data among neighboring land management agencies, while also providing context for interpreting the data.

1.3.5 Interpreting Ecological Integrity

Ultimately, a vital sign is useful only if it provides information useful in guiding management decisions or quantifying the success of past decisions. This information must be presented in a way that is clearly understood by managers, scientists, policy makers, and the public. NETN plans to accomplish this task by 1) developing standard statistical summaries of vital sign measurements, and 2) developing an ecological integrity scorecard that provides basic interpretation of trends.

First, our protocols will clearly specify standard statistical methods for detection of trends for all vital signs. These will include aggregate trends among related vital signs and aggregate trends among vital signs within particular ecosystem types. We hope to co-locate ("bundle") measurements of many vital signs at standard locations, and correlations among them will also permit general inferences about particular regions. By progressing in this manner, we will determine meaningful effect sizes for each vital sign measure (as these dramatically affect sample size and overall cost), and thereby, track the accrual of monitoring costs to make cost-effective decisions about which vital sign measures can be included in the initial phase of program implementation.

Second, NETN plans to develop an ecological integrity scorecard into the reporting process for the NETN Vital Signs Program. Powerful communication tools are necessary to transform a collection of field data into a format that shows managers whether and how ecological integrity is changing. Communicating trends in twenty or more vital signs and the multitude of associated measures will require a framework that clearly and concisely conveys the state of the park ecosystems. The developing of an ecological integrity scorecard during Phase 3 will provide the NETN with the necessary framework to effectively communicate this information. Ultimately this scorecard will be an aggregated matrix, in which individual measures are rated and compiled into an overall assessment of the integrity of an ecological system (Harwell et al. 1999,

NatureServe 2002, Young and Sanzone 2002, Parrish et al. 2003). It may take the form of a series of ecological integrity indices, ranks or scorecards (Appendix A).

1.3.6 Limitations of Monitoring

Managers and scientists must acknowledge limitations of monitoring that result from the inherent complexity and variability of park ecosystems, as well as those resulting from the limitations of resources available for monitoring. Ecosystems are loosely defined assemblages that exhibit characteristic patterns on a range of scales of time, space, and organizational complexity (De Leo and Levin 1997). Definitions of ecological integrity are problematic, partly because key terms such as "natural" remain vague (Noon 2002). Natural systems as well as human activities change over time, and it is extremely challenging to separate natural variability and desirable changes from undesirable anthropogenic sources of change to park resources. Moreover, limiting funding prevents us from directly monitoring all resources that might be at risk. These complexities demand that we recognize our limited understanding of ecological systems and processes, especially as we attempt to use this information to inform management decisions.

In some cases, monitoring data might suggest a cause and effect relationship that can then be investigated by a research study. As monitoring proceeds, as data sets are interpreted, as our understanding of ecological processes is enhanced, and as trends are detected, future issues will emerge (Roman and Barrett 1999). The monitoring plan should therefore be viewed as a working document, subject to periodic review and adjustments over time as our understanding improves and new issues and technological advances arise.

1.4 Ecological Resources of the Northeast Temperate Network

1.4.1 Overview of Parks and Ecological Resources

The NETN contains 11 parks (Table 1.3), including a section of the Appalachian NST. These parks contain diverse cultural and natural resources within eight states (ME, NH, VT, MA, CT, NY, NJ, and PA) and span two ecological divisions (Laurentian / Acadian and Central Interior & Appalachian, Figure 1.4). Parks within the Network range geographically from Acadia NP in coastal Maine to Morristown NHP in central New Jersey.

NETN parks range in size from ≈ 9 acres at Saugus Iron Works to ≈ 85,000 acres covered by the Appalachian Trail (NPS lands from ME-MD), include the beginning and end of the Revolutionary War (Minute Man NHP and Saratoga NHP respectively), and a strategic military location for General George Washington (Morristown NHP). Two National Historic Parks commemorate the lives of artists (Saint-Gaudens NHS and Weir Farm NHS) and Roosevelt-Vanderbilt NHS celebrates the lives of the "Gilded Age". Marsh-Billings-Rockefeller NHP and Boston Harbor Islands NPA are both new to the NPS and unique in their establishment and mandates. Marsh-Billings-Rockefeller NHP is the only national park to focus on conservation history and the evolving nature of land stewardship. Boston Harbor Islands, established in 1996, are a culturally and naturally diverse set of 34 drowned drumlins in the Massachusetts Bay managed by a 13-member partnership. Saugus Iron Works NHS marks the site of the first integrated iron works in North America, which gave rise to the industrial revolution and is known as the forerunner of America's industrial giants. Acadia is the only National Park in the NETN and hosts a diverse array of cultural, natural, and geologic resources. The Appalachian

Trail, crosses some of the most diverse ecological communities in the Northeast, is managed by a unique partnership with the NPS and the Appalachian Trail Conference, and provides an exciting opportunity for ecological monitoring across 2,100 miles of habitat representative of the entire east coast of the US. Fuller details on each of the parks are provided in Appendix B. Eight of the eleven NETN parks are National Historic Parks or Sites, and thus have a primary mandate to maintain historical features, landscapes or practices. This special mandate has a substantial impact on ecological resources within these parks, as they are often managed to maintain early successional habitats, or incorporate agriculture or forestry within the parks to satisfy this mandate.

All the parks in the Network are located within the temperate deciduous forest biome. Temperate deciduous forests are located in mid-latitude areas between the Polar Regions and the tropics and are exposed to both warm and cold air masses that cause this region to have four distinct seasons. Temperature varies widely from season to season, with long, cold winters and warm summers. Within NETN, the average annual temperature ranges from about 11˚ C along the southern coast to 4˚ C in the northern highlands. Annual precipitation ranges from 90-120 cm and is relatively evenly distributed throughout the year.

Table 1.3. *Summary of parks in the Northeast Temperate Network.*

Park Name	Code	Size (acres)	% Total Area	Annual Visits	% Total Visits
Acadia NP (ME)	ACA	47,498	0.34	2,504,708	52
Appalachian NST (ME-PA)	APPA	85,036	0.60	NA	NA
Boston Harbor Islands NPA	BOH	1,465	0.01	NA	NA
Marsh-Billings-Rockefeller NHP	MAB	643	<0.01	28,699	<1
Minute Man NHP (MA)	MIM	967	0.01	1,064,389	22
Morristown NHP (NJ)	MOR	1,707	0.01	422,758	9
Roosevelt-Vanderbilt NHS (NY)	ROV	778	<0.01	594,884	12
Saint-Gaudens NHS (NH)	SAG	150	<0.01	47,801	<1
Saratoga NHP (NY)	SAR	3,392	0.02	152,854	3
Saugus Iron Works NHS (MA)	SAIR	9	<0.01	17,050	<1
Weir Farm NHS (CT)	WEF	74	<0.01	16,820	<1

Temperate deciduous forests are dominated by broadleaf trees, including oak, hickory, maple, beech, and birch, often mixed with conifers such as hemlock, spruce, fir, and pine on drier or higher elevation sites. Network forests range from the drier central hardwoods oak-pine or oak-hickory stands through mesic northern hardwoods to spruce-hardwoods. Other terrestrial habitats include alpine vegetation, rocky outcrop woodlands and both old-field successional habitats and plantations. A variety of wetland and aquatic habitats are present within these forests, including forested and shrub swamps, marshes, wet meadows, fens and bogs, lakes, rivers, ponds and vernal pools. In addition, intertidal habitats are present at Acadia and Boston Harbor Islands.

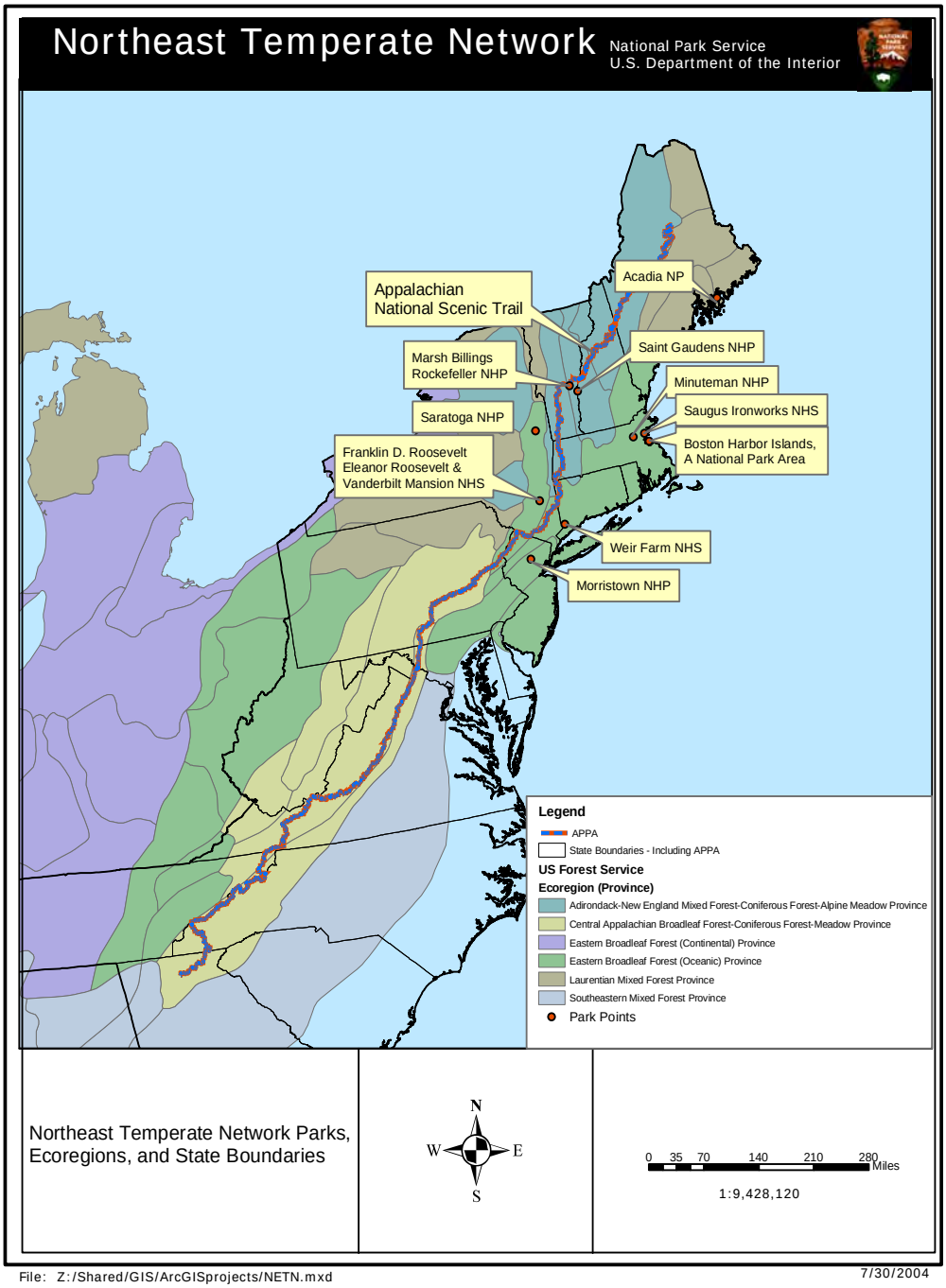


Figure 1.4. *Location of NETN parks with respect to the ecoregions of the eastern US.*

Worldwide, temperate deciduous forests have been highly altered, having the highest index of human disturbance of any major biome (Hannah et al. 1995), and having high indices of fragmentation (Ritters et al. 2000). The northeast is no exception. Temperate deciduous forests in the northeast have been heavily utilized for timber, cleared for agriculture, or converted into

towns and cities. Even so, regrowth of forests on abandoned farms in the last 50-100 years has created a new mix of primary and secondary forests, and increased levels of overall forest cover (Foster and Aber 2004).

1.4.2 Ecological Systems and Communities

An effective monitoring program requires accurate assessments of the patterns of ecological systems. Systems in each park are being mapped using the U.S. Geological Survey - National Park Service (USGS - NPS) Vegetation Mapping Program (http://biology.usgs.gov/npsveg/), which is one of the inventories specified by the Natural Resource Challenge. The vegetation mapping program is mapping a large percentage of the NPS land base using two complementary classification schemes 1) the U.S. National Vegetation Classification (USNVC), a federal standard for classification of terrestrial ecological communities based on vegetation; and 2) NatureServe's Ecological Systems classification (Comer et al. 2003, NatureServe 2003b), a broader classification tool. Many government agencies and other organizations use the USNVC, thus this classification scheme allows comparison of park data with that of other groups. Currently, system and vegetation maps are completed or underway for all Network parks (Table 1.4, and see Appendix B). This mapping and classification effort will also allow NETN to determine the global, state and local conservation status, or relative rarity, of park ecological systems.

Table 1.4. *Expected completion dates for USGS Vegetation Mapping Program project for NETN parks.*

Park Name	Expected completion date for
Acadia NP (ME)	completed
Appalachian NST	scoping
Boston Harbor Islands NPA (MA)	scoping
Marsh-Billings-Rockefeller NHP (VT)	2005
Minute Man NHP (MA)	2005
Morristown NHP (NJ)	2005
Roosevelt-Vanderbilt NHS (NY)	2005
Saint-Gaudens NHS (NH)	2005
Saratoga NHP (NY)	2005
Saugus Iron Works NHS (MA)	2005
Weir Farm NHS (CT)	2005

While these mapping efforts are in progress, information has been compiled from draft maps and other park sources to approximate the extent of major ecological system groups within each park (Table 1.5; see also Appendix C). To address larger issues of historic patterns of land-cover change, the Network has undertaken a project to map present land cover and estimate land cover change since the early 1970s around each NETN park, including part of the Appalachian Trail. This information will provide the landscape context for all NETN parks.

NETN is comprised of a diverse array of ecological systems including terrestrial systems, wetland systems, intertidal systems, and a variety of lakes and streams (Table 1.5). National historic parks and sites also include a variety of human-modified systems that are maintained as

part of the parks' cultural mandate. Parks vary widely in the amount of land area represented by each system group. Terrestrial systems dominate all NETN parks except Boston Harbor and Saugus Iron Works, in which intertidal or wetland systems are dominant. Acadia contains extensive systems in all categories. Minute Man also has extensive wetlands. Important aquatic systems are present at Saint-Gaudens and Saratoga as well as Acadia.

Park size and cultural mandate must both be considered in addition to ecological systems in the design of Vital Sign Monitoring within these parks. All the parks but Acadia and the Appalachian Trail are small, meaning that outside landscape and regional factors have strong influences. The historic parks and sites contain relatively fewer natural ecological systems, but the maintained early-successional habitat within those parks may have other important ecological value, such as providing habitat for grassland birds.

Table 1.5. *Area (hectares) of general system groups within each park.*

PARK	Terrestrial	Wetland	Intertidal	Aquatic
ACAD	13,215	904	118	980
APPA	N/A	N/A	N/A	N/A
BOHA	143	20	420	<1
MABI	218	4	0	6
MIMA	250	105	0	1
MORR	490	15	0	<1
ROVA	251	12	0	6
SAGA	51	5	0	2
SAIR	1	2	0	<1
SARA	1082	37	0	2
WEFA	27	4	0	2

1.4.3 Biodiversity Assessments

A variety of surveys have assessed the species and community diversity of NETN parks. These include surveys of local populations of state or globally ranked rare species, or federally listed species, as well as exemplary occurrences of natural communities. Heritage programs have historically visited parks within the Network to identify these rare communities and species (Appendix D). Over 514 species and 863 occurrences are documented within NETN parks (Table 1.6), the majority found on the Appalachian Trail. Many of these occurrences have been assigned a population viability or ecological integrity rank, based on the qualitative NatureServe/Heritage Network ranking methodology (NatureServe 2002). The ecological integrity ranks will be reassessed as part of this Vital Signs monitoring program, and will serve as a baseline measure of ecological condition. Integration of these ranks into the program will be developed during Phase 3.

1.4.4 Management Issues for Network Parks – Assessing Threats

Scientific and management issues relevant to natural resource stewardship in the 11 NETN parks were synthesized in scoping workshops and questionnaires. Land use change surrounding parks,

Table 1.6. *The number of tracked species and communities found in each park, and the number of occurrences, based on Natural Heritage Program databases. Tracked species and communities include those that are both state and globally rare. (S1-S3, G1-G3. * All communities in each park are being mapped by the USGS Vegetation Mapping Program and additional occurrences may be documented. APPA includes records from Maine to Georgia.*

Park	Plants and Animals	Total No. of Occurrences	Communities*	Total No. of Occurrences
ACAD	15	33	13	15
APPA	485	817	65	122
BOHA	N/A	N/A	6	10
MABI	2	?	N/A	N/A
MIMA	N/A	N/A	2	3
MORR	0	0	0	0
ROVA	4	5	2	2
SAGA	6	6	1	1
SAIR	0	0	0	0
SARA	2	2	N/A	N/A
WEFA	0	0	0	0
Total	514	863	89	153

habitat fragmentation, and invasive species were identified as "high priority" management issues for more than 80% of NETN parks (Table 1.7). The human population in the New England states was 2.5 times greater in 2000 than it was when the NPS was established in 1916 (US Census data 2000). With the doubling of the human population in New England came increasing pressure on space and natural resources and is the primary cause for natural resource issues in the Northeast. The construction and maintenance of roads is among the most widespread forms of habitat alteration (Trombulack and Frissell 2000) to natural communities and 82% of NETN parks identified car traffic as a management issue (Table 1.7). Roads affect terrestrial and aquatic ecosystems through increased mortality caused by collisions with vehicles (Groot Bruinderink and Hazebroek 1996), modification of animal behavior (Brody and Pelton 1989), spread of exotic species (Greenberg et al. 1997), and changes in soil and water chemistry (Trombulack and Frissell 2000). Parks and reserves in the northeast exist in a landscape matrix of developed or agricultural lands with some of the highest road densities in the U.S. Most NETN parks were established for cultural resources but have now become important to the maintenance of biological diversity and ecological integrity in the urbanizing landscapes where they occur and many of them are threatened primarily by external impacts.

Land cover change and the associated threats to natural ecological communities associated with habitat fragmentation are a common theme among NETN parks. Habitats within landscapes are

altered at varying levels of intensity as human demand for space and natural resources increases, leaving many landscapes, especially those where human populations are dense, in a fragmented state(Saunders et al. 1991). Habitat fragmentation can be manifest on the landscape via the direct loss of habitat, reduction in size of remaining patches, increased isolation, and loss of habitat diversity (Saunders et al. 1991). Most ecosystems in the northeast have experienced some level of habitat fragmentation, which has been implicated as a principal threat to most species in the temperate zone (Wilcove et al. 1986). Parks in the NETN, most of which were established for cultural resources, are relatively small in size and located in increasingly urbanizing landscapes. The role they play to the maintenance of regional biological diversity may, however, be substantial. (Falkner and Stohlgren 1997) conducted an analysis of the role of 44 NPS units in the Rocky Mountain region and found small, cultural parks contributed substantially to the conservation of regional biodiversity by acting as biological refugia, migration/dispersal rest stops and corridors, and living outreach programs. They indicated that small units had a disproportionate share of regional biodiversity and an understated role in the conservation of biodiversity in the region.

The ecological effects of invasive plant species were identified by most parks as a primary threat to park ecological communities (Table 1.7). We solicited parks for a list of the invasive plants known to occur within park boundaries to begin the process of identifying priorities for monitoring and management (Appendix E). Non-indigenous species spread at the rate of ≈ 700,000 hectares per year in the US with an impact on human economic systems estimated in the billions of dollars (Pimentel et al. 2001). Invasive species alter ecosystem structure, function, and species composition to such an extent that they threaten native flora and fauna. Non-native species are the second highest threat to the threatened and endangered species in the United States behind habitat loss. Of the 958 species listed, about 400 (42%) are threatened by non-native species (Pimentel et al. 2001).

The NETN parks share some common resource management issues, but also have park specific issues and management priorities (Table 1.7). Clearly, coastal issues are a concern for Acadia and Boston Harbor Islands and high elevation forests are a primary concern for the Appalachian Trail. Deer browsing, a significant stressor to many ecological communities was listed as a management priority for 5 parks. Within this survey, climate change was only identified as a natural resource issue for parks with coastal and high elevation habitats; however, climate change is expected to have substantial impacts over the long-term upon all NETN parks.

Table 1.7. *Potential natural resource threats to NETN parks (present or future) as indicated by natural resource staff. The level of each threat is identified by; 0 = not a threat, 1 = low threat, 2 = high threat w/ present mgt. concern. Categories were added during this process resulting in blank cells for parks that have not seen the additional categories at the time of this draft.*

Potential Threats to Park Natural Resources	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
Air Quality											
Acid Deposition	2	2	1	2	1	2	1	2	1	1	1
Ozone	2	2	1	1	2	2	1	2	1	2	1
Visibility	2	2	1	1	1	2	1	1	1	1	1
External Development											
Cell/Wind Towers	2	2	0	1	2	2	1	2	0	2	1
Encroachment	2	2	1	2	2	2	2	2	0	2	2
Habitat Fragmentation	2	2	1	2	2	2	2	2	0	2	2
Marinas/moorings	0	0	1	0	0	0	0	0	0	1	0
Oil Spills	2	1	0	0	1	1	1	1	1	1	0
Pipeline operations	0	2	1	0	1	0	0	0	0	0	0
Residential/commercial	2	2	0	1	2	2	2	2	1	2	2
Roads	2	2	0	1	2	1	2	2	1	1	1
Septic Systems	2	0	2	0	1	2	2	2	0	1	2
Sound	1	2	1	0	2	2	1	2	1	1	2
Utility right of ways	1	2	0	0	1	0	1	1	1	0	1
Viewsheds	1	2	0	1	1	1	1	1	2	2	1
Night Sky	1	1	0	1	0	0	0	1	0	1	0
Visitor Impacts											
Boat Traffic	1	0	2	0	1	0	0	0	0	1	0
Car Traffic	2	1	1	0	2	2	1	1	0	1	2
Horseback riding	0	1	0	1	0	1	0	0	0	1	2
Over fishing	2	0	0	0	0	0	0	1	0	0	1
Soil compaction	2	2	1	1	1	1	1	1	0	0	2
Hiking Trail Impacts	1	2	2	1	1	1	1	1	0	1	1
Contaminants/Toxics											
PCB	1	1	1	0	1	1	1	1	1	2	0
Hg	2	2	1	0	1	0	1	1	1	2	0
Pb, Zn, Cd	1	2	1	0	0	0	0	0	0	2	0
Natural Disasters											
Droughts	1	1	1	1	1	1	1	1	1	1	1
Floods	0	1	1	0	1	1	1	1	1	1	0
Ice storms	1	1	0	1	1	1	1	1	1	1	2
Wind Events	1	1	2	1	1	1	1	1	1	1	1
Fire	1	1	0	0	0	0	0	0	0	1	0

Potential Threats to Park Natural Resources	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
Internal Park Development	1	1	1	0	0	0	1	0	1	1	0
Nuisance Wildlife											
Beaver	2	1	0	1	2	0	1	0	0	1	0
Raccoons	2	0	1	0	1	1	1	1	1	1	0
Fox	1	0	1	0	1	0	0	0	0	0	0
Feral cats/dogs	1	0	1	1	1	1	1	1	1	1	1
Canada geese	0	0	0	0	0	0	0	0	2	0	0
Woodchuck	0	0	0	0	0	0	0	0	0	0	2
Deer over browsing	0	1	0	2	1	2	2	1	0	2	2
Pest Species (parasites/pathogens)											
Asian Long-Horn Beetle	1	1	0	1	1	2	0	2	1	1	2
Gypsy Moth	1	2	0	1	2	2	1	1	1	1	1
Hemlock wooly adelgid	2	2	0	1	2	2	2	2	0	1	2
Lyme Disease	2	2	1	1	2	2	2	1	1	2	2
West Nile Virus	1	1	1	1	1	2	2	1	2	1	2
Chronic Wasting Disease	0	1	0	1	0	1	1	1	0	1	0
Water Quality											
Agricultural Runoff	1	1	0	1	1	0	0	2	0	1	0
Eutrophication	2	1	0	1	1	0	1	2	2	1	1
Land use change	2	2	0	0	2	2	2	2	2	2	1
Non-point pollution	2	1	2	1	1	2	2	2	2	1	1
Nutrient Loading	2	1	2	1	1	0	2	2	2	1	1
Point pollution	1	2	2	0	1	2	0	1	2	0	0
Road Runoff	1	1	0	1	1	1	1	2	2	1	1
Sedimentation	1	1	1	2	1	1	1	2	2	1	1
Stream bank erosion	1	1	0	1	1	1	0	2	1	1	1
Wastewater treatment	0	1	1	0	1	0	1	0	2	0	0
Climate Change											
Coastal erosion	1	0	2	0	0	0	0	0	0	0	0
Alpine recession	2	2	0	0	0	0	0	0	0	0	0
Sea level rise	1	0	2	0	0	0	1	0	1	0	0

1.5 Summary of Existing Park and Adjacent Monitoring Programs

We solicited information from park resource managers regarding current and historical monitoring efforts within NETN parks to identify opportunities to continue, modify, or expand existing programs. Air quality monitoring within a park is only occurring at Acadia, a designated Class 1 air quality area. Air quality around other network parks is ongoing and conducted by other programs (Appendix F). Acadia, Morristown, Roosevelt-Vanderbilt, Saint-

Gaudens, and Saugus Iron Works currently have water-quality and (or) water-quantity monitoring programs (Appendix G). Boston Harbor benefits from a monitoring program conducted by the Massachusetts Water Resources Authority (MWRA). Water quality monitoring programs are summarized in the water quality Phase I scoping report (Appendix G). The period of data collection varies; some monitoring programs were initiated as early as the 1970s and some as recently as 1998. The parks that do have monitoring programs primarily include measures in the vital sign of water chemistry. Additionally, Acadia, Morristown, Roosevelt-Vanderbilt, and Saint-Gaudens, have some form of invertebrate monitoring in streams. The protocols for these monitoring programs vary among parks. The remaining four parks (Marsh Billings, Minute Man, Saratoga, and Weir Farm) have no known current freshwater-quality monitoring at present (2004). Morristown and Saratoga, two parks with ecological issues caused by over-abundance of deer, have ongoing deer population monitoring (Appendix H). Acadia, Appalachian Trail, and Morristown have specific threatened and endangered species monitoring programs, and Marsh-Billings-Rockefeller and Saint-Gaudens have ongoing forest monitoring programs (Appendix H).

Data collected as a part of pre-existing monitoring programs will provide historical comparisons and context for the data collected by the NETN vital signs program. In some cases, the NETN monitoring program will build on the program currently in place, especially where measures, sampling locations, and/or sampling protocols are similar across programs. In other cases, however, compatibility will vary because the monitoring programs at some of the parks are focused on specific resources or have different objectives than the vital signs program.

To help us develop partnership opportunities with monitoring efforts being conducted by other federal and state agencies, we also reviewed national, regional, and local monitoring efforts that may be relevant to natural resource monitoring in our network. These 'outside the parks' monitoring efforts and available weather stations are summarized in Appendices I and J.

1.6 Goals and Objectives for the NETN Program

Based on our current knowledge of the ecological systems, threats and park resources of the NETN, and the overall goals of the NPS Vital Signs program (Section 1.3.2), we can now outline a series of goals and objectives that guide the development of vital signs and measures. These goals and objectives are still in draft form and will be refined over time in consultation with others and through peer review.

Goal A. *–Drivers and Stressors*- Monitor the status and trends of selected ecological drivers and anthropogenic stressors acting upon NETN ecological systems, to support and inform management decisions.

Objective A.1. Monitor the response of ecological systems to natural disturbances and, where possible, compare to historical responses.

Objective A.2. Detect new invasive plant and animal species before they become a long-term management issue.

Objective A.3. Monitor changes in adjacent land cover and land use to assess the potential impacts from adjacent human activities on park ecosystems.

Objective A.4. Provide accurate meteorological information to all parks to be used as a correlate to aid in understanding trends in other monitoring indicators.

Objective A.5. Summarize existing atmospheric deposition and ozone information and apply these data to better understand their impacts on park ecosystems.

Objective A.6. Monitor the biotic and abiotic response to climate change, including phenological shifts in terrestrial systems and shoreline changes in coastal systems.

Objective A.7. Establish a baseline on white-tailed deer browse intensity for each NETN park and track the level of browse intensity over time.

Objective A.8. Assess role of visitor use in different units of the park, and their impacts on species and ecological systems.

Goal B. – *Species, Ecosystem Structure and Processes, and Ecological Integrity* - Monitor the status and trends of selected taxa and ecological system structure and processes within NETN parks, to support and inform management decisions affecting those taxa and processes. Identify key components of ecological integrity within NETN ecological systems and monitor these components to determine status and trends of NETN systems, in order to support and inform management decisions affecting those ecological systems.

Objective B.1. Monitor status and trends of focal taxa across a broad taxonomic range.

Objective B.2. Monitor status and trends of specialized habitats, such as vernal pools.

Objective B.3. Monitor hydrologic dynamics, especially water quantity, in freshwater aquatic and intertidal systems.

Objective B.4. Monitor changes in forest, wetland, and high elevation vegetation condition, structure, and composition to determine the effects of multiple stressors acting on these systems.

Objective B.5. Monitor changes in the extent and condition of ecological systems within NETN parks.

Objective B.6. Monitor core abiotic and biotic water quality indicators within the primary aquatic resources for each network park.

Objective B.7. Inventory stream geomorphology and lakes morphometry to establish a baseline to better interpret water quality monitoring data.

Goal C. – *Communication and Reporting* - Summarize and communicate the ecological integrity of NETN systems using a combined approach reporting both statistical trends and qualitative ecological integrity ratings.

Objective C.1. Use statistical tools to assess status and trends of vital signs.

Objective C.2. Use selected vital signs and available baseline information to assign and assess change to ecological integrity rankings.

Objective C.3. Use statistical tools and ecological integrity scorecard to inform decision-making processes for park natural resource management.

Goal D. -*Special Park Resources*-. Provide information directly related to special park resource management issues.

Objective D.1. Monitor forest and old-field habitats to determine how best to maintain focal park resources.

Chapter 2: Conceptual Ecological Models

2.1 Introduction

The development of conceptual ecological models to identify key system components, linkages and processes is a critical step in the design of a long-term monitoring program. The need for conceptual ecological models has been well established by many (National Research Council 2000, Elzinga et al. 2001, Noon 2002), including the NPS prototype park monitoring program. Conceptual models improve the planning process for monitoring by explicitly stating key elements of our understanding of system dynamics, which facilitates discussion, evaluation and refinement of the monitoring program (Maddox et al. 1999). Given the complexity of natural systems and the variety of factors that influence ecological processes, there is an obvious need for conceptual modeling as a tool to help organize information and synthesize understanding of system components and interactions. Failures in the development of major ecosystem monitoring programs have been attributed to the absence of sound conceptual models (National Research Council 1995).

As outlined in Chapter 1 of this document, the NPS Vital Signs Monitoring Program seeks to facilitate adaptive management by monitoring status and trends in 1) the ecological condition of park resources, 2) key anthropogenic stressors acting upon park systems, and 3) focal park resources. To accomplish this three-pronged objective, NETN has chosen to develop conceptual models which are both "effects-oriented" and a "predictive or stressor-oriented" (Trexler and Busch 2002). In other words, NETN conceptual models incorporate elements of ecological integrity, which integrate the effects of multiple drivers and stressors acting upon a system over time, as well as specific anthropogenic stressors and focal park resources.

A useful conceptual model or set of models for the NPS Vital Signs Monitoring Program should attempt to accomplish the following:

- Identify the bounds and scope of the system of interest;
- Conceptualize and synthesize current understanding of system dynamics;
- Identify major drivers and stressors acting upon the system and present our current understanding of system responses;
- Integrate across disciplinary boundaries and spatial scales;
- Describe and illustrate alternative hypotheses about key processes or system dynamics.
- Aid in identifying appropriate indicators of ecological integrity and stressors;
- Identify and illustrate key relationships among indicators and system dynamics;
- Identify knowledge gaps which indicate the need for additional research;
- Be updated as new information improves our understanding of the system;
- Facilitate communication among scientists from different disciplines, managers, policy-makers, and the public.

Given these lofty aspirations, it is important to remember that conceptual models are merely abstractions of our current understanding of the system. In reality, ecological systems are far too complex to be fully represented by our models. Moreover, these models must be flexible enough to allow change over time as our knowledge grows. Perhaps the most important characteristic of

good conceptual modeling is the final point listed above: conceptual models foster communication and understanding among people with different backgrounds, goals, and points of view (Abel et al. 1998).

2.2 NETN Conceptual Model Development

2.2.1 Model Framework

Conceptual models may take the form of any combination of diagrams, narratives, tables, or matrices. In the development of conceptual models for the NETN Vital Signs Monitoring Program, we have chosen to employ both diagrammatic conceptual models, which help visualize system components and interactions, as well as narratives, which provide additional detail describing our current understanding of system components and interactions.

We have chosen a hierarchical approach to model development, beginning with a general model for the each of four key NETN ecological system groups (terrestrial, wetland, aquatic and intertidal). These general models identify key ecosystem drivers, stressors, ecological processes, elements of ecosystem (abiotic and biotic) condition, and focal park resources acting upon or present within each of these four major system groups. We present these general models herein as diagrams accompanied by detailed narratives, which lay out our current understanding of each of these components and their interactions.

A set of two diagrammatic models is then developed for each NETN park, which more specifically illustrate the specific stressors acting upon the ecological systems and aquatic resources, respectively, present within each park. These park models are included in Appendix K. The aquatic park models include a hydrologic model of the freshwater inflows and outflows present in the park, as well as information describing freshwater resources. The aquatic models assume that ecosystem-wide processes such as precipitation and evaporation occur throughout the park, and that ground-water/surface-water interactions occur in both directions and also throughout the park.

This nested set of conceptual models incorporates multiple spatial scales that may be of interest to mangers. Landscape-, park-, stand- and species-level elements are all represented herein. Moreover, these models employ the tools and expertise of a range of scientific disciplines: landscape ecology, biogeochemistry, forest ecology, wetland ecology, aquatic ecology and conservation biology.

2.2.2 Identification of Key Model Components

An important step in the development of NETN conceptual models was the careful consideration of all known stressors affecting ecological systems within NETN parks. This “threats analysis” initially considered the potential threats to NETN parks identified within Table 1.7; we then broadened the analysis to consider additional threats identified by the environmental science community, such as harvesting within the intertidal zone, additional taxa of invasive exotic species, such as earthworms and plants, and the broader effect of global climate change. Within the Conceptual Ecological Models we present in this chapter, we include key stressors known or believed to have significant ecological consequences on NETN ecological systems. We have chosen not to include some threats identified in Table 1.7 which are believed not to have

significant ecological consequences in these systems; these include visibility impairment due to poor air quality and light pollution (dark night sky), viewshed issues and cell tower development nearby parks, noise (sound) within parks, some populations of native wildlife, such as raccoons, fox, and woodchuck, and several diseases, such as Lyme disease, West Nile Virus and Chronic Wasting Disease. Several of these "threats" impact visitor experience and thus are important park issues, but are better addressed by other NPS programs. Other issues affect the ecology of the park, but to a much lesser extent than those stressors considered herein.

It is worth noting here that mandated species, or rare, threatened and endangered species that receive legal protection, are an important focal park resource that was considered for inclusion in the NETN Vital Signs program. They were not selected for inclusion because mandated species provide little insight into park ecological integrity, and they are not discussed further herein.

2.2.3 Definitions

We have used the following terminology in developing NETN conceptual models:

Ecosystem drivers are major external driving forces such as climate, hydrology, and natural disturbance regimes (e.g., hurricanes, droughts, fire) that have large-scale influences on natural systems.

Stressors are physical, chemical, or biological perturbations to a system that are either foreign to that system, or natural to the system but applied at an excessive or deficient level (Barrett et al. 1976). Stressors cause significant changes in the ecological components, patterns and processes within natural systems. Examples include water withdrawal, invasive exotic species, landuse change, and air pollution.

Focal park resources are resources that, by virtue of their special protection, public appeal, or other management significance, have paramount importance for monitoring regardless of current threats or whether they are indicative of ecosystem integrity.

Focal taxa are taxa that, by virtue of their sensitivity or exposure to stress, their association with other taxa, or their life history characteristics, might serve as useful indicator species of ecological integrity. While the concept of focal taxa differs substantially from focal park resources (defined above), some taxa fall into both categories.

Ecological integrity is a concept that expresses the degree to which the physical, chemical, and biological components (including composition, structure, and process) of an ecosystem and their relationships are present, functioning, and capable of self-renewal. Ecological integrity implies the presence of appropriate species, populations and communities and the occurrence of ecological processes at appropriate rates and scales as well as the environmental conditions that support these taxa and processes.

Indicators are a subset of measurable ecosystem features or processes that are particularly information-rich in that their values are indicative of the quality, health, or integrity of the larger ecological system to which they belong (Noon 2002). Indicators are a select subset of the physical, chemical, and biological elements and processes of natural systems that represent the overall health or condition of the system.

Vital Signs, as used by NPS, are indicators selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. Vital signs may occur at any level of organization including landscape, community, population, or genetic level, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes).

2.3 NETN Climate

Climate is a key ecosystem driver that affects the structure, composition and function of all ecological systems. The northeastern U.S. has a temperate humid continental climate (Trewartha and Horn 1980); this climate displays large daily and seasonal temperature variation and abundant rainfall evenly distributed throughout the year (Bryson and Hare 1974). Temperature and rainfall vary across the region along latitudinal and altitudinal gradients. Mean annual temperatures range from about 11˚ C along the southern coast to 4˚ C in the northern highlands and annual precipitation ranges from 90-120 cm, of which from 10 to 30% falls as snow (Bryson and Hare 1974). The northern part of this region experiences cool summers, and long, cold winters which typically include a persistent snowpack from mid-December until April. In the southern part of this region, summers are warmer, winter temperatures are milder and snowpack development is more variable. The number of freeze-free days annually varies from only about 90 in the White Mountains of New Hampshire and Maine to as many as 180 in a narrow strip along the southern coast (Bryson and Hare 1974). The climate of coastal regions is strongly influenced by the ocean; temperatures are more moderate and annual rainfall is slightly higher along the coast, and summer fog is common along the Maine coast. The Northeastern U.S. is in the path of many frontal systems; these typically move eastward across the continent until reaching the Atlantic Ocean then travel northeastward along the coast. Low pressure cells in the frontal systems generate counterclockwise winds that being warm, moist air from the Atlantic Ocean onto the mainland (Maloney and Bartlett 1991). Rain or snow is released when a warm air mass meets a cold front.

2.4 Terrestrial Resource Conceptual Model

As described in section 2.2, we have developed a conceptual ecological model to identify key ecosystem drivers, stressors, ecological processes, elements of ecosystem (abiotic and biotic) condition, and focal park resources present within or acting upon each of four general ecological system groups present within NETN. Herein, we present the terrestrial resource conceptual ecological model as a diagram (Figure 2.1) accompanied by the following narrative describing our current understanding of these components and their interactions.

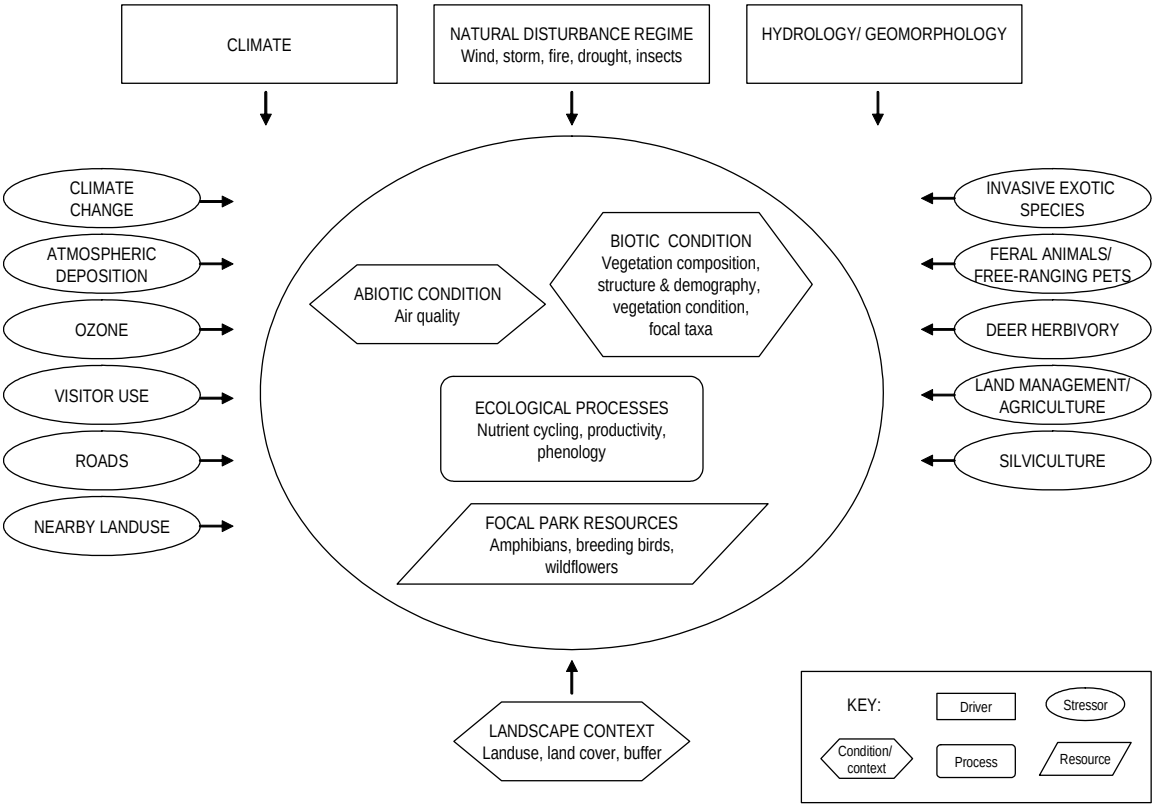
2.4.1 Ecological Systems

Terrestrial ecological systems present within NETN parks encompass a variety of forested systems and several types of open uplands and human-modified systems (Table 2.1). Within the northeastern US, a temperate climate with abundant rainfall acting on gently rolling and occasionally mountainous topography upon mostly acidic bedrock and glacial till creates suitable conditions for a variety of terrestrial vegetation. The topography and ecology of this region reflects its glacial history, which left a varied landscape of lakes, depressions, morainic hills,

drumlins and other glacial features. While fine-scale variation in site conditions and natural disturbance create a diverse patchwork of varied forest associations, broad-scale patterns are evident. Latitudinal and altitudinal variation in temperature, soil quality and disturbance regimes from the coast up into the mountainous regions of New Hampshire, Vermont, and western Massachusetts create the broad ecological system groups described below. These general groups include a variety of more specific terrestrial ecological systems (NatureServe 2003a, b) described in Appendix C. The extent of these terrestrial systems within NETN parks is outlined in Table 2.1, and visually represented within the park-based Conceptual Ecological Models presented in Appendix K.

Figure 2.1 Conceptual Model for Terrestrial Systems

Forest, Open uplands, Alpine zone, Rocky shore, Plantation, Old-field successional, Field



Forested ecological systems within NETN parks can be divided into three general groups (Westveld 1956, Foster 2004): 1) the Central hardwood forests of southern New England and parts of New Jersey and New York, dominated primarily by oaks with other hardwood species; 2) the Northern hardwood forests of northern New England, dominated by American beech, yellow birch and sugar maple, with a variety of other hardwood species and hemlock and white pine; and 3) the Spruce-fir forest found at higher elevations in northern New England and along the Maine coast, dominated by red spruce and balsam fir, with white and black spruce. This Spruce-fir forest is often replaced after major disturbance by a Boreal aspen-birch forest. Within central New England, a broad transition zone exists in which oaks and hickories of the central hardwood forest intermingle with northern hardwood species.

Table 2.1. *Approximate extent (hectares) of NatureServe terrestrial ecological systems present within NETN parks. This information will be updated and improved after completion of the I&M mapping inventory of these parks. Area listed in larger boxes spanning more than one ecological type indicates that current information does not distinguish between related types. Most BOHA terrestrial communities have yet to be classified and are listed here as "other"; information for APPA is not yet available. Descriptions of these ecological system types can be found in Appendix C.*

Ecosystem Category	NatureServe Ecological System Type	ACAD	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
Spruce-fir forest	Acadian Lowland Spruce-Fir-Hardwood Forest	6588									
Northern hardwoods/ mixed forest	Boreal Aspen-Birch Forest	1160									
	Laurentian-Acadian Northern Hardwoods Forest	314		33	20		83	13		273	1
	Laurentian-Acadian White Pine-Red Pine Forest	737									
	Laurentian-Acadian Pine-Hemlock-Hardwood Forest	881		97			77	19		432	
	Appalachian Hemlock-Hardwood Forest										
Central hardwoods forest	Central Appalachian Oak and Pine Forest			1		229					20
	Northeastern Interior Dry Oak Forest				112		3				
	Central and Southern Appalachian Northern Hardwood Forest					44					
Open uplands	Laurentian-Acadian Acidic Rocky Outcrop	3295									
	Laurentian-Acadian Calcareous Rocky Outcrop						0.04				
Cliff and talus	Laurentian-Acadian Calcareous Cliff and Talus			0.2							
	Laurentian-Acadian Acidic Cliff and Talus	11									
Rocky shore	Acadian-North Atlantic Rocky Coast	116									
Modified	Native Plantation			45			2	11		4	
	Exotic Plantation		4	18			12				
	Old-field successional		36	3	62	193	15			162	
	Open fields			17		24		6			6
	Agricultural fields				42		8			206	
	Landscaped grounds	112		4	14		50	2	1	5	
Other			104								

Relatively open vegetation communities occur within NETN at high elevations, upon steep slopes and along the coast. These systems are primarily present along the APPA and within ACAD. These open uplands can be classified generally into four categories: 1) open upland outcrops of oak and pine woodlands and shrublands, often accompanied by low heath shrubs, which occur on and around rocky summits; 2) alpine zone barrens which occur above treeline along the APPA and are characterized by dwarf shrubs, lichens, and areas of sparse vegetation; 3) sparsely vegetated cliff and talus systems which develop near steep cliffs and include the dry, exposed talus slopes that develop beneath the cliffs; and 4) patchy shrub vegetation on rocky shores, which develops within the narrow strip just above the high tide line along the New England coast where tree growth is inhibited by wind, salt spray and fog.

Several human-modified terrestrial habitat types occur within NETN parks. Native and/or exotic tree plantations have been established at MABI, ROVA, and to a lesser extent, at other parks. Successional old-field habitat, maintained open fields and active agricultural fields are all present within the historic parks, which are managed to perpetuate historical landscapes. Finally, some area of landscaped grounds is present within most NETN parks.

The presence of one rare terrestrial community type has been confirmed at ACAD; the Pitch pine/Broom crowberry woodland is ranked G1/G2 by NatureServe, indicating this community type is globally imperiled or critically imperiled.

2.4.2 Ecosystem Drivers

2.4.2.1 Climate

Climate is a key ecosystem driver that affects ecosystem structure, composition and function. The climate of the northeastern U.S. is described above within section 2.3. Temperature and rainfall vary latitudinally and altitudinally across the region creating gradations between the Central and Northern hardwood and Spruce-fir forests, and the open and alpine uplands. The potential and realized impacts of changing climate upon terrestrial systems within NETN parks are described below within section 2.4.7.

2.4.2.2 Disturbance Regimes

Disturbance regimes are a second key driver affecting NETN terrestrial systems. The forces of disturbance work upon this forested landscape to create a shifting mosaic of forest regeneration and succession. Throughout the entire region, frequent windstorms create small- to medium-size gaps that rapidly regenerate; these windstorms are more frequent along the coast and on windward slopes (Lorimer and White 2003). Less frequent hurricanes create much larger openings and temporarily create habitat for earlier successional species within the forest mosaic. Periodic ice storms can cause substantial damage over large regions, but tend to result in regeneration rather than stand replacement (Lorimer and White 2003). The natural role of fire within this region is complex and less well understood. Historically, fire has been infrequent within the northern hardwoods forest, but was more common within the central hardwoods forest and probably also within the transitional mixed forest between northern hardwoods and spruce-fir (Cogbill et al. 2002). At the time of European settlement, the central hardwood oak forests of the southern New England coast were more open forests with sparse understory, perhaps due to propagation of fire by native Americans (Cogbill et al. 2002). European settlement drastically increased the frequency and intensity of fires throughout the northeastern U.S., particularly due to logging and railroad traffic during the 19th century. Much of Acadia National Park burned during a historic fire in 1947. Modern fire suppression regimes have now essentially removed fire as an agent of disturbance in this region. Insect pests and disease are also important agents of natural disturbance, particularly in the low diversity coniferous forest. The native spruce budworm has periodically killed large numbers of mature balsam fir which then blowdown or burn creating large-scale disturbance (Lorimer and White 2003). Additionally, individual trees periodically succumb to disease or senescence, contributing to the gap dynamics of these forests.

Disturbance regimes within terrestrial systems are best considered at multiple scales. Infrequent, larger-scale disturbance is evident at the scale of the landscape and can be monitored using remote sensing. More frequent, smaller-scale disturbance is evident at the scale of the stand and can be monitored on-site. The potential and realized impacts of altered disturbance regimes due to climate change and invasive exotic species are discussed below within section 2.4.7.

2.4.2.3 Hydrology/Geomorphology

As noted above in section 2.4.1 and below in sections 2.5 and 2.6, the hydrology and geomorphology of the area create conditions suitable for terrestrial ecosystems and the wetland and aquatic systems that exist within them. Vital Signs of these drivers are discussed within the Wetland and Aquatic Conceptual Ecological Model sections.

2.4.3 Abiotic and Biotic Condition

Air quality is an important element of abiotic condition affecting terrestrial ecosystems. This parameter is discussed in some detail below in the section describing stressors (2.4.7).

Monitoring biotic condition is critical to understanding the ecological integrity of ecosystems subjected to multiple stressors. Within terrestrial ecosystems, the structure, composition and condition of dominant vegetation play a key role in determining ecosystem function and quality of habitat for other species. For this reason, monitoring key elements of vegetation structure, composition and condition are particularly important elements for long-term monitoring. In addition, NETN has attempted to identify taxa that may be useful indicators of the condition of particular functional or taxonomic groups or of response to specific stressors. While the use of focal taxa as indicators of ecological condition is controversial (Prendergast et al. 1993), this approach can be useful if a range of species representing diverse taxa and various life histories can be included (Terborgh 1974, Griffith 1997, Carignan and Villard 2002). By monitoring diverse taxa, we reduce the chance of failing to detect significant change in the ecological integrity of these systems. In theory, it is attractive to select a parsimonious set of "best" indicators of ecological condition for these systems; in reality, we must realize that our current understanding of ecological systems is limited, and that a narrowly-focused monitoring program will fail to detect change within many important but less-charismatic taxa.

2.4.3.1 Vegetation Composition, Structure and Demography

Vegetation composition, structure and demography are fundamental properties of terrestrial ecosystems. Monitoring the composition and structure of forest communities provides basic information on changes in forest cover type, species composition, and the type and quality of available wildlife habitat; moreover this basic information will allow proper interpretation of many other Vital Signs. Monitoring vegetation demography in the form of tree seedling and sapling regeneration provides an anticipatory indicator of future forest cover type as well as an integrative measure of the impacts of multiple stressors acting upon vegetation. Monitoring canopy and understory tree growth and mortality provides additional key integrative measures of multiple stressor impacts. Stand structural or age class is indicative of both successional stage and habitat quality, and is a particularly useful measure in forest systems subject to silviculture. Legacy features, such as large trees, snags and coarse woody debris provide important habitat for birds, mammals, and herptiles, as well as decomposers, bryophytes and tree seedlings. These legacy features can be useful indicators of wildlife habitat within early- and mid-successional forests and those subject to silviculture.

2.4.3.2 Vegetation Condition

Canopy vegetation condition is an integrative, anticipatory indicator of stress and change within canopy vegetation, which can in turn lead to changes in ecosystem function, habitat quality and stand composition. Canopy condition can be affected by a multitude of drivers and stressors, including climate, outbreaks of insect pests or disease, atmospheric deposition, tropospheric ozone pollution, and nutrient availability (Bonneau et al. 1999, Shugart et al. 2000). Canopy vegetation condition can be measured across the landscape using vegetation stress indices from hyperspectral remote sensing (Sampson et al. 2000, Miles et al. 2003). While hyperspectral imagery is currently expensive to obtain, this technology is advancing rapidly and should be

considered for inclusion in the NETN monitoring program as affordable imagery becomes available. At the stand scale, canopy condition can be assessed visually onsite as the crown condition of each canopy tree in a plot.

2.4.3.3 Focal Taxa

Selection of focal taxa as indicators for long-term monitoring should, to the extent possible, detect response to a wide range of stressors at several spatial scales (Noss 1990, O'Connell et al. 1998), and include the range of functional and taxonomic groups important in a particular ecosystem (Terborgh 1974, Keddy and Drummond 1996, Griffith 1997, Carignan and Villard 2002). Monitoring of taxa with specific functional relevance, such as pollination and decomposition, would incorporate indicators of these important ecological processes into NETN ecological integrity ratings. Within temperate forested ecosystems, mycorrhizal fungi, arthropod pollinators and decomposers, are key taxa performing essential ecosystem functions.

Ectomycorrhizal fungal communities have been shown to be sensitive to nitrogen deposition, a key component of acidic deposition (Arnolds 1991, Lilleskov and Bruns 2001). While short-term trends in ectomycorrhizal sporocarp emergence exhibit substantial temporal variation due to climatic fluctuations and other factors, long-term data collection may allow the elucidation of trends in the relative change in functional groups of ectomycorrhizae from sporocarps (Lilleskov, personal communication).

Selected arthropod taxa could provide useful indicators of environmental condition at the scale of the park. In general, arthropods inhabit smaller home-ranges than many larger and more charismatic fauna, and so may be useful as indicators of environmental condition within these relatively small parks. Moreover arthropods typically have shorter lifespans than larger faunal taxa, which may increase their utility as “early-warning” indicators. Studies have shown that carrion beetles are sensitive to forest fragmentation (Gibbs and Stanton 2001); these beetles are important decomposers, and are straightforward to monitor. Honeybees are another taxa with important functional relevance that may be feasible for inclusion in a long-term monitoring program (Sam Droege, personal communication).

Additional focal taxa which may be useful to incorporate in a long-term monitoring program are high-profile “flagship” taxa which are also sensitive to anthropogenic stressors. In this capacity, avian communities may be particularly well-suited to long-term monitoring due to their sensitivity to habitat fragmentation, and the ease of avian identification using vocalization (Carignan and Villard 2002). Additionally, temperate forests are known for their diverse herbaceous communities, which are highly visible and taxonomically well-known. Finally, the red-backed salamander comprises a significant component of faunal biomass within temperate forested systems, in which it is widely distributed. This species has been monitored as an indicator of acid stress and climate change (Welsh and Droege 2001).

In addition to forested ecosystems, NETN parks contain substantial areas of open field and successional old-field habitat, which is maintained within many NETN historic parks to satisfy cultural mandates. While highly modified, these systems provide important habitat for many grassland and shrubland species, such as the upland sandpiper, Henslow’s sparrow, grasshopper sparrow, savannah sparrow, bobolink and Eastern meadowlark (Bernardos et al. 2004). These birds proliferated within the agrarian landscape of nineteenth and early 20th century New

England, and populations of these birds have declined significantly as the landscape has reforested over the last century. Thus the national historic parks provide essential habitat for these vulnerable species.

2.4.4 Ecological Processes

2.4.4.1 Nutrient Cycling

Nutrient cycling is a fundamental ecological process that is intrinsically linked to the composition, productivity and function of ecosystems. The utility of using some measures of nutrient cycling as indicators of ecosystem status, function or integrity has been widely recognized (Harwell et al. 1999). Plant growth in northeastern forested ecosystems has historically been limited by nitrogen, an essential macronutrient in limited supply. Anthropogenic atmospheric deposition of nitrogen compounds has altered patterns of nitrogen cycling in northeastern forests, increasing both the supply of available nitrogen and nitrate loss from the system, a trend which may lead to nitrogen saturation and increased acidification (Aber et al. 1998). Acidic deposition has also caused the loss of essential base cations from terrestrial systems via leaching, and has increased availability within the soil of aluminum – a phytotoxin (Driscoll et al. 2001a). Monitoring a few simple measures of terrestrial N cycling (nitrification, soil C:N ratio) and base cation and aluminum availability (soil base saturation and Ca:Al ratio) will provide useful information indicating the level of stress from atmospheric deposition experienced by forested systems (Driscoll et al. 2001b). Additionally, monitoring of nitrate in streamwater across the landscape will allow some assessment of patterns and degree of nitrogen saturation.

2.4.4.2 Productivity

Ecosystem productivity provides a measure of energy flow through the system; productivity is the amount of energy stored as organic matter. Patterns of productivity are strongly dependent upon temperature, rainfall, and solar radiation, thus productivity varies with vegetation physiognomy. Within an ecological system, annual productivity varies with climate and patterns of disturbance as well as with stressors such as insect or herbivore browsing and atmospheric deposition and ozone (Ollinger et al. 2002, Laurence and Andersen 2003). Thus productivity provides an integrated measure of the status of an ecological system or of specific taxa. Forest productivity can be measured via remote sensing using indices of chlorophyll concentration (Sampson et al. 2000, Smith et al. 2002), or from stand measurements of forest growth.

2.4.4.3 Phenology

Northeastern temperate systems are characterized by distinct seasonality that drives patterns of floral and faunal phenology. Recent research indicates that anthropogenic climate change may already be driving phenological change in a variety of species (Parmesan and Yohe 2003, Root et al. 2003). Monitoring key phenological occurrences such as bud break and flowering in key species will help determine the magnitude and patterns of such change within NETN systems. This Vital Sign is particularly well suited to implementation at APPA, which exhibits broad climatic variation along its extensive latitudinal and altitudinal gradients.

2.4.5 Focal Park Resources

Several focal taxa discussed above as components of biotic condition are also focal park resources; amphibians, breeding birds, and wildflowers (a subcomponent of forest herbs) are all taxa that have broad appeal to the public and thus receive attention from NPS. The use of these taxa as Vital Signs is discussed above in section 2.4.3.

2.4.6 Landscape Context

The landscape of New England has been profoundly altered by human activities over the last four hundred years (Foster et al. 2004). Widespread clearing for agriculture and logging for timber have left very few terrestrial systems in the northeastern U.S. untouched. In particular, the southern New England coast and adjacent areas of New York and New Jersey are among the most densely settled areas within the U.S., resulting in the elimination or drastic alteration of all of the central hardwoods forest within this region. Remaining areas are small, fragmented and heavily impacted by human activities. Larger areas of northern hardwood forest, and spruce-fir forest remain within central and especially northern New England. Most of these areas were logged, or cleared and plowed during the 19th century, and some have now returned to "mature" forest that in some ways resemble pre-settlement forest, while others are currently managed for timber production.

Remaining natural areas exist in a matrix of managed, rural, and suburban habitat that limits the ability of species to interbreed and disperse, introduces "edge effects" and allows "encroachment" of anthropogenic influences. A network of roads cuts through the northeast, reinforcing edges and introducing disturbance, pollutants, de-icing chemicals, and facilitating invasion by exotic species (Brothers and Spingam 1992, Spellerberg 1998). Compared to forest interiors, forest edges are windier, subject to greater extremes in temperature, are more accessible to specific predators, and receive higher loads of some atmospheric pollutants (Harrison and Bruna 1999, Weathers et al. 2001). A large and growing body of scientific literature documents the negative impacts of habitat fragmentation on biodiversity in a wide variety of ecological systems (Fahrig 2003). The impacts of fragmentation have been especially well documented upon avian communities, and population declines of a variety of forest interior avian species are linked to habitat fragmentation (Rich et al. 1994, Austen et al. 2001). Habitat fragmentation is increasingly being monitored using remote sensing, and a wide variety of indices are available to describe patterns of fragmentation. Landscape buffers can help mitigate these outside influences.

2.4.7 Stressors

The ecosystems of New England currently are subjected to a suite of anthropogenic stressors unlike anything encountered during their long history prior to European settlement. These stressors act as agents of change in a myriad of related and often interacting ways. While the effects of some stressors, like acidic deposition, have been extensively studied and are well understood (Driscoll et al. 2001a), the effects of other important stressors, like climate change, are complex and unpredictable enough to elude our understanding despite concerted and ongoing study (McNulty and Aber 2001). The impacts of still other stressors, such as many newly invading species, are yet to be studied. The impacts of many stressors will vary depending upon landuse history (Foster et al. 2003), and the combined impact of this suite of interacting stressors

is certain to yield unexpected results (Aber et al. 2001). In this section, we summarize knowledge about the effects of key stressors upon NETN terrestrial systems. The park-based conceptual ecological models within Appendix K reveal important stressors acting upon specific parks.

2.4.7.1 Invasive Species

The effects of invasive exotic species on the structure, composition and function of natural systems have become a chief concern of ecologists and land managers for the last 20 years (Drake et al. 1989). The spread of many invasive species is aided by disturbance and may increase as anthropogenic disturbance of native ecosystems continues to increase.

Currently, northeastern terrestrial systems are being seriously impacted by several species of invasive exotic insect pests and pathogens. The hemlock wooly adelgid has caused widespread mortality of hemlock across the eastern U.S. since introduction here in the 1950s, and threatens to rapidly and substantially reduce or eliminate eastern hemlock throughout much of its range (Orwig et al. 2002) which could have substantial impacts on associated taxa such as forest birds. Infestation currently extends into southern New England, but isolated occurrences further north indicate this pest will continue to spread. Only slightly less serious is the threat to American beech. An exotic scale insect has caused the widespread occurrence of beech bark disease throughout the northeastern forests. Caused by the interaction of this insect and a native fungus, beech bark disease has caused substantial beech mortality throughout the region, though most immature and some mature trees have some resistance to the disease. In areas of high beech mortality, increased sprouting of beech suckers can dramatically alter forest structure(LeGuerrier et al. 2003). Beech bark disease may substantially impact wildlife which rely on beech nuts. Another pest that has significantly impacted eastern forests since introduction in the late 19th century is the European gypsy moth. Currently distributed throughout the region, gypsy moth populations fluctuate; during eruptive years, large moth populations cause widespread defoliation of oaks, aspen, and many other trees, including white pine. Successive years of defoliation can kill trees, but annual tree mortality due to gypsy moth seldom exceeds 20% within a region (Morin et al. 2004).

Several other species pose substantial threats if they advance into the region. The Asian longhorned beetle is a large potential threat to maple and other tree species if it invades rural and forested areas from its current documented occurrences in and near New York City. Likewise, the Emerald ash borer is of high concern, though it has not yet been documented in the northeastern U.S. This insect quickly kills all native species of ash, and could have dramatic impacts if it arrives in this region. Finally, the fungal pathogen that causes sudden oak death has not yet been found in the eastern U.S., but could have dramatic impacts on oaks and other trees if unwittingly introduced into this region.

Another important taxa currently spreading through northeastern forests are invasive exotic earthworms. Where they occur, earthworms are “keystone” soil fauna which control many aspects of soil structure and nutrient cycling (Hendrix 1995). Native earthworms are rare in northeastern forests, presumably having been removed by glaciation (Gates 1970). Currently, several species of invasive exotic earthworms are spreading through northeastern forests, probably due to introduction by agriculture and fishermen, though the geographical extent of this invasion remains unknown. In northeastern forests recently invaded by exotic earthworms,

dramatic impacts have been observed. Most notably, earthworm trophic activity dramatically reduces or eliminates the surface organic horizon or "forest floor" (Alban and Berry 1994) – an important structural feature of temperate forest soils important in nutrient cycling, regeneration and protection from soil erosion (Bormann and Likens 1979). In doing so, earthworms accelerate nutrient cycling, redistribute nutrients vertically among soil horizons and alter availability of key forest nutrients such as phosphorus and nitrogen; these effects are likely to vary depending upon many factors including forest composition, land use history, and species of invading earthworms (Bohlen et al. 2004). Some effects on herbaceous species composition have been observed (Hale et al. 2000).

Several species of invasive exotic terrestrial plants are currently impacting northeastern terrestrial ecosystems, by competing with native flora, altering habitat, and altering ecosystem dynamics such as nutrient cycling and hydrology (Mack et al. 2000). A few of the most significant invasive plants are briefly described herein. Norway maple is a hardy and prolific invader of forested habitat. It is very shade tolerant and can dominate regeneration in natural areas near suburban habitat where it has been planted as a landscaping or street tree (Webb et al. 2000). The aggressive shrub, European buckthorn, has escaped from hedgerow and other plantings to become a common species in northeastern forests. A dense understory of exotic Bush honeysuckles smother many northeastern woodlands, shading out native species and attracting bird dispersers. Likewise, the aggressive European garlic mustard invades a wide variety of open and forested habitats, displacing native wildflowers (Welk et al. 2002). Oriental bittersweet is a vine that overshadows forest edges and disturbed woodlands in southern New England and New York, smothering the vegetation beneath.

2.4.7.2 Feral Animals/Free-Ranging Pets

An additional category of "exotic species" that have a significant presence in some NETN parks are free-ranging and feral cats and dogs. While pet cats and dogs have great value to humans, the impacts of free-ranging and feral cats and dogs on natural ecosystems are only beginning to be understood. Free-ranging refers to animals which are kept as pets, but which are allowed to roam outdoors freely; feral animals are those that have escaped domesticity to live in the wild, although these animals are sometimes fed by humans. Both cats and dogs are natural predators. A growing body of literature indicates that free-ranging and feral cats are responsible for substantial mortality to small mammals and birds, and perhaps reptiles and amphibians as well (Pearre and Maass 1998, Fitzgerald and Turner 2000, Hall et al. 2000, Woods et al. 2003, Lepczyk et al. 2004). Because free-ranging cats are fed and cared for by humans, they may attain higher population densities than native predators, and thus exert abnormally high predation pressure on natural ecosystems. Moreover, cats are opportunistic predators (Coman and Brunner 1972, Barratt 1997), indicating adequate food supply at home does not prevent cats from predating native wildlife. Home-range of free-ranging cats was estimated using radio-telemetry in one study to vary up to 28 hectares, with the mean range about 8 hectares (Barratt 1997). Dogs are less effective predators than cats, but free-ranging dogs instinctually chase native mammals and other wildlife, which can stress, injure or kill those animals (Sime 1999, Miller et al. 2001). In addition, anecdotal evidence indicates that free-ranging dogs may negatively impact ground vegetation by digging and trampling; this maybe particularly true in areas near trails which are frequented by dog-owners walking their dogs off-leash. Many NETN parks are small, and several lie within densely inhabited suburban areas presumably with substantial pet populations; thus several NETN parks may be particularly at risk... Table 1.7 indicates that

natural resource staff at most NETN parks recognize this issue as an existing threat. Management options for affected parks include enforcement of regulations requiring dogs to be leashed, or prohibiting dogs from sensitive areas; public education campaigns which inform the public about free-ranging pet impacts upon wildlife, and encourage keeping cats indoors; and removal of nearby colonies of feral cats. A variety of wildlife conservation organizations, including the Wildlife Society and the National Audubon Society, advocate some or all of these management strategies.

2.4.7.3 Deer Herbivory

In addition to exotic species, many northeastern ecosystems currently are impacted by an elevated population of white-tailed deer browsers. In many parts of the northeastern U.S., deer populations have reached historic high levels due a combination of habitat modification and the extirpation of natural predators (Augustine and deCalesta 2003). Natural resource staff at most NETN parks have identified deer herbivory as an existing threat; this threat is greatest at parks in the southwestern and more suburban parts of NETN, and within historic sites and parks that maintain prime deer habitat (Table 1.7)

Increased browsing pressure from these large populations can substantially impact tree regeneration, as well as understory and herbaceous species composition. White-tailed deer browsing preference has been shown to inhibit regeneration of hemlock, northern white cedar and some species of oak and birch, and is implicated in the decline of herbaceous diversity in some mixed forests (Rooney and Waller 2003). The impacts of heavy deer browsing can be assessed by monitoring forest regeneration within and outside deer exclosures; deer population sizes may also be monitored from hunting and roadkill records (Halls 1984). Moreover, the effects of deer browsing on vegetation can have significant impacts on associated taxa including birds (DeCalesta 1994, McShea and Rappole 2000)) and small mammals (McShea 2000).

2.4.7.4 Land Management/Agriculture/Silviculture

The national historic sites and parks within NETN are managed primarily to achieve cultural goals, such as maintaining historical landscapes or practices. In order to achieve this, these parks apply substantial land management to maintain open and/or early successional habitat (MIMA, MORR, ROVA, SAGA, SARA, WEFA), perpetuate agriculture within parks (MIMA, MORR, SARA), or practice silviculture within parks (MABI). These activities have significant ecological impacts due to direct habitat alteration, habitat fragmentation, and the application of herbicides, pesticides and fertilizers. In addition, silviculture alters forest structure, and composition, as well as ecological processes acting within affected forests, and silvicultural re-stocking can introduce exotic species or genotypes. While these activities will continue in order to satisfy park cultural mandates, it is important for the I&M program to consider how these activities affect the ecological integrity of natural park systems. There are many ways to practice land management, agriculture and silviculture, and ample opportunity for monitoring to support and inform adaptive management related to these land management activities.

2.4.7.5 Nearby Landuse/Roads

As discussed above under Landscape Context (section 2.4.6) NETN parks exist within a matrix of suburban and rural landuse fragmented by extensive road networks. These impacts of these

stressors are considered above in that section, and also below within the Wetland and Aquatic Conceptual Models (sections 2.5 and 2.6).

2.4.7.6 Visitor Use

The northeast is among the most densely settled areas within the U.S., and NETN parks such as ACAD, APPA, MIMA, ROVA and MORR have high visitation rates (Table 1.3). Hikers can increase erosion on and around trails, trample nearby vegetation and cause soil compaction. These impacts can be particularly significant in high elevation areas, such as along APPA, and in areas where trails are poorly marked. Hikers can also disturb wildlife. Car traffic within parks can cause wildlife fatality, and reinforce the fragmentation effects associated with roads. Horse-riding is permitted within several NETN parks, and horses can contribute to trampling and erosion, and perhaps aid in the spread of invasive exotic species. Snowmobiling is permitted within ACAD, and may cause winter-time disturbance to wildlife.

2.4.7.7 Ozone

Tropospheric ozone is a damaging phytotoxin of significant concern within the northeastern U.S. (U.S. Environmental Protection Agency 1996). Ozone is formed by sunlight acting upon nitric oxides and simple hydrocarbons from industrial emissions and motor vehicles. Thus, trophospheric ozone levels vary rapidly in space and time, and are highest on sunny, still days in areas within and downwind of urban centers, industrial facilities and transportation corridors, but elevated background levels of trophospheric ozone occur throughout the northeastern U.S.. Natural resource managers have identified ozone as a threat at all NETN parks (Table 1.7); analysis by NPS Air Quality staff indicates that all but three NETN parks (MABI, SAGA and SARA) lie partially or completely within existing ozone "non-attainment" areas (Appendix F), indicating ozone pollution is a significant stressor at most NETN parks.

Ozone damages cell membranes, which may then reduce rates of photosynthesis and plant growth. However, ozone damage varies in a complex manner depending upon exposure, plant species, genotype, plant age, and plant stress, particularly water stress (Chapelka and Samulson 1998). For this reason, ozone is typically monitored both directly in air, and indirectly, as injury to indicator species (Coulston et al. 2003).

2.4.7.8 Atmospheric Deposition

Atmospheric deposition significantly impacts northeastern terrestrial ecosystems in complex ways that vary substantially across the landscape. Acidic deposition, derived from nitrogen and sulfur emissions from electric utilities, manufacturing, agriculture and other sources, is deposited in precipitation (wet deposition), directly onto vegetation immersed in clouds and fog (occult deposition), and also by direct transfer of particles and gases (dry deposition). Large scale patterns of wet acidic deposition across New England are well characterized - they are most extreme at high elevations and in the southern and western parts of this region which are closest to midwestern emission sources; deposition is slightly lower in central New England and along the Maine coast and lowest in northern and eastern New England (Driscoll et al. 2003). However, substantial additional acidity can result from dry and occult deposition, and these patterns of deposition are not well characterized. Within the NETN, coastal fog at Acadia may deposit substantial acidity (Weathers et al. 1986) which is not currently monitored by existing

programs such as the National Atmospheric Deposition Program (NADP) and the Clean Air Status and Trends Network (CASTNET).

The effects of acidic deposition upon forested ecosystems are complex. Acidic deposition acidifies soil, leaching base cations necessary for plant nutrition, such as Ca^{2+}, Mg^{2+}, $K^{+,}$ from the soil, and increasing availability of aluminum, a toxin. Deposition of nitrogen (N) compounds can further alter forested ecosystems - N is a limiting nutrient that has historically been retained within forested systems. As increased N inputs "saturate" forested ecosystems, excess N leaches from the system as nitrate and exacerbates the effects of acidification (Aber et al. 1998). The magnitude of these effects varies spatially across the landscape due to patterns of deposition, species composition, soil buffering capacity, and landuse history (Lovett et al. 2000, Aber et al. 2004). These effects also vary temporally; in particular, spring snowmelt can release substantial acidity accumulated during the winter.

The effects of these changes upon northeastern trees have been most well studied for red spruce and sugar maple. A substantial body of evidence indicates that acid deposition causes dieback of red spruce by decreasing cold tolerance due to interference with Ca^{2+} nutrition (Shortle et al. 1997, Johnson et al. 1998, DeHayes et al. 1999). Additional evidence indicates that acid deposition may contribute to sugar maple decline, particularly on marginal sites, due to base cation depletion (Long et al. 1997, Bailey et al. 1999, Horsely et al. 1999). Attempts to control emissions contributing to acidic deposition using federal regulation have yielded some decreases in sulfate deposition and prevented further increases in NO_x emissions, but recovery of affected ecosystems has lagged behind (Driscoll et al. 2003).

2.4.7.9 Climate Change

Anthropogenic global climate change is both directly and indirectly altering many key environmental parameters that control the structure, composition and function of terrestrial ecosystems. While accurate prediction of the effects of the suite of global change stressors upon terrestrial ecosystems is currently beyond our abilities, a large body of research has been assembled which yields some insight into what may occur. Easiest to predict are the direct effects of elevated atmospheric CO_2 concentrations on vegetation - elevated CO_2 has been shown to increase photosynthetic rates and tree growth, though this may be a short-term effect (Long et al. 1996, Rey and Jarvis 1998) which is likely to be limited under field conditions by nutrient limitation (Curtis and Wang 1998, Johnson et al. 1998). Enhanced CO_2 should also increase plant water use efficiency, but may reduce tissue nitrogen concentrations leaving vegetation more susceptible to herbivory and perhaps altering rates of nutrient cycling (Landolt and Pfenninger 1997, Williams et al. 1998).

It is much harder to predict the effects of changing temperature and precipitation patterns and altered disturbance regimes associated with global change. Current global change predictions suggest that the northeastern U.S. will warm over the next century, particularly during winter and at higher elevations, but it is unclear how patterns of precipitation may change (Mitchell and Johns 1997, Flato et al. 1999). In the short-term, the benefits of enhanced CO_2 may outweigh modest changes in temperature and precipitation causing increased productivity in northeastern forests (Aber et al. 2001). In the mid-term, changing environmental conditions may stress northeastern forests and exacerbate forest decline (Aber et al. 2001). Over the long-term, current predictions suggest that northern hardwood and spruce-fir forests could migrate north out of the

U.S. into Canada, and be replaced by oak-hickory and oak-pine forests (Hansen et al. 2001). Species will respond individually to climate change, causing the most severe impacts to highly mutualistic species, to poor dispersers, and to populations at the southern extent of their ranges. Current assessments of how global change may alter disturbance regimes within northeastern forested ecosystems are even more speculative, but it seems likely that hurricanes will become more frequent, that disturbances caused by invasive exotic insect pests will become more intense and widespread, and that the geographic extent of ice storms in this region may shrink (Dale et al. 2001).

2.4.7.10 Cumulative Effects

The effects of some stressors seem predictable based on current scientific understanding, while the effects of others remain quite speculative. The largest issue currently facing scientists and land managers is understanding the cumulative and interactive effects of these varied stressors upon ecosystems. For example, enhanced atmospheric CO_2 concentrations may increase plant water use efficiency, which might reduce foliar ozone exposure (Aber et al. 2001). However, increased disturbance and forest decline associated with global change is expected to increase the spread of invasive exotic species, while migratory responses of native species may be hindered by habitat fragmentation (Hansen et al. 2001). These are just a few examples - the possible interactions between this formidable suite of anthropogenic stressors are numerous, largely unstudied, and in some cases, very much unpredictable.

2.5 Wetland Resource Conceptual Model

Wetlands represent a diverse set of ecological communities that occur at the transition between terrestrial and aquatic systems. Defined based on hydrology, physiochemical environment, and biota, wetlands are some of the most productive and diverse ecosystems on earth (Keddy 2000). The physiochemical environment of a wetland is defined as the soils, chemical properties, and processes that interact with the hydrology to influence the biota. These three components form the basis for the development and functioning of wetland ecosystems.

Water is present in all wetlands for some time period but the depth and duration of flooding or *hydrology*, varies substantially among wetland types. Hydrology is the defining physical parameter that separates wetland ecosystems from terrestrial and deep water aquatic systems. Hydrology is thus the single most important factor in the establishment and maintenance of characteristic types of wetlands and wetland processes (Mitch and Gosselink 2000). Globally, freshwater species and habitats are among the most threatened in the world (Saunders et al. 2002). Freshwater withdrawals have doubled since 1960 and more than half of all freshwater runoff is used by humans (Loh et al. 1998, Saunders et al. 2002). Wetland loss in the United States has been substantial over the past 200 years. Prior to European colonization, wetlands comprised approximately 9% of the continental USA (Dahl 1990), but presently nearly 50% of the wetland area has been converted (NRC 1995). Of the remaining wetlands, only 25% are in government ownership, making the maintenance and conservation of these habitats on federal lands a high priority.

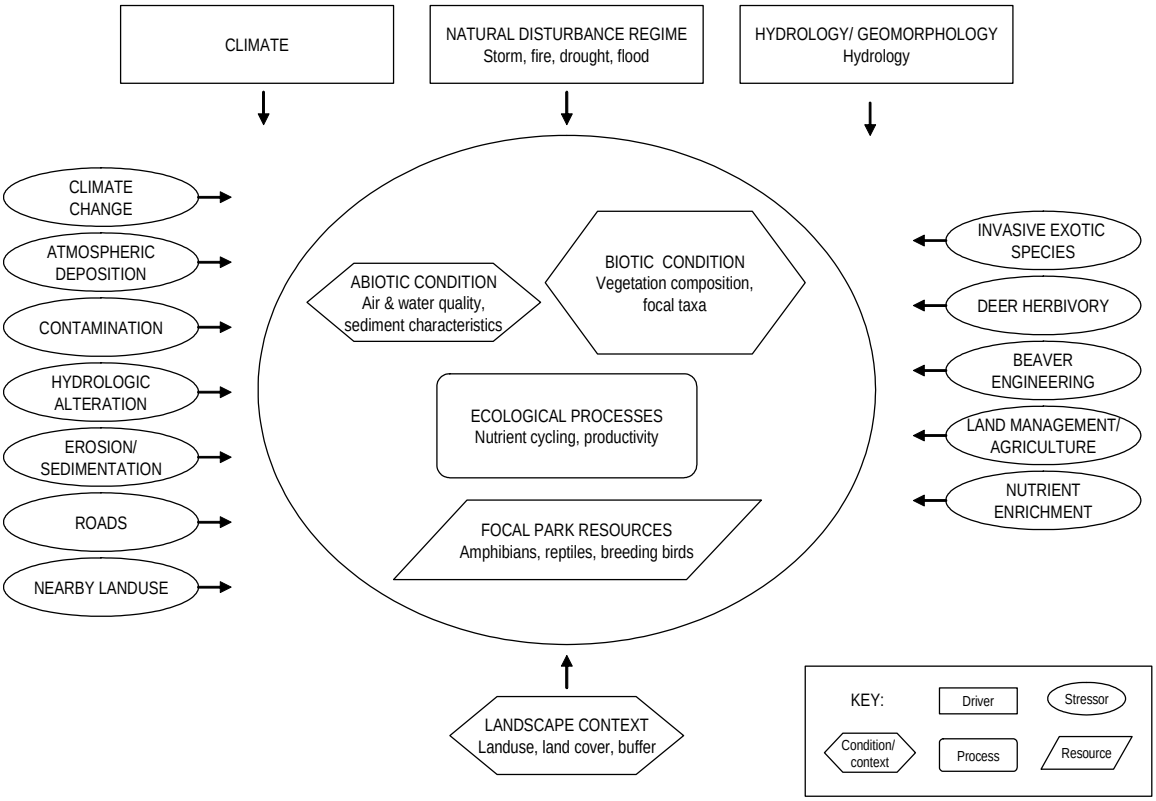
In the northeast United States depressional wetlands and seeps are a priority because of the major function they provide to amphibian breeding (Brinson and Malvarez 2002). These wetlands are most commonly altered or destroyed by urban and suburban development (Brinson and Malvarez

2002), a primary threat to NETN park natural resources. Wetland loss in NETN states has been substantial with an average loss of 38% (± 21%) of the original extent. Connecticut has suffered the most dramatic loss, with 74% of the states wetlands filled or degraded since the 1780's (Mitsch and Gosselink 2000).

In this section we present the wetland resource conceptual ecological model as a diagram (Figure 2.2) accompanied by the following narrative describing our current understanding of wetland system components and their interactions.

Figure 2.2 Conceptual Model for Wetland Systems

Forested wetland, Open/shrub wetland, Peatland, Vernal pool



2.5.1 Ecological Systems

Wetlands in NETN parks are an important component of park ecological condition and provide valuable habitat to a suite of obligate and facultative wetland flora and fauna. Wetlands are present in all NETN parks (Table 2.2 and see Appendix K) and provide valuable ecological and social services therein. Ecologically, wetlands contribute greatly to biological diversity, provide flood storage, and improve water quality, while socially they provide scenic viewsheds, educational opportunities, and contribute to our natural heritage.

Table 2.2. *Approximate extent (hectares) of NatureServe freshwater wetland ecological systems present within NETN parks. This information will be updated and improved after completion of the I&M mapping inventory of these parks. Area listed in larger boxes spanning more than one ecological type indicates that current information does not distinguish between related types. Information for APPA is not yet available.*

Ecosystem Category	NatureServe Ecological System Type	ACAD	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
Floodplain forest	Laurentian-Acadian Floodplain Forest				4					30	
	Central Appalachian Floodplain										
Softwood/hardwood swamp	Eastern Boreal Semi-Treed Bog	146									
	Laurentian-Acadian Acidic Swamp	214		4	58					3	
	North-Central Appalachian Acidic Swamp					6	9				1
Peatlands	Acadian Maritime Bog	37									
	Laurentian-Acadian Acidic Basin Fen	216			2						
	Laurentian-Acadian Alkaline Fen	68									
Wet meadows/shrub swamps	Laurentian-Acadian Wet Meadow-Shrub Swamp and Marsh	223	12	0.2	42	9	3	5	2	4	3

Wetlands in NETN parks are comprised of nine different types of wetland ecological systems (NatureServe 2003) and vernal pools. These types are summarized below, and described in greater detail within Appendix C.

- **Laurentian-Acadian Floodplain Forest**: This system encompasses north-temperate floodplains in the northeastern and north-central U.S. and adjacent Canada at the northern end of the range of silver maple. They occur along medium to large rivers where topography and process have resulted in the development of a complex of upland and wetland temperate alluvial vegetation on generally flat topography. This complex includes floodplain forests, with *Acer saccharinum* characteristic, as well as herbaceous sloughs and shrub wetlands. Most areas are underwater each spring; microtopography determines how long the various habitats are inundated. Associated trees include *Acer rubrum* and *Carpinus caroliniana*, the latter frequent but never abundant. On terraces or in more calcareous areas, *Acer saccharum* or *Quercus rubra* may be locally prominent, with *Betula alleghaniensis* and *Fraxinus* spp. *Salix nigra* is characteristic of the levees adjacent to the channel. Common shrubs include *Cornus amomum* and *Viburnum* spp. The herb layer in the forested portions often features abundant spring ephemerals, giving way to a fern-dominated understory in many areas by mid-summer. Non-forested wetlands associated with these systems include shrub-dominated and graminoid-herbaceous vegetation.

- **Central Appalachian Floodplain Forest**: This system encompasses floodplains from New England to Virginia. Mostly forested, these occur on floodplains of medium to large rivers where topography and process have resulted in the development of a relatively flat floodplain with a complex of upland and wetland temperate alluvial vegetation. This complex includes floodplain forests in which *Acer saccharinum*, *Populus deltoides*, and *Platanus occidentalis* are characteristic, as well as herbaceous sloughs and shrub wetlands. Most areas are underwater each spring; microtopography determines how long the various habitats are inundated. Depositional and erosional

features may both be present depending on the particular floodplain, although there is a history of deposition in the floodplain formation.

- **Laurentian-Acadian Acidic Swamp**: These forested wetlands are found in temperate northeastern and north-central U.S., primarily in glaciated regions in the Laurentian-Acadian region. They occur on mineral soils that are nutrient-poor. There may be an organic epipedon, but the substrate is not deep peat. These basin wetlands remain saturated for all or nearly all of the growing season, and may have standing water seasonally. There may be some seepage influence, especially near the periphery. *Acer rubrum, Fraxinus* spp., *Picea rubens* (rarely *Picea mariana*), and *Abies balsamea* are the most typical trees. The herbaceous and shrub layers tend to be fairly species-poor. *Nemopanthus mucronatus* and *Osmunda* spp. are typical shrub and herb species.

- **Eastern Boreal Semi-Treed Bog**: These peatlands are found at the higher temperate and near-boreal latitudes of the northeastern and north-central United States and adjacent Canada, where climate allows the rate of peat accumulation to exceed its decomposition, resulting in ombrotrophic and acidic peatlands in which the bog surface is raised above the water table. The surface morphology of the bog may be more-or-less level, domed, or eccentric. The vegetation is dominated by low ericaceous shrubs (including *Kalmia angustifolia, Kalmia polifolia, Ledum groenlandicum,* and *Chamaedaphne calyculata*), with patches of conifers, graminoids and bryophyte lawns. Secondary bog pools may be present. While the raised portion defines these bogs, fen vegetation is usually present along the perimeter.

- **North-Central Appalachian Acidic Swamp**: These swamps are distributed through the Central Appalachians south to Virginia. They are found in basins, or on gently sloping seepage lowlands. The acidic substrate is mineral soil, often with a component of organic muck; if peat is present, it usually forms an organic epipedon over the mineral soil rather than a true peat substrate. *Tsuga canadensis* is usually present and may be dominant. It is often mixed with deciduous wetland trees such as *Acer rubrum* or *Nyssa sylvatica*. *Sphagnum* is an important component of the bryoid layer. Basin swamps tend to be more nutrient-poor and less species-rich than seepage swamps; in some settings, the two occur adjacent to each other with the basin swamp vegetation surrounded by seepage swamp vegetation on its upland periphery.

- **Acadian Maritime Bog**: These ombrotrophic acidic peatlands occur along the north Atlantic Coast from downeast Maine east into the Canadian maritimes. When these form in basins, they develop raised plateaus with undulating sedge and dwarf-shrub vegetation. *Trichophorum caespitosum* may form sedge lawns on the raised plateau. The system may also occur as "blanket bogs" over a sloping rocky substrate in extreme maritime settings; here, dwarf-shrubs and *Sphagnum* are the dominant cover. Species characteristic of this maritime setting include *Empetrum nigrum* and *Rubus chamaemorus*. Typical bog heaths such as *Kalmia angustifolia, Kalmia polifolia, Gaylussacia baccata, Ledum groenlandicum,* and *Gaylussacia dumosa* are also present. Morphological characteristics and certain coastal species distinguish these from more inland raised bogs. The distribution is primarily Canadian, and these peatlands are rare in the U.S.

- **Laurentian-Acadian Acidic Basin Fen**:This peatland system ranges over a broad geographic area across the glaciated northeast to the Great Lakes and upper Midwest. The fens have developed in open or closed, relatively shallow basins with nutrient-poor and acidic conditions. Many occur in association with larger lakes or streams. The substrate is *Sphagnum*, and vegetation typically includes areas of graminoid dominance and dwarf-shrub dominance. *Chamaedaphne calyculata* is usually present and often dominant. Scattered stunted trees may be present. These fens often develop adjacent to open water. They lack the ribbed or reticulate microtopographical patterning of the patterned fen system.

- **Laurentian-Acadian Alkaline Fen**: These fens, distributed across glaciated eastern and central North America, develop in open basins where bedrock or other substrate influence creates circumneutral to calcareous conditions. They are most abundant in areas of limestone bedrock, and widely scattered in areas where calcareous substrates are scarce. The vegetation may be graminoid-dominated, shrub-dominated, or a patchwork of the two; *Dasiphora fruticosa ssp. floribunda* is a common diagnostic shrub. The herbaceous flora is usually species-rich, and includes calciphilic graminoids and forbs. *Sphagnum* dominates the substrate; *Campylium stellatum* is an indicator bryophyte. The edge of the basin may be shallow to deep peat over a sloping substrate, where seepage waters provide nutrients.

- **Laurentian-Acadian Wet Meadow-Shrub Swamp and Marsh**: This system encompasses shrub swamps and herbaceous emergent to submergent mineral-soil wetlands of the Northeast and upper Midwest. They are often associated with lakes and ponds, but are also found along streams, where the water level does not fluctuate greatly. The size of occurrences ranges from small pockets to extensive acreages. The emergent wetlands often have a patchwork of shrub and graminoid dominance; typical species include *Alnus incana*, *Spiraea alba*, *Myrica gale*, *Calamagrostis canadensis*, tall *Carex* spp., and *Juncus effusus*. Trees are generally absent and, if present, are scattered. Submergent wetlands include a variety of macrophytes, often with a border of non-persistent emergent vegetation dominated by *Pontederia cordata*. The submergent vegetation zones may be severely impacted by non-native invasive aquatics including *Myriophyllum spicatum* and others.

- **Vernal Pools**: Vernal pools are temporary bodies of fresh water inhabited by many species of wildlife, some of which are totally dependent on the pools for their survival (DiMauro and Hunter 2002). Temporary freshwater pools provide critical habitats for breeding populations of amphibians and invertebrates dependent upon fishless environments for successful recruitment (Semlitsch and Bodie 1998). Periodic drying of vernal pools eliminates fish populations and breeding populations of other predators such as bullfrogs (*Rana catesbeiana* Shaw) and green frogs (*Rana clamitans* Latreille). Thus, vernal pools provide a unusual low predation environments for many amphibians. Vernal pools occur throughout North America within both closed canopy and open canopy communities. In northeastern North America, vernal pools are typically found in upland forest and floodplain depression systems that are filled by spring rains, snowmelt, or seasonally raised water tables (Brooks et al. 1998, Brooks and Hayashi 2002). Candidate systems within the Northeast Temperate Network where vernal pools may occur include

the following: Laurentian-Acadian Floodplain Forest, Central Appalachian Floodplain, Acadian Lowland Spruce-Fir-Hardwood Forest, Laurentian-Acadian Northern Hardwood Forest, Laurentian-Acadian Pine-Hemlock-Hardwood Forest, and Appalachian Hemlock-Hardwood Forest.

2.5.2 Ecosystem Drivers

2.5.2.1 Climate

Climate is a key driver of wetland ecological systems. The temperate climate of NETN parks is described above in section 2.3, and the potential ecological effects of anthropogenic climate change are discussed below in section 2.5.7.

2.5.2.2 Disturbance Regimes

Natural disturbances to wetlands in NETN influence hydrology and therefore change the abiotic and biotic attributes of the wetland system. Changes to hydrology can occur naturally to wetlands through succession, beaver engineering, sediment transports, severe weather events, and ice scouring. Severe weather events are the most common source of natural disturbance for wetlands in the NETN and determine the extent and duration of floods and droughts. The direct consumption of plants by geese, muskrats, and other herbivores can be common in some wetlands and greatly alters the vegetation composition and structure (Mitch and Gosselink 2000). Known as "eat outs", these natural disturbances convert large expanses of wetlands from emergent vegetation to open water (Middleton 1999).

2.5.2.3 Hydrology/Geomorphology

Hydroperiod (the frequency and duration of soil inundation) defines the hydrology of a specific wetland and largely determines the type of wetland that will develop in a particular setting. Wetland hydroperiod is influenced by basin morphometry, wetland size, connection of the wetland to ground–water resources, and long-term climatic conditions (Larson 1995, Lent 1997, Kirkman et al. 1999, Brooks and Hayashi 2002). Annual variation in hydroperiod is thought to be an expression of the annual variation in weather patterns, specifically precipitation (Winter 2001). Moreover, hydroperiod is the most important physical factor driving the composition and diversity of the wetland floral and faunal communities and wetland productivity (Semlitsch et al. 1996, Schneider 1999, Mitsch and Gosselink 2000, Brooks 2004). Therefore, monitoring wetland hydroperiod not only provides detailed information about wetland condition, structure, and function but also can be used as a corollary to better understand the ecological effects of changing weather patterns.

(Weyrauch and Grubb 2004) found hydroperiod to be the most important variable in predicting amphibian species richness and showed a positive relationship between hydroperiod and species richness. (Snodgrass et al. 2000)recommended that an array of small wetlands with variable hydroperiods be conserved in order to maintain biological diversity at the landscape scale. Wetlands of shorter hydroperiods and smaller size are likely to support species not found in permanent wetlands because of the absence of fish predation in ephemeral wetland (Semlitsch and Bodie 1998, Gibbs 2000, Snodgrass et al. 2000). Alterations to hydroperiod that increase flooding can reduce the extent of emergent vegetation, alter the benthic community, and decrease water clarity. Hydrologic alterations that increase the duration of water level drawdown periods

reduce wetland size, limit amphibian breeding, and can increase the probability of invasion by exotic plant species.

The geomorphic setting of the wetland is important in determining wetland type and the dominant sources of water a wetland receives (Brinson et al. 1998). Wetlands of different geomorphic settings usually receive different sources of water, have different hydroperiods and therefore, different species compositions (Brinson et al. 1998, Mitsch and Gosselink 2000). Wetlands with similar geomorphic settings tend to be subjected to the same anthropogenic stressors (Brinson and Malvarez 2002). Depressional wetland hydrology is tightly correlated with groundwater levels making this wetland type subject to complete drying during periods of groundwater withdrawal. Periods of complete drying can eliminate the role of depressional wetlands in maintaining wetland faunal diversity, especially amphibians (Semlitsch and Bodie 1998).

2.5.3 Abiotic and Biotic Condition

2.5.3.1 Abiotic Condition

Soil and water chemistry vary widely among wetlands (Mitsch and Gosselink 2000). The chemistry of freshwater marshes differs substantially from the chemistry of ombrotrophic bogs, with differences related to the magnitude of nutrient inputs and the relative importance of ground water and surface water inflow . Inflowing water to freshwater wetlands tends to have higher amounts of dissolved minerals, including nutrients, compared to bogs that are fed by precipitation only. The pH of most freshwater marshes is generally circumneutral to slightly basic whereas the pH of bogs generally decreases as the organic content increases, creating a gradient of soil acidity among different wetland types (Mitsch and Gosselink 2000).

Nutrient concentrations in wetland systems are greatly influenced by flooding events, connection with groundwater, nutrient uptake by plants, and substrate or parent material (Mitsch and Gosselink 2000). Flooding in wetland systems is controlled by seasonal changes in precipitation, runoff, and evapotranspiration, and in the northeast occurs most frequently during the spring and fall when evapotranspiration is reduced.

Amphibians are very sensitive to wetland water chemistry and ion concentration is particularly important for amphibian development (Cook 1983, Hofstra and Smith 1984, Freda and Dunson 1986, Portnoy 1990, Turtle 2000). Low pH can be especially detrimental to developing amphibian embryos and Portnoy (1990) observed complete mortality of spotted salamander (*Ambystoma maculatum*) embryos in vernal pools having a pH of 4 or lower. Turtle (2000) found that de-icing salts heavily contaminate roadside wetlands and reduced spotted salamander survivorship.

2.5.3.2 Biotic Condition

Algae are an important component of wetland systems and are often a more important source of energy than vascular plants (Neill and Cornwell 1992, Peterson et al. 1993, Adamus et al. 2001). Algae are commonly grouped based on where they occur in the vertical strata. Phytoplankton are algal species suspended in the water column, metaphyton are unattached and floating, benthic algae are attached to the substratum, and epiphytic algae are attached to plants (Adamus et al. 2001). Algal production is often limited by phosphorous and nitrogen and most algal groups are

sensitive to changes in the concentrations of these macronutrients (Bothwell 1989) making them potential indicators of eutrophication and nutrient enrichment.

Vascular plants, or macrophytes, are increasingly being used as indicators of wetland condition (Adamus et al. 2001). Macrophytes are commonly used to delineate wetland boundaries and to classify wetland types. Common plant species in northeast wetlands include: red maple (*Acer rubrum*), silver maple (*Acer saccharum*), green ash (*Fraxinus pennsylvanica*), buttonbush (*Cephalanthus occidentalis*), meadow-sweet (*Spiraea alba*), speckled alder (*Alnus incana*), willow (*Salix spp.*), common cattail (*Typha latifolia*), pickerelweed (*Pontederia cordata*), broad-leaved arrowhead (*Sagittaria latifolia*), and sphagnum mosses (*Sphagnum spp.*).

Wetland invertebrates are important trophic links between plants and their detritus, and animals and fish (Mitsch and Gosselink 2000). Many groups of insects serve important roles in wetland nutrient cycling by shredding plant material to increase availability to bacteria (Adamus et al. 2001). Invertebrate fauna are increasingly being used as indicators of wetland condition (Adamus et al. 2001). Some invertebrate species, such as fairy shrimp (*Eubranchipus* spp.), are also entirely dependent upon vernal pool habitat and many species act as important predators and prey in wetland ecosystems (King et al. 1996).

Amphibians and reptiles are the dominant vertebrate groups in many freshwater systems of NETN parks. Common species include the American toad (*Bufo americanus*), green frog (*Rana clamitans*), American bullfrog (*Rana catesbiena*), gray treefrog (*Hyla versicolor*), pickeral frog (*Rana palustris*), spring peeper (*Pseudacris crucifer*), eastern newt (*Notophthalmus viridescens*), painted turtle (*Chrysemys picta*), Blanding's Turtle (*Emydoidea blandingii*), and snapping turtle (*Chelydra serpentina*). Some species like, wood frog (*Rana sylvatica*), the eastern spadefoot toad (*Scaphiopus h. holbrooki*), and the four species of mole salamander (*Ambystoma* spp.) have evolved breeding strategies intolerant of fish predation and are considered vernal pool obligate breeders. The lack of fish populations is essential to the breeding success of these species. Vernal pools are a high conservation priority in the northeast due to the loss of vernal pools and general lack of regulatory protection for these ephemeral habitats.

Other dominant wetland faunal groups include mammals and birds. Beaver (*Castor canadensis*) and muskrat (*Ondatra zibethicus*) are common in NETN wetlands; both of these species can cause major changes in marsh vegetation structure and composition. Common wetland avi-fauna include least bittern (*Ixobrychus exilis*), American bittern (*Botaurus lentiginosus*), great blue heron (*Ardea herodias*), black-crowned night heron (*Nycticorax nycticorax*), wood duck (*Aix sponsa*), black duck (*Anas rubripes*), Virginia rail (*Rallus limicola*), Sora (*Porzana carolina*), marsh wren (*Cistothorus palustris*), northern waterthrush (*Seiurus noveboracensis*), and red-winged blackbird (*Agelaius phoeniceus*).

2.5.4 Ecological Processes

2.5.4.1 Nutrient Cycling

A major feature that separates wetland from terrestrial systems is the anaerobic nature of wetland soils (Morris 1991). The absence of oxygen in wetland soils slows the decomposition of organic material compared to terrestrial systems. Wetlands, because of the gradients in available oxygen, maintain the widest range of oxidation-reduction reactions of any ecosystem type (Keddy 2000).

This effectively allows wetlands to function as transformers of nutrients and metals where elements are converted among an array of chemical states (Mitsch and Gosselink 2000). Wetland nutrient cycling is dominated by the detritus food web where bacteria and invertebrates are a key component in nutrient cycling. Most nitrogen is stored in these organic sediments. Nitrogen cycling within a wetland is controlled by the temperature, pH, and the amount of available oxygen (Keddy 2000). Both nitrogen and phosphorous are limiting to wetland productivity and are often interdependent (Mitsch and Gosselink 2000).

2.5.4.2 Productivity

Wetland primary productivity estimates are high and range from 500-6000 g $m^{-2}yr^{-1}$ (Mitsch and Gosselink 2000). Productivity varies among wetland types, primarily dependent on wetland hydrology. Wetlands with flowthrough hydrology (e.g., fens) tend to have higher primary productivity than stagnant, ombrotrophic systems (e.g. bogs, (Mitsch and Gosselink 2000). Hydrology, the main pathway through which nutrients are transported into and through wetlands, greatly influences wetland productivity.

Wetlands are pulsed ecosystems where changes in water levels influence the flow of nutrients and oxygen and therefore, productivity. Wetland productivity is also related to the efficient functioning of both the grazing and detritus food chains. In bogs, where there is little or no pulsing, organic matter accumulates to form peat rather than being broken down and released into the system. Variation in productivity can be primarily attributed to summer temperatures, with a positive relationship between temperature and productivity (Gorham 1974) and genetic differences among plant species in photosynthetic efficiency (Kvet and Husak 1978).

2.5.5 Focal Park Resources

2.5.5.1 Amphibians and Reptiles

Amphibians occur in all NETN parks and are the organisms most sensitive to changes in water quality, wetland condition, and wetland landscape context. Amphibians are experiencing species extinctions and population declines globally with causes ranging from direct habitat destruction (Blaustein and Wake 1990, Fellers and Drost 1993), changing climate (Rohr and Madison 2003), disease (Blaustein et al. 1994), contaminants (Beattie and Tyler-Jones 1992), and introduced species (Hayes and Jennings 1986). The extreme sensitivity of amphibians to environmental stressors, their ubiquitous distribution in the northeast, and their importance to the public, make this group an important focal resource to be included in a long-term monitoring program.

Declines and extinctions in amphibian species are not limited to heavily developed or degraded areas. Two species-- the Northern Ducky Salamander (*Desmognathus fuscus*) and the Northern Leopard Frog (*Rana pipiens*) -- were once present in Acadia NP (Manville 1939, Coman 1987), but recent inventory work did not detect these species (Behler et al. 2004). The potential loss of two species from Acadia NP is troubling and emphasizes the need for monitoring amphibian population status, not only as an indicator of wetland condition, but as early warning of species population declines.

Most amphibians and many reptiles require aquatic habitats during some stage of their annual cycle and are therefore especially vulnerable to wetland alteration and/or contamination (Stebbins and Cohen 1995, Dodd and Cade 1998, Lannoo 1998). Amphibians and reptiles,

because of their limited dispersal ability and migration patterns, are especially sensitive to the landscape matrix surrounding wetlands (Gibbs 1998a, b).

2.5.6 Landscape Context

Habitat fragmentation and buffer loss are major anthropogenic stressors to surrounding wetland habitats. Freshwater systems are affected by land-use activities occurring upstream. Land-use practices that alter land cover types to reduce native vegetation can affect freshwater systems by modifying nutrient loads, sediment accretion, water temperature, and contaminant inputs (Saunders et al. 2002).

Wetland density on the landscape is often cited as an important explanatory variable in population and community level studies of species persistence and distribution (Fahrig and Merriam 1985, Kotliar and Wiens 1990). High wetland density on the landscape may reduce the risk of local species extirpation by maintaining hydrologic regimes and minimizing costs associated with dispersal (Morris 1992, Mitsch and Gosselink 2000). Landscape orientation of wetlands, especially small isolated wetlands, is a critical determinant of obligate species population viability (Gibbs 1993, Guerry and Hunter 2002). Wetlands tend to be spatially aggregated and hydrologically linked (Brooks et al. 1998). Dispersal opportunities among wetlands are needed to maintain viable populations of organisms dependent on wetland habitats. In this context, metapopulation models may serve as a basis for understanding amphibian dispersal and colonization behavior. However, quantitative information needed for effective population modeling is lacking (Brooks et al. 1998).

Wetland patch size has also been shown to be an important metric in determining wetland condition and many studies have shown that patch size is fundamentally important in maintaining biodiversity (Fahrig and Merriam 1985, Robinson et al. 1992).

Amphibians and reptiles are especially sensitive to the matrix of habitats surrounding a wetland because they spend the majority of their lives foraging, resting, and hibernating in the surrounding terrestrial habitat (Semlitsch 1998). Upland habitats immediately surrounding wetlands serve as important dispersal corridors and are also used as foraging and aestivation areas for many amphibian species (Semlitsch 1998). (Weyrauch and Grubb 2004) found woodlot characteristics surrounding a wetland to be the most important variables predicting caudate species richness. Semlitsch (1998) monitored terrestrial migrations for six Ambystomid salamander species and concluded buffer areas 164 m from wetland edges were needed to encompass 95% of population forays. Total forested area around the wetland also seems to be an important landscape component in the maintenance of wetland fauna. Guerry and Hunter (2002) found that wood frogs, green frogs, eastern newts, spotted salamanders, and salamanders of the blue-spotted/Jefferson's complex (*Ambystoma laterale*/*A. jeffersonianum*) were more likely to occupy ponds in more forested areas than areas with low forest cover.

Roads are among the most widespread forms of habitat modification on the landscape and can have profound effects on wetland communities (Trombulack and Frissell 2000, DiMauro and Hunter Jr 2002, Gibbs and Shriver 2002, Forman et al. 2003). Road construction has been implicated in the significant loss of wetland biodiversity at both local and regional scales for birds, herptiles, and vascular plants (Findley and Houlahan 1997). Fragmentation resulting from road construction and the associated traffic intensity can act as a barrier to amphibian movement

and reduce amphibian abundance (Fahrig et al. 1995, Gibbs 1998a, deMaynadier and Hunter 2000). The combined effects of ionic inputs, edge effects (deMaynadier and Hunter 1998), and adult mortality make roads an important landscape component to monitor when estimating wetland condition. (Findley and Bourdages 2000) documented lag times associated with the negative response of species richness to road construction and suggested that the affects of road construction may not be detectable for decades.

2.5.7 Stressors

In this section, we summarize knowledge about the effects of key stressors upon NETN wetland systems. The park-based conceptual ecological models within Appendix K reveal important stressors acting upon specific parks.

2.5.7.1 Atmospheric Deposition

Anthropogenic atmospheric deposition can dramatically affect water quality in wetland systems. Acidic deposition, in the form of nitrogen and sulfur oxides, can alter wetland structure and function (Morris 1992). Another significant component of anthropogenic air pollution is mercury. Although mercury is a naturally occurring element, studies show that human activities have more than tripled its concentration in the environment, which can cause negative impacts in wetland systems, such as direct toxicity and reduced fecundity of secondary consumers.

The deposition of nitrogen compounds is the major stressor to wetland systems caused by atmospheric deposition. Bodies of water receiving elevated amounts of nitrogen compounds often show signs of water quality degradation. Atmospheric deposition of nitrogen occurs as wet (in precipitation) and dry (sorption of nitrogen gasses by wet surfaces) deposition and through the capture of fog or cloud droplets by vegetation (occult, (Morris 1992). Atmospheric deposition of nitrogen compounds can lead to eutrophication, or harmful increases in the growth of algae within wetland systems. Nitrogen pollution and the resulting eutrophication of wetlands, alters species composition of both flora and fauna and in some cases, nitrogen pollution can contribute to the acidification of water bodies.

Acidification is also common in water bodies in the eastern United States where weather patterns deposit acids derived from air pollutants generated in the Midwest and points further west. The effects of acid deposition depend greatly upon characteristics of the water body in which they are deposited. Aquatic organisms in acidified waters often suffer from calcium deficiency, which weakens bones and exoskeletons and can cause eggs to be weak or brittle. It also affects the permeability of fish membranes and particularly, the ability of gills to take in oxygen from water. Increasing amounts of acid in a wetland change the mobility of certain trace metals like aluminum, cadmium, manganese, iron, arsenic, and mercury. Acid deposition has lowered the pH, decreased the acid-neutralizing capacity (ANC), and increased the aluminum concentrations causing a decline in aquatic species diversity and abundance in the northeast (Driscoll et al. 2001a). Many amphibian species are susceptible to increasing pH, especially those breeding in temporary wetlands or vernal pools. Permanent wetlands may have a natural buffer capacity to neutralize acidification but ephemeral wetlands are created by snow melt or spring runoff which tends to concentrate acid and lower pH. Algae are affected by acidification as a result of direct toxicity and changes in competition with organisms less sensitive to rising pH (Adamus et al. 2001). Either extreme of acidity can diminish species richness of algal communities.

2.5.7.2 Hydrologic Alterations/Beaver Engineering

Beaver engineering is one of the most pervasive hydrologic alterations to NETN park wetlands. Water diversions of any kind can be viewed as potential agents of both positive and negative change to wetlands. Beaver can affect almost any wetland type but are especially common along streams and ponds where they build dams. Dam construction typically kills all woody vegetation, reduces the water velocity, and drastically changes plant species composition and structure (Thompson and Sorenson 2000). Beaver alteration of wetlands occurs in decadal cycles with an initial period of flooding after dam creation and impoundment followed by abandonment after the beaver deplete the food source. Thus, beavers both destroy through flooding unusual vegetation of bogs and fens, for example, but conversely create many highly productive wetlands along streams formerly dominated by upland vegetation.

2.5.7.3 Climate Change

A growing body of evidence indicates that human activities have accelerated the concentration of greenhouse gases in the atmosphere (IPCC 2002). Atmospheric models predict the average surface temperature to rise from 1.4 to 5.8ºC by 2100 (IPCC 2002). The climate of the northeastern United Sates is projected to become warmer and perhaps wetter over the next 100 yrs (New England Regional Assessment Group 2001), changes that will likely affect the structure, function, and distribution of wetlands. Both annual and seasonal minimum temperatures are predicted to increase at a greater rate than maximum temperatures (Brooks 2004). These projected increases in temperature would also increase the rate of evapotranspiration which in turn would alter wetland hydrology. Hydrologic alterations that reduced the flooding period would have the most negative impacts on ephemeral wetland or vernal pools (Brooks 2004). Changes in wetland water temperature due to rapidly changing climate are also predicted to alter the sex ratios of turtle populations because of their temperature dependent sex determination (Root and Schneider 2002). Wetland herpetofauna may be especially sensitive to changing climate caused by the synergistic effects of habitat fragmentation and the increased need for dispersal caused by a reduction in habitat quality. Increases in the rate of temperature change to wetland habits may force many individuals to disperse more frequently. As landscape matrices have become more hostile to dispersing wetland herptiles the increase dispersal may reduce populations and further bias sex ratios (Gibbs and Shriver 2002, Steen and Gibbs 2004).

Increases in temperature have already been shown to change the breeding and dispersal phenology of many species (Schneider and Root 2002). Climate change is anticipated to have a pronounced effect on freshwater ecosystems, especially those in northern latitudes (IPCC 2002). The combined effects of changes in temperature and precipitation are likely to severely alter wetland hydrology and water quality, thus jeopardizing the flora and fauna dependent on these systems. In the northeast, several frogs have advanced their first calling dates by 10-13 days since the early 1900's (Gibbs and Breisch 2001). Because amphibians are especially sensitive to temperature they can be valuable indicators of the biotic response to climate change in wetland systems.

2.5.7.4 Contamination

Within this ecological model, contamination is defined as the increase in concentration, availability, and/or toxicity of metals and synthetic substances (Adamus et al. 2001). Wetland

contamination is typically associated with runoff from agricultural areas, residential and urban areas, waste water treatment facilities, and atmospheric deposition.

Heavy Metals-Heavy metals such as mercury, lead, zinc, and cadmium can be directly toxic to wetland fauna (Adamus et al. 2001). Mercury is especially problematic in the northeast where deposition is high. When mercury becomes deposited within a water body, microorganisms can transform it into a very toxic substance known as *methyl mercury*. Methyl mercury can accumulate in the tissues of fish to concentrations much higher than in the surrounding water. *Methyl mercury* tends to remain dissolved in water and does not travel very far in the atmosphere.

Combustion Emissions-Dioxins and furans are families of chemicals that are present in *combustion emissions* and are known to be highly toxic to wildlife. The most toxic dioxin compound is 2,3,7,8-tetrachlorodibenzo-p-dioxin or TCDD. In animal populations, TCDD has been shown to disrupt the endocrine system, weaken immune systems, and cause reproductive damage to wildlife populations. Similarly, the most toxic furan is a compound known as 2,3,7,8-tetrachlorodibenzofuran or TCDF. In animals, furans can cause serious damage to the stomach, liver, kidneys, and immune system. Both families of compounds are persistent in the environment and can concentrate in the tissue of fish and other animals.

Polycyclic aromatic hydrocarbons (PAHs) are a complex mix of compounds that occur in soot and exhaust from automobiles and the incineration of many different materials.

Polychlorinated biphenyls (PCBs) are extremely stable and can concentrate in the tissues of aquatic animals. Concentrations of PCBs in the tissue of some animals can reach literally hundreds of thousands of times greater than the surrounding water. PCBs can cause bronchitis, irritation of the gastrointestinal tract, nervous system impairment, fertility problems, and changes in liver function. They have been shown to cause cancer in lab animals, and are a suspected human carcinogen.

2.5.7.5 Invasive Species

Invasion of native habitats by nonindigenous species or by native species whose densities are becoming unnaturally inflated (e.g., white-tailed deer) is presently recognized as second only to direct habitat loss and fragmentation as a threat to biodiversity. Pimentel et al. (2001) estimated that invasive species cost the United States $138 billion annually making the reduction of these species a shared priority of many agencies and organizations in the United States (National Invasive Species Council 2001). Once viable populations of invasive plants become established in novel habitats, they inflict a suite of ecological damage to native species including loss of habitat, loss of biodiversity, decreased nutrition for herbivores, competitive dominance, overgrowth, struggling, and shading, resource depletion, alteration of biomass, energy cycling, productivity, and nutrient cycling (Dukes and Mooney 1999). Invasive plant species can also affect hydrologic function and balance, making water scarce for native species (Enright 2000).

Wetland invasive plant species in NETN parks presently include, but are not limited to purple loosestrife (*Lythrum salicaria*), Japanese knotweed (*Polygonum cuspidatum*), water chestnut (*Trapa natans*), flowering rush (*Butomus umbellatus*), yellow iris (*Iris pseudacorus*) and phragmites (*Phragmites australis*). These species have been detected in most parks and cause a

substantial management effort to control and reduce wetland condition. Invasive plants significantly alter species composition and diversity and often form monotypic stands.

2.5.7.6 Nutrient Enrichment

Sources of nutrients, especially nitrogen and phosphorous, enter wetlands via surface water, groundwater, and the atmosphere (Brinson and Malvarez 2002) and can dramatically change the composition of both the floral and faunal communities (Bedford et al. 1999). Nutrient enrichment also increases the risk of invasive species establishment in many wetlands, a primary threat to NETN wetland and terrestrial resources. Increases in nitrogen and phosphorous in wetlands causes eutrophication, often at concentrations that exceed natural levels. The dominant source of nutrient inputs into wetland systems comes from agricultural and residential runoff. The most obvious response of wetland systems to nutrient enrichment are harmful algal blooms where algal biomass increases rapidly (Humphrey and Stevenson 1992). Eutrophication can also lead to simplification of algal communities expressed by a decrease in species richness, diversity, and evenness (Steinman and McIntire 1990). Changes in nutrient concentrations can alter macroinvertebrate populations which in turn can change the trophic dynamics between those that consume algae and those that consume vascular plants (Adamus et al. 2001).

Excessive nutrients can affect the wetland plant communities by: 1) shifting species composition from dominance by species that uptake nutrients slowly to those that exploit rapid pulses of nutrients, 2) triggering algal blooms that can shade out submersed herbaceous plants, and 3) causing dead plant material to accumulate faster than it can decompose (Adamus et al. 2001). Wetlands exposed to long-term nutrient enrichment tend to have lower plant species richness than reference wetlands. Bogs and nutrient poor wetlands are most sensitive to the negative effects of nutrient enrichment.

2.5.7.7 Soil Erosion/Sedimentation

Sedimentation is a naturally occurring process in wetland systems, but accelerated rates can have negative effects on wetland condition. Sedimentation is regarded as one of the major threats to fresh-water aquatic systems, primarily due to the effects of burial (Richter et al. 1997). Increased rates of sedimentation can affect wetlands by adding sediment-born pollutants, burial of vegetation and seed banks (Neely and Baker 1989), and change the water depth and hydroperiod. Burial can smother aquatic invertebrates and fish eggs, and reduce oxygen availability by stimulating plant growth through nutrient addition (Keddy 2000).

2.6 Aquatic Resource Conceptual Model

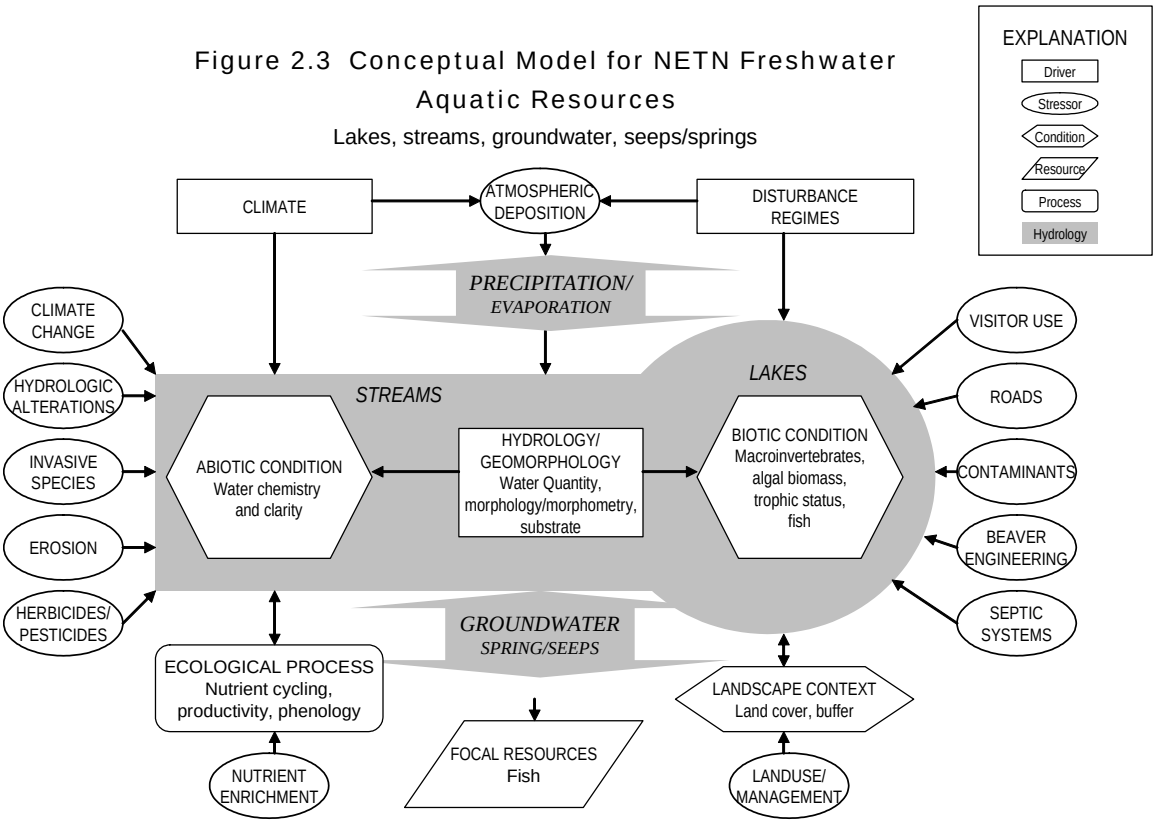
In this section we present the aquatic resource conceptual ecological model as a diagram (Figure 2.3) accompanied by the following narrative describing our current understanding of aquatic system components and their interactions.

2.6.1 Ecological Systems

Freshwater aquatic resources within NETN parks consist of lakes, ponds, streams, groundwater, and springs/seeps. These resources resulted from the activity of glacial ice sheets during the past 2.5 million years. Ice sheets deepened valleys, and transported and deposited vast quantities of sediment upon scoured bedrock as glacial drift (Randall 2001). Currently, the topographic landscape varies from rolling to mountainous upon mostly acidic bedrock and glacial till. The extent of aquatic ecological systems within NETN parks is shown in the park-based ecological models found in Appendix K.

Figure 2.3 Conceptual Model for NETN Freshwater Aquatic Resources

Lakes, streams, groundwater, seeps/springs



2.6.1.2 Lakes and Ponds

Lakes and ponds are found where the water table is at or above land surface, and are generally areas of ground-water discharge. The majority of the lake basins in the northeast U.S. were caused by unequal thickness of drift deposited in preglacial valleys; the thicker masses created dams. Thousands of such basins held lakes when the ice vanished and have become swamps or meadows (Fenneman 1938).

Nine NETN parks contain ponds smaller than 15 acres, many of which are man-made impoundments that pre-date the establishment of the parks. ACAD is the only park in which numerous lakes greater than 15 acres are a dominant part of the landscape. Lakes and ponds within NETN parks vary in type, size and trophic status (Appendix K).

2.6.1.3 Streams and Rivers

Streams and rivers within NETN parks vary from first order headwater streams to tidal rivers. Drainage patterns of northeastern streams were altered by the last glaciation. As drift was deposited in varying thicknesses, dams were created and channels blocked. Streams followed a new course based on the slope of the drift surface. After a stream cut through the drift, it often crossed ridges or ledges of hard rock and developed falls and rapids, eventually carving gorges disproportionate to the changes in relief (Fenneman 1938). Several of the parks border large rivers such as the Hudson River and the Connecticut River, and are occasionally impacted by these larger river systems during times of high water.

Information about groundwater resources and the properties and extent of aquifers making up this resource varies greatly in the northeast. The stratified drift deposited by glaciers includes a nonsorted, nonstratified mixture of grain sizes from clay and silt to large boulders. These sand and gravel deposits comprise the most productive aquifers in the northeast. These aquifers vary greatly in grain size, water-transmitting properties, and saturated thickness of the stratified drift (Randall 2001). Groundwater is also influenced by the type of bedrock underlying the stratified drift. The igneous and metamorphic bedrock that underlies much of the northeast has a hydraulic conductivity that is much lower than that of stratified drift (Randall et al. 1988). Ground-water/surface-water interactions occur in both directions and occur throughout the parks.

Springs occur where the water table intercepts the ground surface and discharge is sufficient to flow most of the time. If no flow is evident, the resulting wet areas are called seeps. Discharge of the spring is determined by the permeability and recharge of the aquifer, and thus can indicate the location and extent of an aquifer. Springs can be found at the toe of hillslopes, along depressions such as stream channels, and where the ground surface intercepts an aquifer covered by an aquiclude – a geologic barrier to groundwater flow (Brooks et al. 1991). NETN parks vary in the presence and quantity of springs and seeps.

2.6.2 Ecosystem Drivers

2.6.2.1 Climate

Climate is one of the main drivers affecting ecological properties and processes in aquatic ecosystems. The temperate climate of the northeastern U.S. is described above in section 2.3; briefly, it is characterized by changeable weather, wide ranges in diurnal and annual temperatures, distinct seasonal trends, and precipitation distributed evenly throughout the year.

2.6.2.2 Disturbance Regimes

Disturbance regimes are another major driver affecting aquatic ecosystems. Floods and droughts are the primary disturbances that affect aquatic ecosystems in NETN parks. Floods can occur during any season in the northeast, but are most widespread in the spring when large frontal systems bring steady rain which falls on frozen or saturated ground. In the summer and fall, thunderstorms and hurricanes can cause local flooding (Maloney and Bartlett 1991). Floods are natural recurring events that can cause major morphological shifts in river systems, and cause widespread erosion and sedimentation.

Droughts are more difficult to define and quantify than floods, but are also natural recurring events in the northeast. Hydrologic drought can be defined as reduced streamflows, declining ground-water levels and/or reductions in lake or reservoir levels (American Meteorological Society 1997). They can be widespread across the entire northeast, or affect only parts of the region. Droughts affect all aspects of water quantity and water quality, and can result in water use conflicts.

Long-term streamflow records show both floods and droughts and thus reflect the natural range of variability in aquatic ecosystems. Short-term records may be skewed depending upon the period of record.

2.6.2.3 Hydrology/Geomorphology

Aspects of the hydrology/geomorphology which characterize NETN parks also drive the ecological properties and processes operating in the park aquatic systems, and are described above under ecological systems (section 2.6.1).

2.6.3 Abiotic and Biotic Condition

Understanding and tracking abiotic and biotic condition is an integral part of the Inventory and Monitoring program and is directly addressed in two of the program goals. The condition of the ecosystem relates to the status of the aquatic habitat and the condition of individual species. The ecological condition of freshwater resources includes abiotic attributes such as water chemistry as well as biotic attributes such as trophic status, species composition of selected taxa, and microorganisms.

Water chemistry is critical for interpreting the biotic condition and status of ecological processes of a resource. Measures such as water temperature, dissolved oxygen and pH define the habitat in which various flora and fauna can survive. Water chemistry affects the trophic status of an ecosystem, the metabolism of aquatic species and the bioavailability of contaminants.

Vital signs that reflect biotic condition, such as composition and abundance of fish, macroinvertebrates and zooplankton, are highly relevant indicators of ecological condition that integrate the state of physical, chemical, and biological attributes of the environment. Fish communities integrate their physical, chemical, and biological environment over multiple years while macroinvertebrates do so over a single year. Zooplankton community composition and abundance is indicative of the trophic status of lakes, and reflects primary and secondary production (Porter 1977).

2.6.4 Ecological Processes

2.6.4.1 Nutrient Cycling/Productivity

Nutrient cycling, or the movement of nutrients through the water, plants, animals and sediments of freshwater ecosystems, is linked to the productivity and function of these ecosystems. The trophic status of a waterbody is also a measure of its productivity, or the rate at which organic matter is produced. The invertebrates, algae, bryophytes, vascular plants, and bacteria of freshwater systems, which are responsible for much of the work of nutrient cycling, are adapted to the specific sediment and organic matter conditions of their environment and are thus sensitive

to changes in the type, size, or frequency of sediment inputs. Understanding nutrient cycling and productivity in NETN aquatic systems may provide links between ecosystem condition, ecosystem function, and stressors such as nonpoint source pollution and land use.

2.6.4.2 Phenology

Phenology, or the response of living organisms to seasonal and climactic changes in the environment, is a process that helps define the condition of the ecosystem. The combined effects of climate change and other stressors have the potential to substantially alter hydrological and biogeochemical processes, and thus, the floral and faunal communities of freshwater ecosystems of the New England/Mid Atlantic region (Moore et al. 1997). A century of data on lake ice-out dates within the northeastern U.S. shows an advance in spring ice-melt (Hodgkins et al. 2002). Similarly, a shorter record shows an advance in the timing of spring peak river flow (Hodgkins et al. 2003). These trends could affect the ecological integrity of lakes and streams by causing lower oxygen levels, eutrophication, and/or shifts in floral and faunal communities. Further research is needed to better understand relations between documented trends in freshwater systems, and the ecological integrity of these systems.

2.6.5 Focal Park Resources

Fish, discussed above as a component of biotic condition are also a focal park resource; they have broad appeal to the public and thus receive attention from NPS. The use of fish as Vital Signs is discussed above in section 2.6.3.

2.6.6 Landscape Context

The relationship between freshwater aquatic ecosystems and the surrounding landscape contributes to the condition of these ecosystems. The dimensions of a river channel reflect the interplay between the ability of water to erode the land surface and the ability of the land surface to resist erosion. Landuses such as farming, forestry, development, and water management can all affect the magnitude and frequency of streamflow and thus a river's ability to erode the land. When streams are constrained from meandering by urban alterations, hydraulic instability can cause increased deposition, erosion, slumping, over-widening or the abandonment of existing channels for new ones (Dunne and Leopold 1978). As waterbody buffers expand or contract, sources and amounts of nonpoint source pollution and runoff to the waterbody can also change. Barriers between waterbodies, such as impoundments, can inhibit the movement of species and thus affect the floral and faunal composition of a waterbody. Landscape context is linked to and reflects changing landuse, which is further discussed in the section below regarding stressors.

2.6.7 Stressors

Stressors to freshwater ecosystems in NETN parks include physical, chemical, or biological perturbations acting both inside and outside park boundaries. Many parks are not self-contained watersheds, but are at lower points in a watershed, and can be greatly influenced by alterations to the rivers, streams, or lakes that occur upstream from the parks. Furthermore, some areas that are now protected within parks were substantially altered prior to protection as a national park unit. Thus threats to freshwater aquatic resources in NETN parks cannot be evaluated without examining current and historic landuse in the region. As the landscape of the region has been

transformed from agricultural to urban over the past 150 years, the increased use of automobiles and shifts in predominant industry from paper and textile mills to high-tech industry have had substantial impacts on the region's freshwater ecosystems. Key stressors currently acting on freshwater resources within NETN parks include climate change, atmospheric deposition, contaminants, nutrient enrichment, hydrologic alterations, erosion, herbicides and pesticides from both agricultural and residential use, roads, landuse and land management, visitor use, invasive exotic species, and beaver engineering. Important stressors affecting aquatic systems in specific parks are shown by the park-based conceptual ecological models within Appendix K.

2.6.7.1 Climate Change

Climate change has the potential to affect the abiotic and biotic condition of freshwater resources across the region. Several geophysical and biological studies indicate that spring is coming earlier in New England. The annual date of the last hard spring freeze became significantly earlier from 1961 to 1990 (Cooter and Leduc 1995) and lilac bloom dates at 4 stations became significantly earlier from 1959 to 1993 (Schwartz and Reiter 2000). The impacts of climate change on hydrology in the northeast are just beginning to be understood. Much of the significant change toward earlier lake ice-out dates in New England since the 1800's occurred from 1968 to 2000 (Hodgkins et al. 2003). All of 11 studied rivers in New England had significantly earlier winter/spring high flows from earlier snowmelt, with most of the change occurring in the last 30 years (Hodgkins et al. 2003). Furthermore, snow density on or near March 1 has significantly increased in coastal Maine over the last 60 years, indicating earlier spring melting (Dudley and Hodgkins 2002).

2.6.7.2 Atmospheric Deposition

Atmospheric deposition is the largest source of nitrogen to streams in the northeast. Measures of atmospheric deposition are critical for understanding water chemistry and stress (Likens and Bormann 1974). Fifty percent of total nitrogen entering New England rivers and streams in 1992-1993 was estimated to come from atmospheric deposition originating both inside and outside the region (Moore et al. 2004) Atmospheric deposition is particularly problematic in NETN parks for the surface water bodies with low acid neutralizing capacity (ANC). This parameter is a key indicator of recovery, determining the capacity of lakes and streams to buffer acidic inputs and prevent further acidification (U.S. Environmental Protection Agency 2004). The relationship between atmospheric pollution and the acid base status of surface waters is complex and nonlinear. The complexities of ecosystem response are related to confounding factors such as climate change affecting water chemistry, and the natural organic acidity of surface waters (U.S. Environmental Protection Agency 2004). Long term monitoring of atmospheric deposition as well as the water chemistry of freshwater ecosystems are critical to improving understanding of this relationship.

2.6.7.3 Nutrient Enrichment/Septic Systems

Nutrients are necessary for productive aquatic ecosystems, but in high concentrations, they can adversely affect aquatic life through excessive plant growth in streams, lakes, and coastal waters, leading to depleted dissolved oxygen, and fish kills. Nutrient concentrations in water generally are related to land use in the upstream watershed or the area overlying a ground-water aquifer (Mueller and Helsel 1996).

Total nitrogen loadings from rivers to coastal estuaries increased from 1900-1994 as a result of increasing use of nitrogen-based fertilizers, the increase in wastewater from municipal and industrial sewage, increased use of de-icing salts on roads, and increased atmospheric deposition of nitrogen. Nitrogen is released into the atmosphere from numerous sources, including fossil fuel combustion, agricultural fertilizers, and animal manure. Large amounts of municipal and industrial sewage were released directly to surface waters in the U.S. as late as the mid-1960s (U.S. Department of the Interior 1968). Aquatic concentrations of chloride, and nitrate, increased during the 20th century due to municipal and industrial wastewater discharges (Jaworski and Hetling 1996). Specific conductance and dissolved chloride concentrations increased in rivers in New England over this same period (Bell 1993, Kulp and Bohr 1993, Strause 1993, Toppin 1993, Trench 1996) likely due to the increased use of de-icing salts on roads. The passage of the Federal Water Pollution Control Act in 1972 resulted in significant improvements in wastewater treatment throughout New England. Although wastewater practices are much improved, wastewater discharges and septic system effluent can still affect water temperature and increase nutrient concentrations such as nitrogen in aquatic ecosystems.

Total phosphorus in northeast waters increased until the 1960s for many of the reasons listed above for total nitrogen, but has decreased since then because of a ban on phosphate-containing detergents (Roman et al. 2000). Water quality of three northeast rivers over the last century showed decreasing concentrations of sulfate and total phosphorus; but increasing concentrations of nitrate and chloride (Robinson et al. 2003).

2.6.7.4 Contaminants

Contaminants, including trace metals such as copper, lead, mercury, zinc, cadmium, and nickel; organic chemicals such as PCBs; polynuclear aromatic hydrocarbons (PAHs); and pesticides all have been found to adversely affect the quality of surface water and sediments in the northeastern U.S. (Maine Department of Environmental Protection, written communication, 1992). Contaminants accumulate in sediments, are consumed by bottom-feeding organisms, and then work their way up the food chain. Contaminants inhibit the growth, reproduction, and immune systems of aquatic organisms.

Anthropogenic sources of contaminants include industrial effluent, municipal wastewater, runoff from agricultural, urban and forested areas, and atmospheric deposition. Human activity speeds the rate at which naturally occurring metals leach into the environment. Concentrations of lead, mercury and zinc within stream-bottom sediments were positively correlated with urban land use in the Hudson Connecticut, Housatonic and Thames River Basins from 1992-1994 (Breault and Harris 1997, Wall et al. 1998). PCBs were used in electrical equipment until the 1970s and now persist in stream bottom sediments and biota. PAHs, released into the atmosphere by the incomplete combustion of wood, coal, petroleum products, were also found in stream bottom sediments in the Hudson River Basin, and were found to be correlated with the location of current or historic point sources (Wall et al. 1998).

2.6.7.5 Roads

As noted above in section 2.6.7.3 specific conductance and dissolved chloride concentrations have increased in rivers in New England over the 20th century (Bell 1993, Kulp and Bohr 1993, Strause 1993, Toppin 1993, Trench 1996). This is likely due to the increased use of de-icing

salts on roads. Contamination of aquatic systems by road runoff and de-icing chemicals, such as rock salt and magnesium chloride, can substantially impair water quality and affect a variety of organisms.

2.6.7.6 Herbicides/pesticides

Pesticides and herbicides can enter surface water bodies through overland runoff or enter groundwater through infiltration. Concentrations and types of pesticides detected in New England streams depended upon landuse (Garabedian et al. 1998). Diazinon was most often detected at the urban sites while atrazine, metolachlor, and simazine were most frequently detected at sites draining agricultural land. Atrazine was detected at 88 percent of the agricultural sites, was frequently detected in combination with other pesticides, and was the most commonly detected pesticide overall. The high percentage of insecticides detected in urban basins reflects the use of these products on lawns. While wide spectrum pesticides such as DDT have been banned in the U.S., contemporary insecticides are soluble in water and can be toxic to fish. Herbicides, while less toxic to fish, can kill aquatic plants (Welsch 1992). Pesticides degrade slowly, accumulate over time, and can be detected in fish tissue even when the concentrations are too low to be detected in stream bottom sediments.

2.6.7.5 Hydrologic Alterations

Hydrologic alterations have many causes, including increases in impervious surface area associated with development; installation of culverts; water withdrawals and discharges; the installation of water storage and release from impoundments; and straightening and/or confining a channel within an urban area. These alterations can directly affect the aquatic flow regime, and water quality. Alterations can also affect geomorphology over the long term by dampening peak flows, changing patterns of aggradation and degradation, constricting a meandering channel, and causing local scour. Hydrologic alterations such as impoundments can restrict the movement of aquatic organisms.

2.6.7.5 Erosion

Although soil erosion is a natural aquatic process, human activities can accelerate erosion to the point where it is harmful to ecosystems. Excessive suspended sediments can block sunlight and impair photosynthesis; reduce visibility and the ability of fish and other organisms to feed; raise water temperatures and reduce dissolved oxygen; clog and damage filter feeders and fish gills. Human activities which accelerate erosion include the creation of impervious areas which increase the volume and speed of stormwater runoff and erode stream banks. Construction and forestry projects that leave the soil exposed can also accelerate erosion.

2.6.7.5 Beaver Engineering

Beavers can also cause hydrologic alterations in aquatic ecosystems. They create wetlands and marshy areas that provide habitat for hundreds of species by building dams and engineering wetlands. The near-elimination of beavers by the beginning of the 20th century led to a drying of wetlands and an expansion of meadows and forests to the detriment of marshy species. Beaver ponds and dams function as water filters that capture silt and pollutants, and result in improved water quality downstream. Despite beavers' reputation for causing flooding, their marshes help buffer adjacent landscapes against the effects of flash floods. Their network of channels, dams,

and sloughs slows and holds water in the landscape longer, insulates areas from drought, and recharges underground aquifers. (Wilkinson, T., National Parks Conservation Association, written communication, 2004). Despite the many positive effects of beaver engineering, beavers create challenges for park managers when they occur at an excessive level. Beavers topple trees, flood roads, crops, and woodlands, create impoundments, flood riparian areas, and alter riparian vegetation.

2.6.7.6 Invasive Exotic Species

The presence and persistence of invasive exotic flora and fauna is a serious issue at all NETN parks. Invasive exotic species can displace native species in wetlands and riparian areas. Invasive plants contribute to the channeling (narrowing and deepening) of streams and the eutrophication and depletion of dissolved oxygen of lakes and ponds. Invasive exotic species can also profoundly affect visitor experience, by changing the quality of water used for swimming, boating, fishing, and drinking. The most prolific invasive exotic flora within NETN freshwater aquatic habitats are common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), and curly pondweed (*Potamogeton crispus*). Bass and bluegill are the primary invasive exotic fauna present in NETN systems (Mather et al. 2002); these species have the potential to displace native fish communities through habitat disruption, competition for resources, and/or predation. Other exotic invasive exotic species such as zebra mussels have the potential to become management issues if introduced into NETN parks.

2.6.7.7 Visitor Use

Visitor use could be one of the most important stressors acting within boundaries of NETN parks. The NPS aims to preserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations as a part of its mission. It is a complex task to balance the NPS mission of preserving resources unimpaired, while also having the public enjoy, and be educated and inspired by those resources. Stressors to freshwater aquatic resources related to visitor use include the extraction of natural resources (such as fish), erosion stemming from multiple uses, road runoff and contamination stemming from the many roads that allow visitor access within the parks, and the introduction of invasive species carried in by visitors. While little research has been done relating visitor use to the condition of the aquatic resources, the potential for this use to cause stress to natural ecosystems is great, especially when compounded with other stressors such as climate change and invasive exotic species.

2.7 Intertidal Resource Conceptual Model

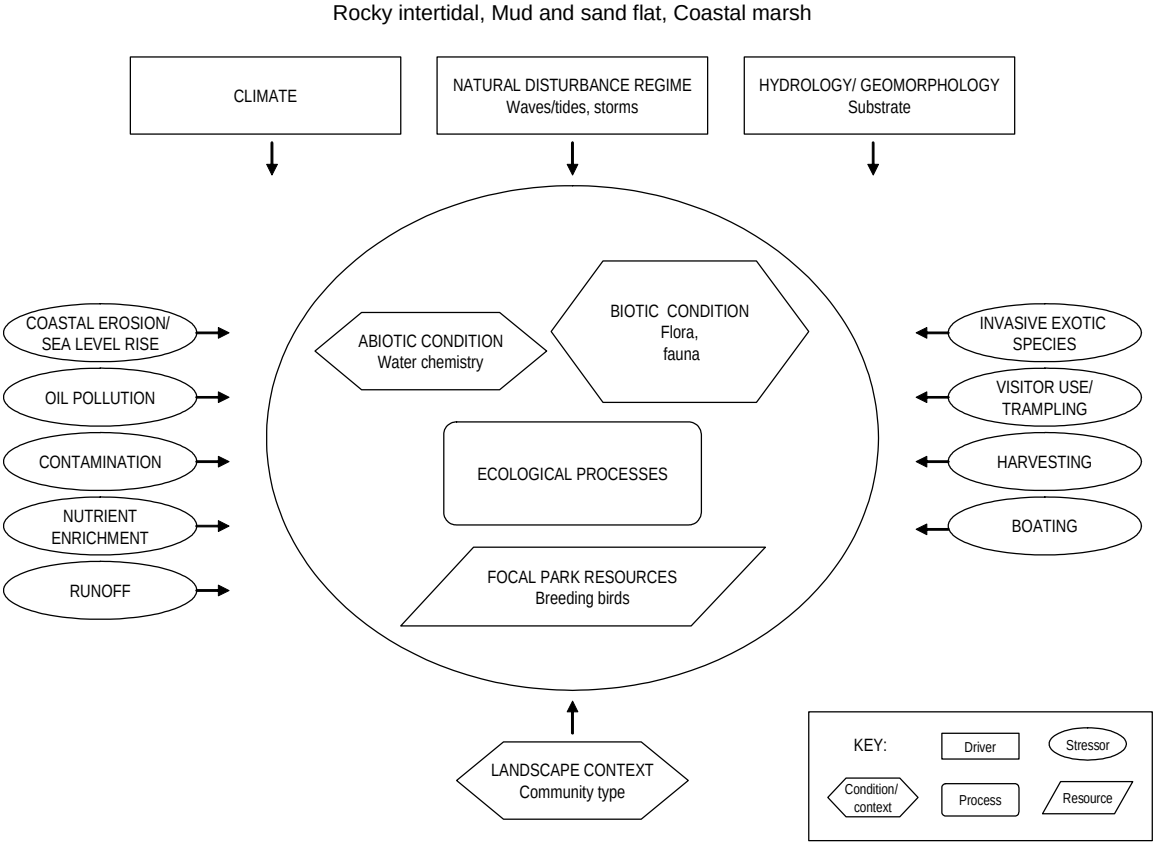
In this section we present the intertidal resource conceptual ecological model as a diagram (Figure 2.4) accompanied by the following narrative describing our current understanding of intertidal system components and their interactions.

2.7.1 Ecological Systems

Intertidal systems are present in two NETN parks - Acadia and the Boston Harbor Islands. Unlike intertidal systems further south, the systems in these northeastern parks are primarily rocky intertidal systems, with limited areas of mud and sand flats, coastal marsh systems. This is

due to the geologic history of New England (Bertness 1999). Pleistocene glaciation scoured sediments from New England shores, so the New England coast lacks the extensive barrier beach and salt marsh habitats which develop from sediment accumulation and are common south of Boston Harbor. These ecological systems are summarized briefly below, and described in greater detail within Appendix C. The extent of these systems within ACAD and BOHA is summarized below in table 2.3, and visually presented in the park-based conceptual models within Appendix K.

Figure 2.4 Conceptual Model for NETN Intertidal Systems



2.7.1.1 Rocky Intertidal

The rocky intertidal systems which dominate the New England coast are characterized by strongly fluctuating physical conditions, caused by tides, and creating stark patterns of vertical zonation from the low to high tide zones. The rocky substrate offers less respite from extreme temperatures, desiccation, and buffeting waves than soft-sediment shores, and thus favors algae and invertebrates which can withstand these physical challenges. The rocky intertidal food chain is supported by high plankton productivity, harvested by filter-feeding barnacles and mussels, and also by benthic algae, consumed by herbivorous snails and urchins. Dominant predators include shell-drilling snails and starfishes in open-coast habitats, and crabs in bays and estuaries. The intertidal zone also provides food for many species of birds, and haul-out habitat for harbor seals. Native species composition of northeastern rocky intertidal habitats is relatively depauperate due to Pleistocene extinctions caused by climatic extremes and changes in sea level associated with glaciation (Stanley 1986). This has left these systems vulnerable to exploitation

by invasive exotic species. Many classic experiments in community ecology have been undertaken in rocky intertidal habitats because their zonation and relatively simple communities make them attractive for study (Connell 1961, Lubchenco 1978, Roughgarden et al. 1985); thus patterns of disturbance, recruitment, competition, and trophic relationships are relatively well understood in these well-studied systems. Within the upper intertidal zone, physical stress is a primary driver of ecological pattern, while life in the lower intertidal zone is controlled by consumer pressure and competition.

Table 2.3. *Approximate extent (hectares) of NatureServe intertidal ecological systems present within NETN parks. Within NETN, intertidal systems are only present within ACAD and BOHA. This information will be updated and improved after completion of the I&M mapping inventory of BOHA. Area listed in larger boxes spanning more than one ecological type indicates that current information does not distinguish between related types.*

Ecosystem Category		NatureServe Ecological System Type	ACAD	BOHA
Intertidal wetlands	Coastal marsh	Acadian Coastal Salt Marsh	38	33
		Acadian Estuary Marsh		
	Rocky shore	North Atlantic Cobble Shore		387
		North Atlantic Rocky Intertidal	74	
	Mud and sand flats	North Atlantic Intertidal Mudflat	7	
		North Atlantic Tidal Sand Flat		

2.7.1.2 Mud and Sand Flats

Intertidal mud and sand flats form in protected areas along the coast where diminished water movement allows the accumulation of fine sediments. In contrast to rocky intertidal habitats, organisms inhabiting mudflat systems interact more dynamically with the substrate, burrowing or growing into the mud and respectively increasing or decreasing habitat stability by doing so. Sediments in mudflats possess strong vertical biogeochemical gradients due to subsurface anoxic conditions caused by submersion. Often, a sharp boundary demarcates the anoxic zone, below which anaerobic decomposition processes and chemotrophic bacteria prevail (Howarth and Teal 1980). Intertidal mudflats often support large predator populations - birds, fishes and crabs which feed on worms, clams, and small crustaceans. Food supply in mudflats is strongly linked to water movement processes, which supplies both plankton for filter-feeding bivalves, and detritus for deposit-feeding organisms.

2.7.1.3 Coastal Marsh

Like mudflats, coastal marshes also develop in protected coastal habitats, often the mouths of estuaries, where fine sediment accumulation enables colonization by halophytic vegetation. Salt marsh systems are successional, beginning with colonization by smooth cordgrass, *Spartina alterniflora*, which binds additional sediment to create higher marsh habitat above tidal influences and subject to colonization by additional species (Redfield 1972). Disturbance from winter ice-scour is common in northern salt marshes, and resets this successional development. Like rocky intertidal systems, salt marshes exhibit strong elevational zonation due to gradients of physical stress and competition, though in salt marshes physical stressors (from anoxia and salt)

drive ecological patterns at lower elevations while competition dominates at higher elevations more suitable for plant growth. Plant survivorship in salt marshes has been shown to be enhanced by positive neighbor interactions, such as increased oxygenation of soils and reduced salt stress, and these effects are considered important in these systems (Howes et al. 1986, Hacker and Bertness 1999). Salt marsh food chains are typically detritus-based, with consumers primarily feeding on plant detritus. Salt marshes provide numerous benefits, serving as protected nursery grounds for many species of fish, shrimp and crabs, providing feeding and nesting area for birds and mammals, buffering shorelines from flood and storm damage, limiting erosion, and reducing coastal nutrient loading by providing sinks for excess nitrogen and sulfur. Despite these numerous benefits, New England coastal marshes have been extensively grazed, drained, filled, developed and otherwise altered (Dreyer and Niering 1995). Of particular note are coastal road and rail corridors built during the early 20th century, which filled many marshes and isolated many remaining marshes from coastal water flows.

2.7.2 Ecosystem Drivers

2.7.2.1 Climate

The temperate climate of this region is described above within section 2.3.

Basic climate data is critical for understanding and interpreting intertidal zone species change. Important measures include air and water temperature, precipitation, and wind speed and direction. In addition, snow/ice depth within the intertidal zone may significantly control species composition and abundance. Storms and tides are important agents of disturbance within the intertidal zone. The frequency and duration of storm events should be monitored via measures of climate or landscape pattern. Wave energy data may be available from existing offshore wave gauges, deployed by agencies such as NOAA.

2.7.2.2 Hydrology/Geomorphology

Substrate composition is the primary determinant of community type within the intertidal zone, and thus is also an important indicator of biotic change. While bedrock and boulder substrates exhibit little change over time, cobble, gravel, sand and mud substrates change both seasonally and over the long-term, in response to storms and sometimes human use.

2.7.3 Ecological condition

2.7.3.1 Water Chemistry

Water chemistry is directly related to changes in floral and faunal distribution within the intertidal zone. This basic information supports the establishment of relationships between physical and biological processes, and informs management decisions. Important measures of water quality in the intertidal zone include water temperature, conductivity/salinity, and water clarity.

2.7.3.2 Intertidal Flora and Fauna

Determining and monitoring species richness, abundance and distribution of intertidal macro-algal vegetation is critical to understanding status and trends of the intertidal zone. Monitoring should focus on attached flora, which form the base of the community within the rocky intertidal

zone. Much of this vegetation is perennial; some, like *Ascophyllum* can live for decades and exhibit low recruitment and slow growth (Bertness 1999). Ephemeral green algae such as *Ulva* flourish in high nitrogen waters and thus indicate eutrophication. Invasive species like *Codium* are invading the northeast, and may be indicative of climate change and other disturbance.

Species richness, abundance, and distribution of intertidal fauna can also be valuable information for long-term monitoring, though fauna exhibit higher spatial and temporal variability than flora. Monitoring of select intertidal fauna may be a particularly useful indicator of visitor trampling. Potential faunal groups that would be useful indicator taxa include key predators, such as gulls, Eider ducks, and green crabs; mussel populations, which may be indicative of trophic change or offshore disturbance from salmon pens; or the invasive Asian shore crab, which is an aggressive invader capable of thriving in cold Maine temperatures. Periwinkles may also be useful taxa for monitoring. Intertidal faunal monitoring should consider seasonal patterns.

2.7.4 Focal Park Resources

The intertidal zone of the Boston Harbor Islands provides breeding habitat for several species of birds; these are focal park resources.

2.7.5 Landscape Context

A well-documented map of intertidal community types, including substrate type and biotic assemblage, is essential for understanding current conditions and monitoring long-term change.

2.7.6 Stressors

Pollution, invasive exotic species and harvesting are the most serious threats currently facing New England intertidal systems, though sea level rise and shoreline erosion are expected to seriously threaten these systems over the next century. Visitor impacts are also important stressors on NETN intertidal systems.

2.7.6.1 Pollution/Contamination

Pollution from many sources significantly impacts intertidal systems. Oil pollution, from urban and suburban runoff and from tanker spills, is a chronic problem (Suchanek 1993). Some seaweeds and many crabs, gastropods and amphipods are very sensitive to oil pollution. Sewage runoff is likewise a pervasive nearshore stressor, which can cause coastal eutrophication and toxic algal blooms that negatively affect native species (Valiela et al. 1992). Toxic, anti-fouling paints routinely applied to the undersides of boats are another widespread, chronic stressor; these paints leach into nearshore waters and affect many intertidal organisms.

2.7.6.2 Invasive Exotic Species

Invasive exotic species are widespread within New England intertidal systems. The native species composition of these systems was depleted by extinctions caused by Pleistocene glaciation (Stanley 1986), leaving these systems particularly vulnerable to invasion by exotic species. Historic and modern shipping practices have supplied a steady influx of invaders, including some of the most common species now encountered (Carlton 1985). These factors have drastically altered New England intertidal community composition over the last few

hundred years and probably caused many local extinctions, but we lack knowledge of intertidal community composition prior to European exploration and settlement. Within New England salt marshes, the exotic reed *Phragmites australis* has been particularly destructive, out-competing native marsh plants and altering habitat. New invasive exotic species continue to arrive and spread.

2.7.6.3 Harvesting

Throughout the history of human settlement in New England, humans have harvested a wide variety of intertidal organisms. While some species are now protected from over-harvesting, collection of many species continues. Shellfish and bait worms are harvested from soft-bottom flats within both ACAD and BOHA. Rockweed and knotted wrack (*Fucus* and *Ascophyllum*) are harvested for lobster-packing. In addition, many species are commercially harvested from the subtidal zone, immediately adjacent to the intertidal zone; these species include sea cucumbers, lobsters, and sea urchins. Some data describing the intensity of harvesting activity could be compiled from exiting data collected by local regulatory agencies, such as state agencies and town shellfish wardens.

2.7.6.4 Sea Level Rise/Shoreline Erosion

Sea level controls the distribution and spatial pattern of intertidal habitats, thus as sea level rises, the boundary of intertidal habitat types will shift. Currently, sea level is rising about 2-4 mm/yr along the New England coastline due to global warming, and this rate of change is predicted to accelerate. Sea level data can be compiled from data collected by existing tide gauges in Boston and Bar Harbor operated by NOAA. In addition to sea level rise, shoreline erosion can cause change in the distribution of intertidal communities by loss of physical habitat via movement of intertidal sediment. Shoreline erosion is caused by a variety of natural and anthropogenic forces, including storm wave energy and boat wakes. Shoreline change could be monitored in part as change in mapped distribution of intertidal community types.

2.7.6.5 Visitor Use

Finally, the rocky and sandy intertidal zone is a frequently visited habitat and often the focus of park-led interpretive tours at both ACAD and BOHA. Visitor use at both these parks can cause substantial trampling and removal of resources. In order to truly understand biotic change within the intertidal zone, it will be important to monitor visitor use, and more specifically, visitor intensity, location, and activity, such as walking, boating, or recreational shell-fishing. Trampling and other visitor use impacts are likely to be localized within areas accessible to parking or ferry. Some data on visitor use may be available for compilation from existing park efforts.

Chapter 3: Selecting and Prioritizing Vital Signs

3.1 Introduction

A primary component of the Inventory and Monitoring (I&M) program phased reporting process is to select and prioritize vital signs for parks and networks. Networks are base funded to design and implement monitoring in parks but it is not possible, nor would it be meaningful, to monitor everything of interest to parks, scientists, or the public. The Vital Signs program, by definition, is charged with identifying the key components of park ecosystems that can be tracked over time and indicate ecological condition. To achieve the goal of selecting the subset of vital signs that will be monitored from a comprehensive list of possible monitoring variables, an objective process for selecting and then prioritizing vital signs must be established and adhered to. This chapter outlines the Networks' process for selecting and prioritizing vital signs, how the Network decided on the process, and the resulting list of Network vital signs.

3.2 Strategy for selecting Vital Signs

Early in program development, the Network established a core science team representing expertise in forest ecology and vegetation science, aquatic ecology, wetland ecology, amphibians, ornithology, biogeochemistry, conservation biology, and ecological data management. The primary responsibilities of this team were to draft, select, and prioritize vital signs. The Network also solicited the expertise of the Technical Steering Committee and required Board approval to decide on the vital sign (VS) selection process and, ultimately, the proposed list of Network vital signs.

The Network prioritized and selected potential vital signs using a sequential peer review process. The core science team first drafted a list of more than 150 potential vital signs, (Appendix L) representing the five major categories identified in NETN conceptual ecological models: 1) system drivers and stressors; 2) components of biotic and abiotic integrity; 3) ecological processes; 4) landscape context; and, 5) focal park resources. This was a comprehensive list -- targeted at ecological systems present within the Network that spanned spatial, temporal, and ecological scales of organization.

We reviewed and prioritized this list with a multi-stage process, comprised of 1) initial review by the Network core science team, which initiated the list of potential VS and criteria for selection (see table 3.1); 2) external peer-review by a group of more than 40 scientists and park managers; 3) review by the Network Technical Steering Committee, composed of both external scientists and NPS staff; 4) additional review and revision by the Network core science team; and, 5) National I&M Program Review and Approval (in process).

3.2.1 Technical Steering Committee Guidance

As part of this planning process, the Technical Steering Committee met 18-19 November 2003 to discuss and determine the Network's vital sign selection strategy. The results of this meeting provided the framework for how the Network would proceed through phase 2 of the vital signs process. Following I&M program guidance, the Technical Steering Committee agreed that vital signs would be selected from priority park issues based on ecological systems and park

conceptual models (See Chapter 2). The Technical Committee and the core planning team agreed that integrating the fiscal reality of the Network's vital signs base funds early in the selection process would reduce the need for re-selecting vital signs post-prioritization. To that end, we developed three hypothetical staffing and implementation scenarios and projected the cost of each scenario over a 10 yr period (Appendix M). The results of this exercise were used throughout the vital signs selection process to provide the fiscal "side-boards" for subject matter experts when providing recommendations for what a core monitoring program should contain.

The Technical Committee decided that an effective and focused means for selecting vital signs required establishing workgroups based on the four major ecological system groups present within NETN parks: terrestrial, aquatic, wetland and intertidal ecological systems. These workgroups were responsible for identifying priority issues related to the general ecological systems and providing guidance on selecting vital signs that would track changes in resource condition over time.

Three possible strategies for how to select vital signs were presented to the Technical Steering Committee for review to determine the best approach for prioritizing vital signs.

Strategy 1: Park Meetings/Expert Workshop/Technical Committee Review

Decisions made by consensus

- Step 1: Park-by-park meetings held with core science team
  - Present park conceptual models that integrate ecological systems and park priority resource issues and threats
  - Select indicators with park staff and core team
  - Document why specific indicators were not selected
- Step 2: Hold an expert workshop to review and select indicators
  - Experts review indicators selected by parks and core team
  - Technical steering committee member responsible for identifying subject matter experts (3-5) to participate in review
  - Core team summarizes results of park based and workshop indicator selection processes
- Step 3: Technical steering committee reviews draft chapter
  - Responsible for soliciting reviews from other subject matter experts

Strategy 2: Expert Workshop/Technical Committee and Park Review

Decisions made by consensus

- Step 1: Hold a subject matter expert workshop to review and select vital signs
  - Core team develops park based conceptual models and lists of potential vital signs for each workgroup
  - Workgroups meet at breakout sessions to select vital signs
  - workshop attendees include;
    - subject matter experts
    - core science team
    - park staff
  - Core team summarizes results and workshop indicator selection processes

- Step 2: Technical Steering Committee reviews draft chapter
  - Responsible for soliciting reviews from other subject matter experts
- Step 3: Re-convene Network parks to present selected vital signs
  - make necessary adjustments based on park input
  - workshop attendees include;
    - park staff
    - core science team
    - Technical Steering Committee
    - Board of Directors

Strategy 3: Delphi

Decisions made by ranking and scoring lists of vital signs

- Step 1: Core team develops database of potential vital signs
  - Database sent to wide audience
    - Parks;
    - Subject matter experts;
    - technical committee;
    - Network staff
  - Participants score indicators based on management significance, ecological significance, and legal/policy mandates
  - Network summarizes ranks to identify priorities based on highest scoring indicators
- Step 2: Technical steering committee reviews ranked indicators
  - Incorporates feasibility, cost, and measurability into selection criteria
  - Indicators re-scored
- Step 3: Core science team summarizes results.

The Technical committee thought that park-by-park meetings with the core team would take too long and would not advance the selection of vital signs for the network. The committee did not like the idea of the Delphi type scoring procedures and thought that using consensus and subject matter experts was the most effective approach for vital signs selection. The Technical Committee recommended Strategy 2 where subject matter work groups would meet for a 2-day workshop to select vital signs and work group decisions were made by consensus. The core science team developed the necessary materials for the workshop, generated a list of potential participants based on the 4 system based workgroups and facilitated each workgroup.

After the workshop, the results were summarized (Appendix N), reviewed, and then presented to a meeting of the parks, Technical Steering Committee, and the Network Board of Directors. Finally, the Network and the core planning team drafted the Phase 2 report for national I&M program approval. This process is summarized in Figure 3.1.

3.2.2 Network Vital Signs Selection Workshop

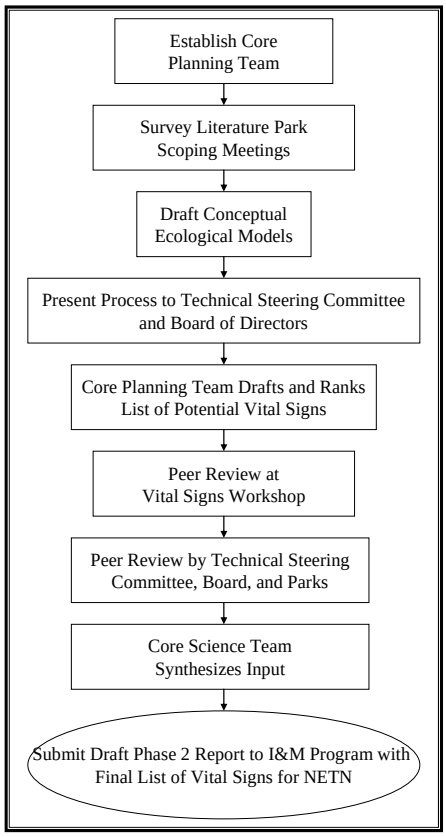


Figure 3.1. *Planning process for NETN vital signs selection.*

The core science team organized and hosted a 2-day workshop at the Acadia NP Schoodic Education and Research Learning Center where subject matter experts provided the first tier in peer review to select vital signs for NETN. The workshop was a primary step in planning the NETN vital signs monitoring program to select the most critical indicators that should be monitored.

The purposes of the workshop were to:

- Review and revise the proposed list of vital signs;
- Generate monitoring questions that address park management issues;
- Prioritize indicators for long term monitoring that provide quantitative information about the integrity of park ecosystems;
- Identify the best measures for each vital sign; and,
- Discuss thresholds of ecological integrity for each measure.

In preparation for the workshop, the core science team generated a comprehensive list of potential vital signs based on the conceptual ecological models that identified priority park natural resources, resource condition, and stressors (Table 3.1). We organized vital signs using major categories suggested by the conceptual models as a means to ensure that selected vital signs were comprehensive and would track changes to ecological condition and park stressors over time (Chapter 2). We established linkages among the comprehensive vital signs list and the stressors and/or natural resource issues to assist in the initial prioritization of vital signs.

***Table* 3.1** *Proposed list of vital signs for NETN prior to the workshop. Initial priority rating based on vital signs rating criteria and ranked by the core science team. H = high, M = medium, L = low. X's in cells indicate the workgroup for each vital sign. Potential vital signs shown in bold are those with initial medium or high rankings.*

Category	Potential Vital Sign	Initial Priority	Terrestrial	Wetland	Aquatic	Intertidal
Climate	**Basic climate**	M	X	X	X	X
Disturbance	Natural disturbance regime	L	X	X	X	X
Hydrology/ Geology	**Hydrology**	M		X		
	Morphology - channel	M			X	
	Morphometry - lake	M			X	
	Spring/seep	L			X	
	Substrate composition	M			X	X
	Tidal patterns	M				X
	Water quantity	H			X	
Abiotic condition	**Core water chemistry**	H		X	X	X
	Sediment characteristics	L		X		
Biotic condition	Bats	L	X			
	Demography - dominant vegetation	H	X			
	Focal taxa - additional	M	X			X
	Focal taxa - Amphibians	H		X		
	Focal taxa - Fish	L			X	
	Focal taxa - Forest interior breeding birds	M	X			
	Focal taxa - Obligate lepidopterans/odonates	L	X			
	Focal taxa - Red backed salamander	M	X			
	Focal taxa - Soil biota	L	X			

Category	Potential Vital Sign	Initial Priority	Terrestrial	Wetland	Aquatic	Intertidal
	Focal taxa - Spring ephemerals	M	X			
	Focal taxa -Grassland birds	M	X			
	Rare plant community	M	X	X		
	Species composition - fauna	H	X	X	X	X
	Species composition - flora	H	X	X	X	X
	Species migration - climate change	L	X			
	Species of concern	L	X	X	X	X
	Stand structural retention - legacy features	M	X			
	Stand structure	M	X			
	Vegetation condition	H	X	X		X
	Water quality - algal biomass	H		X	X	
	Water quality - clarity	H			X	
	Water quality - lake trophic status	M			X	
	Water quality - macroinvertebrates	M		X	X	
	Water quality - microorganisms	H			X	
	Water quality - nutrient loading	H		X	X	
	Water quality - total dissolved ions	M			X	
	Water quality - total organic carbon	L			X	
Ecological process	**Nutrient cycling**	M	X	X	X	X
	Phenology	M	X	X	X	X

Category	Potential Vital Sign	Initial Priority	Terrestrial	Wetland	Aquatic	Intertidal
	Productivity	M	X	X		X
	Soil respiration	L	X			
	Trophic dynamics	M	X	X	X	X
Focal park resource	**Amphibians**	M	X	X		
	Breeding birds	M	X	X		X
	Harbor seals	L				X
	Mandated Species	M	X	X	X	X
	Viewshed	L	X	X		X
Landscape context	**Landcover**	M	X	X	X	X
	Landscape buffer	H	X	X	X	X
	Landuse	H	X	X	X	X
	Park boundary	M	X	X	X	X
Management	**Land management**	H	X	X	X	
	Park infrastructure	M	X	X	X	X
	Trail network	M	X	X	X	X
	Visitor use	M	X	X	X	X
	Wetland restoration	M		X		
Stressor	**Acidic deposition & stress**	H	X	X	X	X
	Beaver engineering	H	X	X	X	
	Contamination	M	X	X	X	X
	Dark night sky	L	X	X		X
	Feral animals/free-ranging pets	M	X	X		X
	Fertilizer use	M	X	X	X	X
	Heavy metal contamination	H	X	X	X	X
	Herbicide/pesticide use	M	X	X	X	X

Category	Potential Vital Sign	Initial Priority	Terrestrial	Wetland	Aquatic	Intertidal
	Hunting	M	X	X		
	Hydrologic alteration	M		X	X	X
	Invasive exotic species	H	X	X	X	X
	Noise	L	X	X		X
	Ozone	M	X	X		
	Roads	H	X	X	X	X
	Septic systems/wastewater discharge	M		X	X	X
	Shoreline erosion/sea level rise	H			X	X
	Soil erosion	H	X		X	
	UVB	M	X	X	X	X
	White tailed deer herbivory	H	X	X		

3.2.2.1 Initial Vital Signs Ranking

Prior to the workshop, the core science team pre-ranked each vital sign based on four ranking criteria to provide a draft list of vital signs that were then reviewed and revised by the workshop participants (Table 3.1). We listed all potential vital signs in a matrix indicating the stressors or issues addressed by information from each vital sign. This matrix provided a means by which we could determine how useful each vital sign would be in monitoring park ecological integrity and aided in our initial prioritization. The science team ranked all vital signs prior to the workshop using a four-tiered rating scheme (Table 3.2). For all the vital signs, each planning team member assigned a score from 1-3 (low = 1, medium = 2, high priority = 3) for each of the four categories. We summed the scores and used the average to assign a high, medium, or low rank to each vital sign (Appendix L). Discussion within the workgroups at the Vital Sign Selection Workshop was used to refine these initial rankings, focusing on vital signs with high and medium initial priority scores (from 10-12, and 8-10 respectively). Vital signs with low initial priority scores (< 8) were presented at the workshop but were unlikely to be included in program implementation unless workgroup members specifically advocated elevating their priority.

Table 3.2 *Rating criteria used by the core planning team and the vital signs workshop participants to rank Network vital signs.*

Rating Category	Rating Criteria
Management Significance & Utility	-relevant to assessment questions and/or determining thresholds -sensitive to and/or indicative of stress -not redundant unless improves performance -relative to determining quantitative thresholds -linked to management actions -widely applicable (e.g., useful for multiple purposes)
Ecological Relevance	-clear linkage to ecological function or integrity or specific resource -anticipatory -indicative of status of other resources
Feasibility of Implementation	-availability of standard, well-documented methods -lack of sampling impacts on indicator -rapid, cost-efficient and/or can be bundled with other indicators for measurement -easily measured with little equipment or specialized knowledge, and large sampling window -baseline data available -long-term data management feasibility
Response Variability	-low or controllable measurement error, high repeatability of measurement -temporal variability predictable and/or described -spatial variability understood or controllable -sufficient discriminatory ability

3.2.2.2 Workshop Process

The core science team developed the workshop materials in order to set the stage for identifying and prioritizing Network vital signs. We defined general ecosystem categories for the workshop that were representative of Network natural resources and identified potential vital signs prior to the workshop.

We established workgroups based on the following four ecological system groups:

- Aquatic resources (lakes, ponds, rivers, streams)
- Freshwater wetlands (forested wetlands, open/shrub wetlands, peatlands, vernal pools)
- Intertidal (cobble beaches, rocky intertidal, soft-sediments)
- Terrestrial (forests, open uplands, rocky coast, plantations, fields and old-field successional habitats)

The intertidal workgroup did not include systems already prioritized by the Northeast Coastal Barrier Network (i.e. salt marshes and estuaries). The Northeast Temperate Network will prioritize these systems in relation to all park ecosystems for both Acadia and Boston Harbor Islands. If salt marshes and estuaries are a high priority for these two parks, the Network will

implement the Northeast Coastal Barrier Network (NCBN) protocols for these systems to expand the standardized regional coastal monitoring program.

Workshop participants were selected based on knowledge of these general system types, regional issues, and park management concerns and divided into the four workgroups (Table 3.3).

Table 3.3 *Workshop participants and workgroup assignments. Participants listed in bold were workgroup leaders.*

Workgroup	Participant	Affiliation
Aquatic	Beth Johnson	NPS I&M Regional Coordinator
	Pam Lombard	USGS - ME/ NETN Partner
	Alan Ellsworth	NPS – Hydrologist
	Bob Breen	NPS - Acadia
	Michael Bank	Univ. Maine
	Jack Gibs	USGS
	Richard Evans	NPS - Delaware Watergap
	Robert M. Lent	USGS - ME/ NETN Partner
	Steve Kahl	Univ. Maine
	Bob Goldstein	USGS – ME
	Sarah Nelson	Univ. Maine
	Chris Waldron	USGS MA/RI
Intertidal	**Charles Roman**	NPS – CESU / NETN Technical Comm.
	Richard Bell	URI
	Karen Anderson	NPS
	Bruce Connery	NPS
	Susan Brawley	Univ. Maine
	Patricia Rafferty	NPS
	Robert Buchsbaum	Mass Audubon
	Larry Harris	UNH/Jackson Lab
Terrestrial	Andy Cutko	ME Nat. Heritage
	Bill Livingston	Univ. Maine
	Bob Kohut	Cornell University

	Dan Lambert	Vermont Institute of Nat. Science
	Don Faber-Lagendoen	NatureServe/ SUNY-ESF/ NETN Partner
	Geri Tierney	SUNY-ESF/ NETN Partner
	Kerry Woods	Bennington Forest
	Linda Gregory	NPS – Acadia
	Mary Foley	NPS
	Jim Comiskey	NPS I&M/MIDN
	Matt Marshall	NPS I&M – Penn State
Wetland	Fred Dieffenbach	NPS - I&M/ NETN
	Greg Shriver	NPS - I&M/ NETN
	James Gibbs	SUNY-ESF/ NETN Partner
	Allison Aldous	The Nature Conservancy
	Hilary A. Neckles	USGS Patuxent Wildlife Research Center
	John Swords	USFWS - Region 5
	David Manski	NPS – Acadia

In an attempt to have all four workgroups develop similar products, we generated step-by-step instructions to guide workgroups through the process, and captured all information in a database. The database was projected onscreen during each workgroup so all participants could view the list of proposed vital signs and keep track of all comments and revisions to the list during the workshop. The database was combined at the end of the workshop to present the high priority vital signs of the four workgroups. This provided an opportunity for workshop participants to see the overlap among workgroups and to ensure that all issues were considered.

The desired outcomes from the workshop were to generate:

- a prioritized list of vital signs with justification for why certain vital signs were selected as high priority and why others were determined to be medium or low priority;
- a set of management issues and monitoring questions that can be addressed by each vital sign; and,
- a list of the best measures available for monitoring each vital sign with references to existing protocols and partner organizations, and indication of the need to conduct a pilot study if existing data are not available.

The first step in the work group process was to determine if the proposed list of vital signs was complete. At this time work group participants were asked to add or subtract vital signs and provide a justification for why. The second step was to determine if the pre-ranked category

(high, medium, or low) ratings were appropriate. It was during this portion of the workshop that vital sign ratings were changed, especially attempting to reduce the number of medium ranked vital signs. Once the workgroup agreed on the vital sign ratings the next step was to identify the following for each high priority vital sign:

- applicable management issues;
- applicable monitoring questions; and,
- mandatory and optional measures for each vital sign.

After competition of the workshop, the participants agreed on a final draft list of 27 vital signs (Table 3.4). A complete review of the workshop proceedings and a summary of the aquatic resource monitoring program are presented in Appendices N and O.

Table 3.4 *Twenty-seven high priority vital signs for Northeast Temperate Network Parks based on prioritization at the vital signs selection workshop. The number of workgroups (#WG's) that rated each vital sign as a high priority, and the parks where each vital sign applies to natural resource management decision making, are both shown herein.*

Category	High Priority Vital Signs	# WG's	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
Climate	Climate	4	X	X	X	X	X	X	X	X	X	X	X
Disturbance	Natural disturbance regime	1	X	X	X	X	X	X	X	X		X	X
Hydrology/ Geo-morphology	Hydrology	2	X	X	X	X	X	X	X	X	X	X	X
	Intertidal substrate composition	1	X		X								
	Lake morphometry	1	X			X				X			X
	Spring/seep distribution	1	X	X	X	X	X	X	X	X	X	X	X
	Stream morphology	1	X	X		X	X	X	X	X	X	X	
Abiotic condition	Water chemistry	3	X	X	X	X	X	X	X	X	X	X	X
Biotic condition	Fish community composition	1	X	X		X	X	X	X	X	X	X	X
	Intertidal community type	1	X		X								
	Zooplankton community – lakes	1	X			X				X			X
	Species composition – fauna	3	X	X	X	X	X	X	X	X	X	X	X

Category	High Priority Vital Signs	# WG's	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
	Species composition – flora	3	X	X	X	X	X	X	X	X	X	X	X
	Water quality - trophic status	1	X			X				X			X
	Macro-invertebrate community comp. in streams	1	X	X		X	X	X	X	X	X	X	X
	Vegetation community structure and demography	1	X	X		X	X	X	X	X		X	X
	Focal Taxa – breeding birds	1	X	X	X	X	X	X	X	X		X	X
Landscape context	Landcover/ Landuse	3	X	X	X	X	X	X	X	X	X	X	X
Management	Visitor impacts	2	X	X	X	X	X	X	X	X	X	X	X
	Harvesting	1	X		X	X							
Stressor	Atmospheric deposition	3	X	X	X	X	X	X	X	X	X	X	X
	Contamination	3	X	X	X	X	X	X	X	X	X	X	X
	Invasive exotic species	4	X	X	X	X	X	X	X	X	X	X	X
	Shoreline erosion/Sea level rise	1	X		X								
	Ozone	1	X	X	X		X	X	X			X	X
	White-tailed deer herbivory	1	X	X		X	X	X	X	X		X	X
	Nutrient enrichment	2	X	X	X	X	X	X	X	X	X	X	X

The majority of vital signs (60%) were identified as a high priority by only 1 work group and only 2 vital signs (7%) were identified as a high priority by all four workgroups (Table 3.4).

3.2.3 Re-convening and review

The vital sign list from the workshop was then further refined and integrated into the national framework for review by the Technical Committee and parks. Presenting NETN vital signs

within the national framework, rather than in our initial categories, allows easier comparison of vital signs across networks; thus from this point forward we present NETN vital signs within this framework. Following the Vital Signs Selection Workshop, the core science team identified specific areas in which additional scientific input was necessary to select appropriate Vital Signs and the best measures to quantify those Vital Signs. NETN solicited additional scientific input from a select group of additional scientific experts in the fields of biogeochemistry and remote sensing to address lingering questions in those areas. A list of those scientists and their responses are summarized in Appendix P.

Using this additional input, the core science team reviewed and revised the list of vital signs from the workshop to better define some vital signs and incorporate the NETN list into the national framework. The revised list expanded the "species composition – fauna" and "species composition – flora" vital signs into more specific vital signs associated with specific conservation targets or ecosystems. We presented a total list of 38 vital signs and 26 high priority vital signs to the Technical Steering Committee, the Board, and the parks for review on 19 August 2004.

3.3 Proposed list of Northeast Temperate Network Vital Signs

The Technical Steering Committee, the Board, and the parks reviewed the proposed list of vital signs and approved a "short-list" of 23 vital signs that the Network should develop as part of Phase 3. Below, we present a summary of the 23 high priority vital signs with justification for why these are an important component of a long-term monitoring program in the Northeast. The NETN vital signs are comprehensive in scope and include multiple stressors, drivers, ecological processes, biological condition and biotic response indicators (Table 3.5).

Table 3.5 *Proposed list of 23 high priority ("short-list") Northeast Temperate Network vital signs presented in the 3-tiered National Framework with potential measures.*

Level 1	Level 2	Level 3	Vital Sign	Potential Measures
Air and Climate	Air Quality	Ozone	1) Ozone	Atmospheric ozone concentration (synthesize existing data), (*foliar injury to indicator species*)
		Wet and dry deposition	2) Acidic deposition & stress	Wet and dry deposition rates (synthesize existing data), soil nitrification, soil base cation availability, soil Ca:Al ratio, streamwater ANC, streamwater nitrate concentration (*Total deposition rates including occult*)
			3) Contaminants	Heavy metal deposition (synthesize existing data)
	Weather and Climate	Weather and Climate	4) Climate	Air temperature, precipitation by type, relative humidity, total solar radiation, wind speed, wind direction, snow water equivalent, snow depth

Level 1	Level 2	Level 3	Vital Sign	Potential Measures
			5) Phenology	First flowering of sensitive plant species, first amphibian call dates, length of growing season, ice out/in dates for lakes and ponds
Geology and Soils	Geo-morphology	Coastal / oceanographic features	6) Shoreline geomorphology	Relative surface elevation (salt marsh), shoreline position
Water	Hydrology	Surface water dynamics	7) Water quantity	Water depth, water duration, lake levels, streamflow, groundwater levels/inputs, spring/seep volume, sea level rise
	Water Quality	Water chemistry	8) Water chemistry	Stream water nitrate, stream alkalinity/ANC, water temperature, % dissolved oxygen, specific conductance, pH, turbidity, color, salinity, chlorophyll a, photosynthetically active radiation (PAR)
		WQ Nutrients	9) Nutrient Enrichment	Turbidity, #septic systems in and near park, algal biomass, total and dissolved phosphorus, amount fertilizer used within park, residential density near park
		Aquatic macroinvertebrates and algae	10) Streams - macroinvertebrates	Diversity of selected communities and sub-communities
Biological Integrity	Invasive Species	Invasive/Exotic plants	11) Exotic plants - early detection	Presence/absence
		Invasive/Exotic animals	12) Exotic animals - early detection	Presence/absence
	Focal Species or Communities	Intertidal communities	13) Intertidal – vegetation	Diversity of salt marsh and rocky intertidal community and subcommunities, exotic species extent
		Wetland communities	14) Wetland – vegetation	Diversity of community and subcommunities, exotic species extent, beaver activity
		Forest vegetation	15) Forest – vegetation	Community diversity (all layers), tree species, rates of mortality and regeneration, stand structural dynamics, tree basal area by species, canopy condition, snag density, coarse woody debris volume; percent exotic species
		Vegetation communities	16) High elevation – vegetation	Diversity of community and subcommunities; percent exotic species
		Fishes	17) Fish – lakes and streams	Diversity of community and subcommunities; percent exotic species.

Level 1	Level 2	Level 3	Vital Sign	Potential Measures
		Birds	18) Breeding birds	Diversity of forest, high elevation, grassland/scrub, old-field, and coastal communities and subcommunities
		Amphibians and Reptiles	19) Amphibians and Reptiles	Diversity of wetland/vernal pool communities and subcommunities (*red-backed salamander abundance in forests*)
		Mammals	20) White-tailed Deer herbivory	Browse intensity in forests
Human use	Visitor and Recreation Pressure	Visitor usage	21) Visitor Usage	Number of visitors by location and activity, trampling impacts, soil erosion
Ecosystem Pattern and Processes	Land Cover Land Use	Land cover and use	22) Land Cover / Ecosystem Cover	Change in area and distribution of ecological systems (including intertidal communities) within park and adjacent landscape, patch size distribution, patch connectivity, patch fragmentation, extent of major disturbance, ecological integrity index by ecological system
			23) Land Use	Road network extent, nearby housing development permits, proportion of nearby lands in various categories of human uses, % impervious surface in watershed, nearby human population density, landscape buffers

3.3.2 Summary of Northeast Temperate Network Vital Signs

3.3.2.1 Ozone

Ozone pollution is an important stressor of terrestrial vegetation with clear ecological relevance. Atmospheric ozone concentration data is available from CASTNET network and other sources, and need only be acquired by NETN. Ozone stress on specific indicator species should be monitored within some NETN parks to provide the necessary information to better ascertain the ecological effects of ozone. Ozone monitoring is presently ongoing in Acadia and Saratoga. Other Network parks are within 35 miles of an ozone monitoring station and therefore it is not necessary to install any new ozone monitoring stations. This is not true, however, for large segments of the Appalachian Trail where portable ozone monitors may need to be deployed. Acadia is a Class 1 air quality park and therefore has a GPRA goal to maintain or improve park air quality. The Network will work with Acadia to ensure that necessary levels of ozone monitoring within the park are maintained to provide park managers with information to meet the air quality GPRA goal (Appendix B). The Network will also work with Air Resources Division to summarize existing ozone monitoring data and make these data available to parks.

3.3.2.2 Atmospheric Deposition and Stress

Atmospheric deposition is a stressor to both terrestrial and aquatic systems throughout the NETN and has been implicated in the decline and/or degradation of many ecological systems in the

region. Estimates of atmospheric deposition are critical for understanding water chemistry and stress (Likens and Bormann, 1974). Swain et al. (1992) estimated that 90% of the mercury entering remote lakes in Voyageurs National Park (Minnesota) was derived from atmospheric deposition. Acidic deposition stresses terrestrial vegetation and alters system functioning and biogeochemical cycles. Compiling acidic deposition data is important for any long-term monitoring program because this stressor has demonstrated negative affects on water chemistry and can alter wetland function and biogeochemical processes. Acid deposition is a pervasive stressor to all network parks and affects all ecological systems within parks.

3.3.2.3 Contamination

Contamination, including heavy metal contamination, is of high ecological relevance to both terrestrial and aquatic resources due to the accumulation of trace elements and organic compounds, especially in aquatic organisms. Accumulated contaminants bioaccumulate and can cause fitness reductions or death in many taxa. Baseline conditions of heavy metals within parks may be occurring at high levels "naturally," and responses may be difficult to interpret without long-term data.

3.3.2.4 Climate

Climate is a key driver of natural systems affecting system structure, composition, and function. Climate data can provide a background explanation for changes or variation in other vital signs. Measures of climate such as precipitation and temperature are critical to understanding the ecological condition of aquatic and terrestrial resources and biota (Hynes, 1975; Poff, 1997). Monitoring this basic variable will provide a long-term record of the stress associated with climate change. While management applications related to climate are limited, climate data is useful for ruling out other causes for system responses. The Network should cooperate with existing snow cover monitoring programs to obtain annual snow cover trends. These measures should minimally include snow depth and snow cover duration because of the relationship between winter precipitation and seasonal wetland hydrology.

3.3.2.5 Phenology

Biotic responses to climate change are likely one of the most important conservation issues in the coming decades. By establishing baselines of phenological indictors in Network parks, we should be able to document biotic response to climate change in Network parks, should it occur. This vital sign is especially important for the Appalachian Trail, effectively a 2,100 mile long transect along the entire east coast. The Appalachian Trail traverses gradients of latitude and elevation that make it ideal in examining climate-change associated shifts in biological processes. Moreover, it includes ecosystems, such as alpine areas, predicted to be highly vulnerable to climate change.

3.3.2.6 Shoreline change/sea level rise

Sea level is an important physical parameter that controls the distribution and spatial pattern of intertidal habitats. As sea level rises, the boundary and extent of intertidal habitat types will shift. Sea level is presently rising at a rate of about 2-4 mm/yr along the New England coastline and is predicted to accelerate in response to global warming. Sea level is presently measured by NOAA tide gauges in Boston, Massachusetts and Bar Harbor, Maine. Shoreline erosion results

in the movement of intertidal sediments and change in biotic communities. Storm wave energy is an important factor inducing shoreline erosion. Boat wakes are thought to be a significant human-induced process that can increase shoreline erosion. A study to evaluate the impact of boat wakes on shoreline geomorphologic processes at BOHA is presently underway. Shoreline types should be monitored. This may be best accomplished by the substrate-type mapping identified in the "substrate type" high priority vital sign.

3.3.2.7 Water quantity

Information about water quantity is necessary for the interpretation of other vital signs such as eutrophication, sediment processes, or contaminants because stream discharge is used in calculating annual loads and annual watershed yields. Water quantity determines the physical extent and volume of aquatic habitat at the parks. Numerous factors affect water quantity including, precipitation, evapotranspiration, water withdrawals, and ground water recharge. Hydrologic conditions are extremely important for wetland structure and function. Hydrology affects most abiotic factors, which in turn affect the biotic condition of the wetland. Without basic hydrologic information, it is not possible to interpret the condition of any wetland resources and this is therefore, a high priority for any wetland monitoring.

3.3.2.8 Water chemistry

Water chemistry directly addresses one of the inventory and monitoring objectives: to detect change in the status of physical, chemical, or biological attributes or vital signs of the ecosystem. It is an essential indicator to any long-term aquatic monitoring program (Gilliom and others, 1995). It is widely applicable, and critical for interpreting the biotic condition, and ecological processes of a resource. Water chemistry affects the bioavailability of contaminants, and the metabolism of aquatic species. For example ionic conditions affect osmoregulation (Hoar and Randall 1969) and contaminant uptake (Sinley and others, 1974; Luoma 1989; Spry and Weiner 1991), dissolved oxygen and temperature affect metabolic rate (Hoar and Randall 1969). Successful reproduction requires the appropriate chemical conditions for fertilization and development of eggs and larvae (Holtze and Hutchinson 1989). Water quality parameters are sufficiently well known that abnormal conditions and trends can be recognized or determined statistically. Information from basic water chemistry measures can be directly related to the condition of a wetland and may be correlated with other wetland vital signs. In order for causal relationships between physical and biological processes to be fully understood, it is necessary to obtain basic water chemistry measures in wetlands.

3.3.2.9 Nutrient enrichment

The negative effect of nutrient enrichment in wetlands, and other waters, is well documented. Habitat quality can be adversely impacted from increased nutrient inputs, anoxic conditions can arise, and changes to the biotic community can occur. Excessive nutrients can affect the wetland plant communities by: 1) shifting species composition from dominance of species that uptake nutrients slowly to those that exploit rapid pulses of nutrients; 2) triggering algal blooms that can shade out submersed aquatic plants; and, 3) causing dead plant material to accumulate faster than it can decompose (Adamus et al. 2001). Wetlands exposed to long-term nutrient enrichment tend to have lower plant species richness than reference wetlands. Bogs and nutrient poor wetlands are most sensitive to the negative effects of nutrient enrichment.

3.3.2.10 Stream macroinvertebrates

Invertebrate community taxa richness and composition is a highly relevant vital sign in streams because macroinvertebrates integrate their physical, chemical, and biological environment like fish, however, they do so in a shorter temporal period than fish -- most invertebrate life cycles are accomplished in a single year vs. multiple years for fish. Therefore invertebrates may provide a "first response" vital sign. The integration is manifest in the taxa richness and composition. Macroinvertebrate community composition has been used to evaluate water quality and aquatic resources (Hilsenhof, 1987; Lenat, 1993). Collection of invertebrate samples is relatively easy. Numerous protocols exist (Lazorchak and others, 1998; Moulton and others, 2002). For direct collections from natural stream substrates, two people can collect a sample in about an hour using standard equipment. U.S. EPA recommends nets with a 595/600 micron mesh (Environmental Monitoring and Assessment Program, Lazorchak and others, 1998). For indirect collections of artificial substrates or natural substrates placed in the stream for colonization, the collection time is less, but an initial site visit is necessary to insert the sampler. The analysis, counting and identification, is not a trivial matter and can take up to a day per sample. The identification of invertebrate taxa requires specialized training or a specialty laboratory (Moulton and others, 2000). Several invertebrate multimetric environmental indices are available for invertebrate data. The USGS has an Invertebrate Data Analysis System which calculates over 130 metrics available for use (Cuffney, 2003).

3.3.2.11/12 Exotic plants and animals – Early detection

The presence and extent of invasive exotic species is a critical management concern at all parks in the network. Parks would benefit from quick identification and removal of new invasive species. Catastrophic consequences to native species can result if this vital sign is not addressed with loss of biodiversity and replacement of native flora and fauna. Invasive exotic species are a significant and growing stressor with clear ecological relevance to terrestrial systems within NETN. This vital sign has relatively strong management implications via exotic species control programs. Numerous groups of invasive exotic species are of concern within NETN, including terrestrial and wetland plants, insect pests and pathogens, earthworms, and intertidal and aquatic fauna. Routine surveys for the presence/absence of particular invasive species should be mandatory at all parks. Lists of non-native species with the potential to invade individual parks already exist in most states. These lists will identify the types of habitats to examine for invasion.

3.3.2.13/16 Vegetation – intertidal, wetland, forest, and high elevation

Vegetation structure and composition are highly relevant and applicable to ecosystem condition. Knowing the relative abundance, species composition and condition of the floral community provides an integrated measure of vegetation response to stress, in addition to basic information about habitat quality for a variety of other species. Moreover this information will allow proper interpretation of many other vital signs. Monitoring the vegetation community is also a good early detection strategy for management of invasive species. Monitoring flora is relatively low cost, sampling is efficient, and changes in plant species composition and abundance can be accurately measured. Knowledge of macro-algal species richness, abundance, and distribution is critical to an intertidal monitoring program. This may be an especially important indicator of trampling by park visitors.

Within forests, monitoring vegetation demography in the form of tree seedling and sapling regeneration provides an anticipatory indicator of future forest cover type as well as an integrative measure of the impacts of multiple stressors acting upon vegetation. Monitoring canopy and understory tree mortality provides another key integrative measure of multiple stressor impacts. Stand structure, or age class is indicative of both successional stage and habitat quality, and is a particularly useful measure in forest systems subject to silviculture. Legacy features, such as large trees, snags and coarse woody debris provide important habitat for birds, mammals, and herptiles, as well as decomposers, bryophytes and tree seedlings. These legacy features can be useful indicators of wildlife habitat within early- and mid-successional forests and those subject to silviculture. In addition, canopy vegetation condition is an integrative, anticipatory indicator of stress and change within canopy vegetation, which can in turn lead to changes in ecosystem function, habitat quality and stand composition. Canopy vegetation condition can be measured across the landscape using vegetation stress indices from hyperspectral remote sensing (Sampson et al. 2000, Miles et al. 2003); while hyperspectral imagery is currently expensive to obtain, this technology is advancing rapidly and should be considered for inclusion in the NETN monitoring program as affordable imagery becomes available. At the stand scale, canopy condition can be assessed visually onsite as the crown condition of each canopy tree in a plot.

3.3.2.17 Fish – lakes and streams

Fish species richness and composition is a highly relevant and applicable vital sign because fish communities integrate their physical, chemical, and biological environment through time (Tonn and others, 1983; Gurtz, 1993). The integration is manifest in the species richness and composition. Fish species composition can be evaluated with multimetric indices of biological integrity such as an IBI or by examination of species traits (Karr and others, 1986; Goldstein and Meador 2004). These indices evaluate the quality of the resource by rating the ecological structure and functional composition of the community. While normally a reference site is used for comparison, for the monitoring program, the initial sample will constitute the baseline condition for comparison. Certain metrics can be diagnostic of specific environmental changes (Karr and others, 1986).

3.3.2.18 Breeding birds

This faunal group provides a useful biotic indicator of the effects of habitat fragmentation, and is a highly visible and charismatic group that can garner much public support. The NPS has some management control over fragmentation within the park, though fragmentation outside the park boundary is a critical stressor for many of the smaller parks. The high elevation habitats on the Appalachian Trail maintain a unique bird community that may be especially sensitive and indicative of changes in atmospheric deposition and climate change. Partnering with existing forest, mountain, and coastal bird monitoring programs provides an opportunity to make inferences related to changes in resource condition beyond park boundaries. This vital sign provides an opportunity for NPS to coordinate with other organizations monitoring bird populations, and to incorporate volunteers into the I&M program. Many reference datasets and standard methods are available, and the response variability is fairly well understood.

3.3.2.19 Reptiles and amphibians

Reptiles and amphibians are important park resources associated with wetland communities and many species in this group are sensitive to changes in water quality, hydrology, landscape condition, and climate changes. Integrating wetland faunal groups into the NETN monitoring program will provide valuable partnership opportunities with two USGS programs: 1) the North American Amphibian Monitoring Program (NAAMP); and, 2) the Amphibian Research and Monitoring Initiative (ARMI). By integrating NETN monitoring initiatives with ongoing, nationally implemented programs, information can be interpreted at multiple scales and established protocols can be adopted.

3.3.2.20 White-tailed deer herbivory

White-tailed deer populations have reached historic high levels across much of the eastern US. The associated deer herbivory has high ecological relevance for vegetation regeneration and substantial management significance. Many parks in the southern part of the Network have already experienced substantial degradation in resource condition caused by extensive deer herbivory. By establishing present herbivory rates in Network parks and tracking changes over time, this vital sign will provide necessary information for supporting and improving related management activities.

3.3.2.21 Visitor Usage

Visitor impacts ranked high priority due to the clear management implications of this fundamental park issue. Many of the NETN parks are heavily visited, and thus allow substantial opportunity for adaptive management of visitor impacts. Impacts related to trail use were considered of particular importance to the Appalachian Trail, and poor trail maintenance could substantially impact resources along the trail. The intertidal zone, especially the rocky intertidal, is a frequently visited habitat and often the focus of park-led interpretive tours at both ACAD and BOHA. Trampling and removal of resources can be significant. It is important to monitor visitor use, and more specifically, intensity of visitors, location of visitor use, and activities of visitors (e.g., walking, resource removal). Trampling and other visitor use impacts are likely localized to areas with available parking (e.g., at ACAD) or ferry access (at BOHA).

3.3.2.22/23 Land Cover / Ecosystem Cover / Land Use

Landcover data provides key information on the status and extent of ecological systems; landuse data for the larger park region provides important information on habitat alteration and a wide variety of stressors associated with landuse change. Landcover change was identified as a high priority issue for all network parks due to concerns arising from the negative effects of habitat conversion adjacent to park boundaries. This is particularly true within NETN because many NETN parks are relatively small and potentially more affected by outside activities. At a watershed level, land use and land cover affect the quality of aquatic environments (Stauffer and others, 2000; Meador and Goldstein, 2003). An initial inventory of land use and land cover will provide context for the observed ecological conditions. If changes occur to this “baseline” condition, they can be interpreted in the context of land use or land cover at the watershed scale. Aquatic ecosystems respond to changes in landuse and this response has been documented in urban, agricultural, and forested environmental settings (Meador and Goldstein, 2003). This vital sign includes measures of “buffers” to natural systems and to the parks in general, which

are useful indicators of the degree of anthropogenic influence. Landcover is an important vital sign because it integrates across multiple spatial scales; from the buffer around an individual stand, to the larger ecosystem complex within a park's boundary, to the distribution of systems within the region. By implementing a basic landcover change monitoring program, inferences can be drawn between measurable changes in park ecological integrity and anticipated negative effects. Landcover change detection has been identified by most other networks within the Inventory and Monitoring Program, especially those in the eastern United States where human populations have increase dramatically during the last century.

Conclusions

These Vital Signs represent an integrated list of ecological processes, elements of biotic and abiotic condition, system drivers and stressors, landscape condition, and focal park resources. Moreover, these vital signs are directly relevant to the natural resource management issues of a majority of NETN parks (Table 9). Nineteen of the twenty-seven Vital Signs (70%) apply to nine (9) or more network parks, creating a framework to design a standardized, comprehensive monitoring program where protocols can be designed and implemented within the majority of network parks. The exceptions to a comprehensive, network-wide monitoring program occur with the intertidal and lake ecological systems where these resources add system specific vital signs that are not readily transferable to parks without lakes and intertidal communities (i.e. intertidal substrate composition, sea-level rise, lake morphometry, and zooplankton community).

All four workgroups identified climate, species composition flora/fauna, and invasive exotic species as high priority Vital Signs, but 59% (16/27) of high priority Vital Signs were identified by just 1 workgroup (Table 9). Three workgroups identified water chemistry, landcover/landuse, atmospheric deposition, and contamination as high priority Vital Signs and two workgroups identified hydrology, visitor impacts, and nutrient enrichment.

Table 3.6 *Proposed Northeast Temperate Network vital signs, measures, and parks where each vital sign will likely be implemented. Bold and numbered indicates core vital signs the network should include in the initial phase of protocol development. Shaded vital signs are a high priority and will be included over time as the cost of program development and implantation are realized. Vital Signs highlighted with an Asterisk* were added by the core planning team after the May 2004 workshop. Potential Measures in italics will be investigated for inclusion during Phase 3 but may require pilot studies or further evaluation.*

Level 1	Level 2	Network Vital Sign	Potential Measures	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
Air and Climate	Air Quality	**1) Ozone**	Atmospheric ozone concentration (synthesize existing data), (*foliar injury to indicator species*)	X	X			X	X	X			X	X

Level 1	Level 2	Network Vital Sign	Potential Measures	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
		2) Acidic deposition & stress	Wet and dry deposition rates (synthesize existing data), soil nitrification, soil base cation availability, soil Ca:Al ratio, streamwater ANC, streamwater nitrate concentration (*Total deposition rates including occult*)	X	X	X	X	X		X	X		X	
		Contaminants	Heavy metal deposition (synthesize existing data)	X	X	X	X	X	X	X	X	X	X	X
	Climate	**4) Climate**	Air temperature, precipitation by type, relative humidity, total solar radiation, wind speed, wind direction, snow water equivalent, snow depth	X	X	X	X	X	X	X	X	X	X	X
		5) Phenology*	First flowering of sensitive plant species, first amphibian call dates, length of growing season, ice out/in dates for lakes and ponds	X	X		X		X	X			X	
Geology and Soils	Geo-morphology	**6) Shoreline geomorphology**	Relative surface elevation (salt marsh), shoreline position	X		X								
Water	Hydrology	**7) Water quantity**	Water depth, water duration, lake levels, streamflow, groundwater levels/inputs, spring/seep volume, sea level rise	X	X	X	X	X	X	X	X	X	X	X
	Water Quality	**8) Water chemistry**	Stream water nitrate, stream alkalinity/ANC, water temperature, % dissolved oxygen, specific conductance, pH, turbidity, color, salinity, chlorophyll a, photosynthetically active radiation (PAR)	X	X	X	X	X	X	X	X	X	X	X
		9) Nutrient Enrichment	Turbidity, #septic systems in and near park, algal biomass, total and dissolved phosphorus, amount fertilizer used within park, residential density near park	X	X	X	X	X	X	X	X	X	X	X
		10) Streams – macro-invertebrates	Diversity of selected communities and subcommunities	X	X		X	X	X	X	X	X	X	
		Contamination	Concentrations of relevant EPA priority pollutant metals	X	X	X	X	X	X	X	X	X	X	X
		Lakes – zooplankton	Diversity of community and subcommunities	X										

Level 1	Level 2	Network Vital Sign	Potential Measures	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
Biological Integrity	Invasive Species	**11) Exotic plants – early detection**	Presence/absence	X	X	X	X	X	X	X	X	X	X	X
		12) Exotic animals – early detection	Presence/absence	X	X	X	X	X	X	X	X	X	X	X
	Focal Species or Communities	**13) Intertidal – vegetation**	Diversity of salt marsh and rocky intertidal community and subcommunities, exotic species extent	X		X								
		14) Wetland – vegetation	Diversity of community and subcommunities, exotic species extent, beaver activity	X	X	X	X	X	X	X	X	X	X	X
		15) Forest – vegetation	Community diversity (all layers), tree species, rates of mortality and regeneration, stand structural dynamics, tree basal area by species, canopy condition, snag density, coarse woody debris volume; percent exotic species	X	X		X	X	X	X	X		X	X
		16) High elevation – vegetation	Diversity of community and subcommunities; percent exotic species	X	X									
		17) Fish – lakes and streams	Diversity of community and subcommunities; percent exotic species.	X			X	X		X	X			X
		18) Breeding birds	Diversity of forest, high elevation, grassland/scrub, old-field, and coastal communities and subcommunities	X	X	X	X	X	X	X	X		X	X
		19) Amphibians and Reptiles	Diversity of wetland/vernal pool communities and subcommunities (*red-backed salamander abundance in forests*)	X	X	X	X	X	X	X	X		X	X
		20) White-tailed Deer herbivory	Browse intensity in forests	X	X		X	X	X	X	X		X	X
		Insects	Selected indicator groups (*Pollinators (bees), decomposers (burying beetles), carabids, ants, odonates, butterflies and skippers*)	X	X	X	X	X	X	X	X		X	X
Human use	Visitor and Recreation Pressure	**21) Visitor Usage**	Number of visitors by location and activity, trampling impacts, soil erosion	X	X	X	X	X	X	X	X	X	X	X
	Consumptive Use	Harvesting – Intertidal	Analysis of existing sources	X		X								

Level 1	Level 2	Network Vital Sign	Potential Measures	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
		Harvesting – Forestry	*(Board feet removed by species, cords removed by species)*				X							
Ecosystem Pattern and Processes	Land Cover Land Use	**22) Land Cover / Ecosystem Cover**	Change in area and distribution of ecological systems (including intertidal communities) within park and adjacent landscape, patch size distribution, patch connectivity, patch fragmentation, extent of major disturbance, ecological integrity index by ecological system	X	X	X	X	X	X	X	X	X	X	X
		23) Land Use	Road network extent, nearby housing development permits, proportion of nearby lands in various categories of human uses, % impervious surface in watershed, nearby human population density, landscape buffers	X	X		X	X	X	X	X	X	X	X
	Extreme Disturbance Events	Extreme Disturbance Events	Extent and duration of large scale natural and anthropogenic disturbances	X	X	X	X	X	X	X	X	X	X	X

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APPENDIX A: Development of an Ecological Integrity Scorecard

We can illustrate some of the features needed to go from vital sign selection to ecological integrity ranks and scorecards through the following sequence. First, a series of steps are taken to draft a list of potential vital signs and measures for the network and parks. These include the development of conceptual models and potential vital signs in Phase I, and a selection process for the high priority vital signs and measures in Phase II. The Vital Signs and measures can then be linked to specific ecosystem targets known to be in each park. In this way, assessments of trends in the VS and measures are tailored to the systems that they will be measuring.

In Phase III, the protocols for each measure are developed, including guidance on how frequently to remeasure a set of Vital Signs. By compiling information from baseline studies in the park, reference sites outside the park, and understanding the historic range of variability of vital signs and measures for each system, it may be possible to improve our understanding of how best to measure the vital signs. The same information can help develop a rating scale for each measure, whereby values are placed on a scale from Very Good to Poor (Figure 1). The reasoning behind the rating scale is that properly chosen measures should help inform managers' understanding of changes to ecological integrity. Changes in the values of the measures can be interpreted as

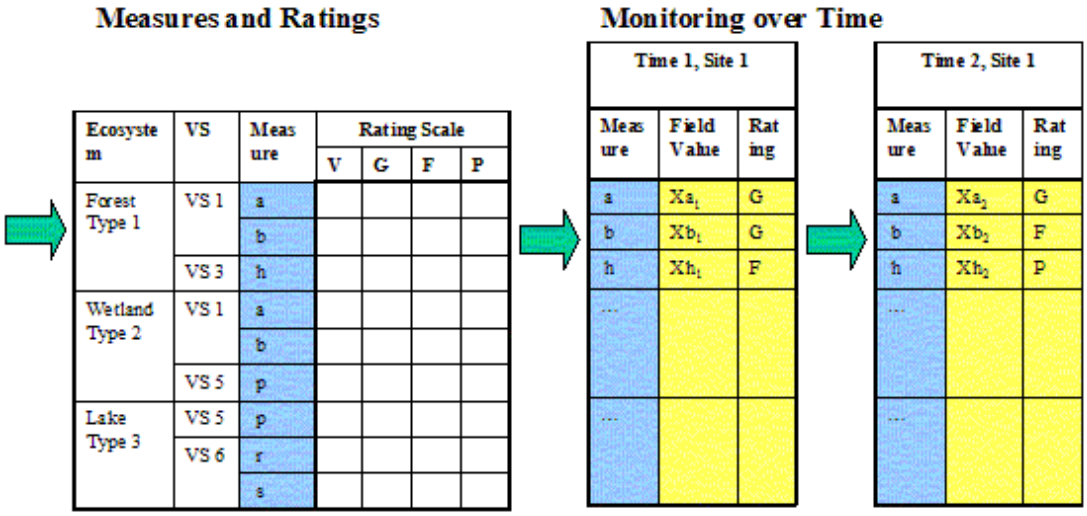


Figure 1. Illustration of the steps that could be taken in Phase III to establish ratings for the vital signs and measures. Ratings = V = Very Good, G = Good, F = Fair, P = Poor. For example, Measure a = exotic species percent cover, where A= < 1 % cover exotic species, B = 1-4 % cover, C = 5-20%, D = >20%. Ratings can also be ecosystem specific. E.g., percent exotic species cover may have different thresholds in a wetland ecosystem as compared to a terrestrial forest ecosystem, even though the method for collecting the field values may be identical across these systems.

improving or degrading ecological integrity. Note, however, that field values are still recorded and stored independently of the ratings, allowing for ongoing refinement of the rating scale.

Once measures and ratings are in place, it may be possible to aggregate the measures within a system, and perhaps across systems, to communicate trends into a kind of ecological integrity scorecard, (Karr and Chu 1995, Young and Sanzone 2002, EPA 2002a, NatureServe 2002, Parrish et al. 2003).

One example of such an approach is provided by NatureServe and the Natural Heritage Network, which has established and maintained an approach for documenting the integrity and viability of individual locations or occurrences of biodiversity elements, including species, ecological communities, and systems. Historically, this methodology has been based on a more qualitative, or expert-driven protocol (see Stein et al. 2000, Brown et al. 2004). This basic approach is now being advanced through the identification and use of key ecological attributes (= to vital signs) and quantitative indicators (measures) (Parrish et al. 2003, Brown et al. 2004). One or more indicators (measures) of each key ecological attribute (vital sign) are chosen and measured in the field. Thresholds among a range of indicator ratings describe the relative conditions of a given occurrence. Standard procedures can then be used to integrate the ratings for each indicator into overall scores for the relative ecological integrity of occurrences, from "poor – D" to "excellent – A." (Figure 2). The basic methodology is well established (NatureServe 2002, Brown et al. 2004), and is in wide use across the NatureServe network. Integrating this kind of approach into the Vital Signs program not only provides an effective communication tool but also aids in setting clear monitoring objectives and management thresholds, such as ensuring that no occurences fall below a B rank (Figure 2). It also provides the opportunity to compare the condition of park ecosystems with those in the surrounding region, thereby providing a regional perspective on park ecosystem condition that may further assist in management and monitoring prioritization.

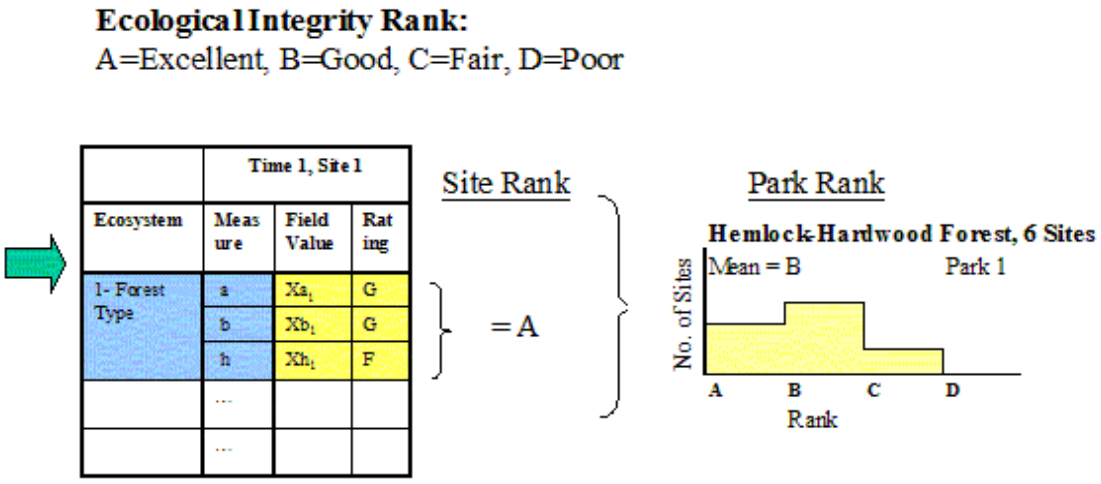


Figure 2. Illustration of how a Vital Signs program can be integrated into an Ecological Integrity Scorecard approach. Ratings are developed for individual measures, and field values can be assigned the rating score. These scores are then combined into an overall ecological integrity rank for the Ecosystem at a given site. All sites within a park for a given ecosystem type could also be rolled up into a park rank or displayed as a histogram. Note: Because field values for individual vital signs and measures are stored, they can always be assessed independently of the scorecard approach.

APPENDIX B: Summary of parks in the Northeast Temperate Network

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Acadia National Park (ACAD) Bar Harbor, Maine

Background

Acadia National Park was established in 1916 as the Sieur de Monts National Monument by Presidential Proclamation 1339. In 1919, the park was renamed Lafayette National Park, and in1929, the park name was again changed to what we known it as today, Acadia National Park. The 1929 legislation also authorized expansion of the park, and in 1986 the permanent boundary was established. Today, Acadia National Park protects 47,498 acres, including the highest rocky headlands on the Atlantic shore of the United States. The Park protects 30,300 on Mount Desert Island, 2,728 acres on Isle Au Haut, 2,194 acres on Schoodic Peninsula. Further, Acadia holds 10,452 acres in conservation easements and maintains interest in 1,110 other acres, all within the Acadian Archipelago of down east coastal Maine.

The glacial history that shaped Acadia is especially apparent in Sommes Sound, the inlet bisecting Mount Desert Island and the only fjord on the east coast of the United States.

Located in the Northeastern Coastal Zone ecoregion at 44 degrees latitude, the climate of Acadia is primarily influenced by maritime conditions. Special attention has been drawn to the role the islands play as nesting and wintering sites for a large number and wide diversity of bird species. The park supports breeding pairs of peregrine falcon (*Falco peregrinus*) and bald eagles (*Haliaeetus leucocephalus*) as well as the largest wintering population of harlequin ducks (*Histrionicus histrionicus*).

Acadia is located in a broad transition zone between southern deciduous and northern coniferous forests with local habitats ranging from seashore to mountaintop including old growth spruce forests, wetlands, and jack pine forests. Especially noteworthy natural resources in the park include old growth forests, sub-alpine communities, heaths, meadows and marshes, as well as a diverse flora and fauna. Nearly 20% (183) of the vascular plants known to reside in the park have been designated as locally rare or State-listed, and 6 are globally rare. These numbers might increase with additional floristic inventory. One third of the vascular plants found in the park (283 species) are exotic.

Acadia is designated a mandatory Class I federal area under the Clean Air Act, placing stringent constraints on facilities emitting air pollutants that may affect park resources.

Mission

The National Park Service at Acadia National Park protects and conserves outstanding scenic, natural and cultural resources for present and future generations. These resources include glaciated coastal and island landscapes, biological diversity, clean air and water, and a rich cultural heritage.

Acadia National Park also offers opportunities for high-quality non-consumptive recreation, education and scientific research.

Management Planning and Legislation

Document	Description
General Management Plan, 1992	"Management actions are directed to retain and enhance the unique qualities and resources of the park, particularly the natural resource base on which Acadia National Park was established."

APPENDIX B: Summary of parks in the Northeast Temperate Network

Document	Description
Resource Management Plan, 1998	The RMP discusses the natural resources within the park and the conditions and threats to these resources. Acadia is a "transition zone between temperate, deciduous, and northern coniferous forests overlaying glacially sculptured granite mountains with interspersed glacially scoured lakebeds and bounded by high rocky headlands. Noteworthy natural resources within the park include old-growth forests, sub-alpine communities, heaths and marshes, an exceptionally diverse flora, over 40 species of mammals, and documented sightings of over 300 bird species."
Enabling Legislation	"The topographic configuration, the geology, the fauna and the flora of the island, largely embraced within the limits of the Monument, also, are of great scientific interest." • July 8, 1916: Presidential Proclamation 1339 Establishes Sieur De Monts National Monument. • February 26, 1919: 40 Stat. 1778 Establishes Lafayette National Park from Sieur De Monts Monument. • January 19, 1929: 45 Stat. 1083 Authorized Park to accept donations of land in fee or easement, including buildings or money. Changed park name from Lafayette to Acadia. • May 23, 1930: 46 Stat. 377 Directs Navy to transfer Seawall radio station and 233 acres to the park. • August 24, 1935: 49 Stat. 795 Directs Navy to transfer Otter Cliffs Radio Station to the park; directs the park to transfer to the Navy a new radio site at Schoodic. • October 15, 1982: PL97-335 Established park boundary at Isle au Haut and required that a carrying capacity for IAH be established. • September 25, 1986: PL 99-420 Established park boundary (except Isle au Haut) and authorized acquisition of private lands within the boundary, deletion of tract outside the boundary by exchange, and authorized acquisition of conservation easements.

Natural Resources

Intertidal habitat	Terrestrial habitat	Aquatic/wetland habitat	Resource Issues
• Intertidal - 200 acres • Coastal salt marsh - 93 acres	• Spruce-fir-hardwood - 16300 acres • Pine-hemlock-hardwood - 2180 acres • Northern hardwoods - 775 acres • Pine forest - 1820 acres • Aspen-birch forest - 2870 acres • Rocky uplands - 8170 acres • Rocky coast - 290 acres • Cultural vegetation - 275 acres	• 14 Great ponds - 2370 acres • 10 Small ponds - 50 acres • Forested wetlands - 890 acres • Open/shrub wetlands - 660 acres • Peatlands - 690 acres • Springs/seeps	• Atmospheric deposition/ozone • Water quality • Contamination • External land-use/development • Roads • Visitor impacts, Boats • Harvesting • Land management • Deer, beaver, feral animals/pets • Invasive species • Climate change

APPENDIX B: Summary of parks in the Northeast Temperate Network

Intertidal habitat	Terrestrial habitat	Aquatic/wetland habitat	Resource Issues
			• Coastal erosion/sea level rise

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
Air and Climate	Air Quality	Ozone, acidic deposition and stress, air contamination	By 09/30/2005, air quality in Acadia National Park has remained stable or improved.
	Weather and Climate	Air temperature, precipitation by type, relative humidity, total solar radiation, wind speed and direction, snow water equivalent and depth	None established
Geology and Soils	Geomorphology	stream geomorphology, lake morphometry, substrate composition, shoreline change and sea level rise	None established
Water	Hydrology	Water depth and duration	None established
	Water Quality	Water chemistry, nutrient enrichment, contamination, aquatic macroinvertebrates	By 09/30/2005, Acadia National Park has unimpaired water quality
Ecosystem Pattern and Process	Land Use/Land Cover	Monitor changes within and adjacent to park	None established
	Extreme Disturbance	Harmful algal blooms	None established
Biological Integrity	Species of Special Concern	Intertidal, wetland, forest, and freshwater communities; forest vegetation; mammals, fish, and birds	By 09/30/2005, 100% of the 1999 identified Acadia National Park park populations [1 of 1] of the State of Maine listed species of special concern are at a scientifically acceptable level.
	Exotic Plant Species	Early detection of exotic species	By 09/30/2005, 55 (22%) of 55 acres of Acadia National Park's lands impacted by exotic vegetation (purple loosestrife) targeted by September 30, 1999, are contained.
	T&E Species	Not a selected vital sign or measure	By September 30, 2005, 1 (100%) of Acadia National Park's 1 identified populations of federally listed threatened and endangered species with critical habitat on park lands and/or requiring NPS recovery actions, as of 1999, have a stable status.
Human Use	Visitor Usage	Identify and monitor impacts associated with increased visitation	None established

APPENDIX B: Summary of parks in the Northeast Temperate Network

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
	Visitor Satisfaction	Not a selected vital sign or measure	By 09/30/2005, 98% of the park visitors to Acadia National Park are satisfied with appropriate park facilities, services, and recreational opportunities.
	Consumptive Use	Intertidal harvesting	None established
	Resource Knowledge	Not a selected vital sign or measure	By 09/30/2005, 12 of 12 primary Acadia National Park's primary natural resource inventories identified in a Resource Management Plan and General Management Plan are completed

Notes:

[1] Vital signs and measures were identified by park staff, network staff, and cooperators to fulfill the objectives of the National Park Service Inventory and Monitoring program, and may not directly parallel the needs and/or requirements of any established GPRA goals.

2 GPRA Goals may not exist for all vital signs and/or measures, and not all GPRA Goals are identified on this list.

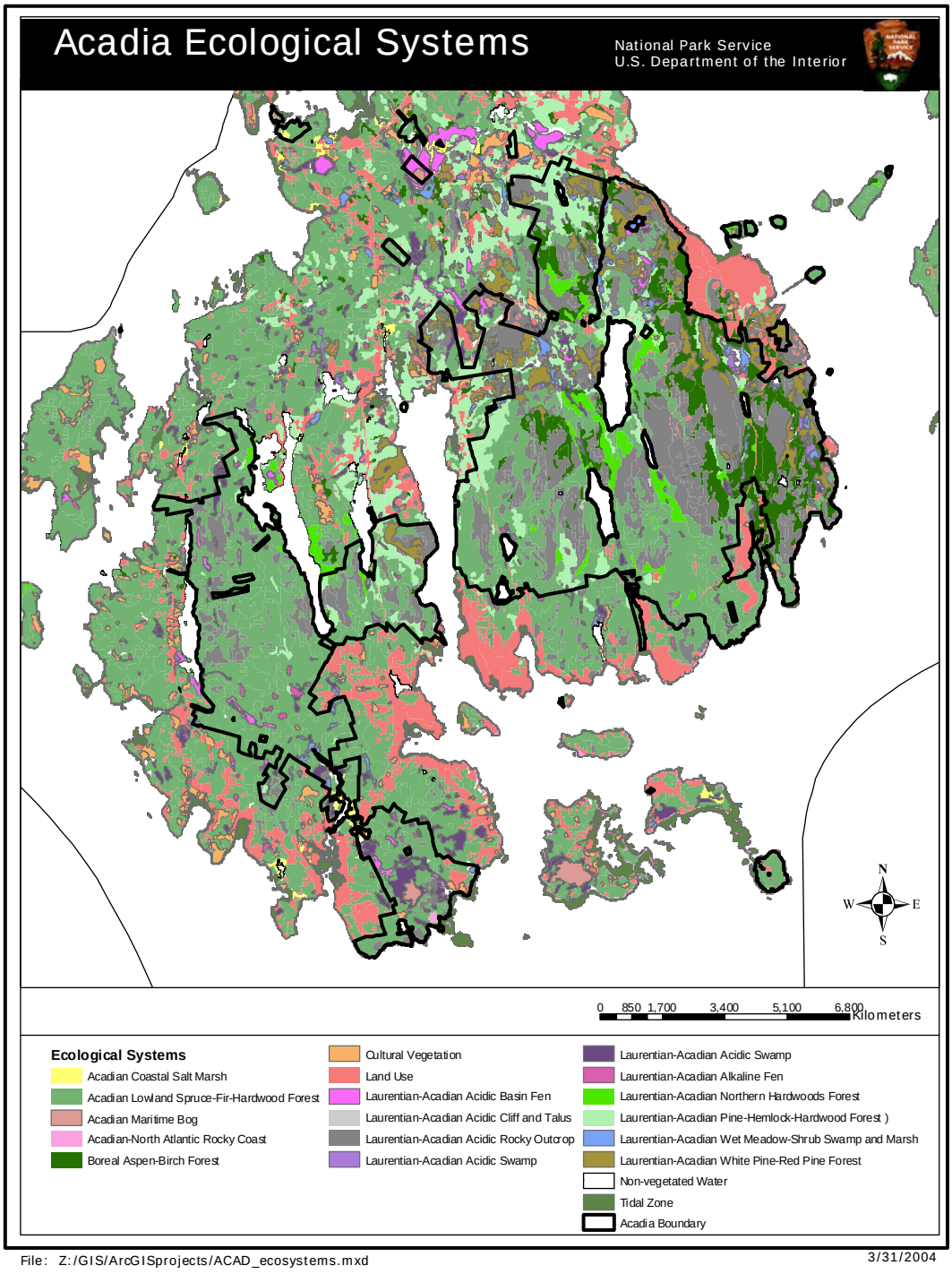


Figure B.1. Ecological Communities of Acadia National Park.

Appalachian National Scenic Trail (APPA), Maine-to-Georgia

Background

Established as the first National Scenic Trail by Congress with passage of the National Trails System Act in 1968, the Appalachian National Scenic Trail is the longest unit within the National Park System, stretching from Springer Mountain, Georgia to Mt. Katahdin, Maine. The Trail is administered cooperatively between the National Park Service and over 105 agencies and organizations. The trail passes through 14 states, 6 existing National Park Service units, 7 National Forests, and numerous state parks and forests.

The trail corridor averages 1000 feet in width, is comparable in size to Rocky Mountain National Park, and has visitation levels comparable to Yosemite.

The trail passes through five National Park Service Inventory and Monitoring networks. The portion of the trail that traverses the Northeast Temperate Network extends from Mount Katahdin to the Pennsylvania-Maryland border, comprising nearly 80% of the Appalachian Trail land that is owned by the National Park Service. This section of the trail covers 1,108 miles, includes 155,972 acres of state and federally managed lands, and has yielded 1,003 documentations of rare species occurrences and exemplary ecological communities (based on Natural Heritage Inventories). Within this section, the Trail traverses 4 ecoregions, incorporating habitats ranging from wetlands to alpine vegetation communities, and is representative of all terrestrial communities in the Northeast. The Trail contains some of the last remaining old growth forests in the East, some of which are subjected to high levels of human disturbance including air pollution, land cover change, and invasive species.

For the purpose of developing an inventory and monitoring program strategy, the five networks through which the trail passes have identified the Northeast Temperate Network as the lead Network for the Appalachian Trail. In return, the Northeast Temperate Network has committed to work with other networks, parks, and agencies to develop long-term ecological monitoring priorities for the entire corridor.

Mission

The Appalachian Trail Park Office fosters the Cooperative Management System of the Appalachian National Scenic Trail in order to preserve and provide for the enjoyment of the varied scenic, historic, natural and cultural qualities of the areas between the states of Maine and Georgia through which the Trail passes.

The Appalachian National Scenic Trail is administered primarily as a footpath in cooperation with the United States Forest Service and the 14 States encompassing the Trail, providing for maximum outdoor recreation potential as an extended trail and for the conservation and enjoyment of the nationally significant scenic, historic, natural, or cultural qualities of the areas through which the Trail passes. The Appalachian Trail is a way, continuous from Maine to Georgia, for travel on foot through the wild, scenic, wooded, pastoral, and culturally significant lands of the Appalachian Mountains.

Legislation

Document	Description
General Management Plan	In progress

Resource Management Plan	In progress
Enabling Legislation, 1968	"…trails so located as to provide for maximum outdoor recreation potential and for the conservation and enjoyment of the nationally significant scenic, historic, natural, or cultural qualities of the areas through which such trails may pass. National scenic trails may be located so as to represent desert, marsh, grassland, mountain, canyon, river, forest, and other areas, as well as landforms which exhibit significant characteristics of the physiographic regions of the Nation." • October 2, 1968: Public Law 90-543, the United States Congress passed the National Trails System Act that designated the Appalachian Trail as the nation's first national scenic trail. The Act gave overall responsibility for protection and management of the Trail to the Secretary of Interior, in cooperation with the Secretary of Agriculture; encouraged state agencies to pass similar legislation and take active steps to protect the Trail; and, authorized federal land acquisition as necessary to establish a permanent route and protective corridor surrounding the footpath. • March 21, 1978: Public Law 95-248, Congress amended the National Trails System Act by passing the "Appalachian Trail Amendments," that directed the National Park Service and USDA Forest Service to substantially complete protection of the Trail within three years. • March 28, 1983: Public Law 98-11, President Reagan signed an Amendment to the National Trails System Act that strengthened support for volunteers and volunteer-based organizations; refined the process for side and connecting trails; provided authority for administrative transfers; authorized whole tract acquisition with the consent of the landowner; provided the authority to use NPS unit authorities; defined trail uses; and, clarified that donated easements qualify as conservation tax exemptions.

Natural Resources

Air Quality

Because the Appalachian Trail traverses high elevations for much of its length, concerns about air quality typical of other parks are magnified for the Appalachian Trail. Because of human health concerns over extremely high ozone concentrations documented in the Great Smoky Mountains National Park (GRSM), three universities, in cooperation with NPS, have undertaken a study of lung function in hikers at high elevations at GRSM that will have similar application to hikers along the Appalachian Trail.

Fauna

There are five Federally-listed T & E animals in the Trail corridor.

Flora

At least 14 major forest types occur on the Appalachian Trail within the Appalachian Highlands. Lower elevations are dominated by oak and oak-pine forests with rich cove forest common in topographically sheltered areas. At higher elevations on the trail, northern hardwood species such as American beech, sugar maple, yellow buckeye and yellow birch become common. At the highest elevations, spruce-fir forest dominates, although much of the Fraser fir overstory has been eliminated by an introduced insect pest, the balsam wooly Adelgid. The trail also encompasses small unique habitats such as grassy balds, heath balds, mountain bogs, cliffs and rock outcrops, talus slopes and beech gaps. There are three Federally-listed endangered and threatened plants in the trail corridor.

Invasive Species

Because of the narrow corridor occupied by the Appalachian Trail, invasion by exotic plant species is a constant problem. At least 15 of the Trail's endangered species sites are threatened by invasive exotic plants.

The Appalachian Trail, in cooperation with the Southern Appalachian Man and the Biosphere Program, has undertaken a mapping and monitoring project for invasive exotic plants within the Appalachian Highlands Network.

Species of Special Concern

Most of the Trail's natural resource monitoring is carried out by volunteers, and the bulk of what has been done to date has focused on rare plant species.

Within the Trail corridor are populations of eight Federally-listed species:

- Carolina northern flying squirrel (*Glaucomys sabrinus coloratus*) – E
- Eastern cougar (*Felis concolor cougar*) (extirpated) - E
- Roan Mountain bluet (Houstonia (=Hedyotis) montana) – E
- Rock gnome lichen (*Gymnoderma lineare*) – E
- Shenandoah salamander (*Plethodon shenandoah*) - E
- Spreading avens (*Geum radiatum*) – E
- Spruce-fir moss spider (*Microhexura montivaga*) – E
- Virginia northern flying squirrel (*Glaucomys sabrinus fuscus*) - E

Nineteen globally rare community types have been identified to date on the Trail in the Appalachian Highlands Network, including red spruce/Fraser fir forest and Southern Appalachian mountain bogs as two of the most endangered ecosystems in the United States.

Unsustainable or Incompatible Uses

The Trail traverses many fragile, high-elevation communities. The challenge for trail managers is to provide a quality recreational experience for hikers, while minimizing damaging impacts to sensitive natural resources. Trail maintenance can also threaten rare species that grow immediately adjacent to the tread.

Water Resources

Maintaining waters in an unimpaired state represents a special challenge for the Appalachian Trail. Almost all sources of pollution are from offsite sources. Water quality is a major concern because long-distance hikers in remote areas of the Trail are dependent upon springs and creeks for their drinking water.

An inventory of the Trail's water resources is underway, and a water quality monitoring project is being developed.

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
Air and Climate	Air Quality	Ozone, acidic deposition and stress, air contamination	None established

APPENDIX B: Summary of parks in the Northeast Temperate Network

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
	Weather and Climate	Air temperature, precipitation by type, relative humidity, total solar radiation, wind speed and direction, snow water equivalent and depth	None established
Water	Hydrology	Water depth and duration	None established
	Water Quality	Water chemistry, nutrient enrichment, contamination, aquatic macroinvertebrates	By September 30, 2005, ATPO will define and inventory its water resources.
Ecosystem Pattern and Process	Land Use/Land Cover	Monitor changes within and adjacent to park	None established
Biological Integrity	Species of Special Concern	Wetland and forest communities; forest vegetation; mammals, fish, and birds	By September 30, 2005, 8 (50%) of the 16 globally rare plant and animal species on ATPO land are being monitored and are in stable or improving condition.
	Exotic Plant Species	Early detection of exotic species	By September 30, 2005, the locations and estimated acreages of invasive exotic plant species will be identified on 500 miles of the A.T., with concentration given to finding and documenting exotic species within natural heritage sites along the Trail.
	T&E Species	Not a selected vital sign or measure	None established
Human Use	Visitor Usage	Identify and monitor impacts associated with increased visitation	None established
	Visitor Satisfaction	Not a selected vital sign or measure	By September 30, 2005, 98% of trail visitors are satisfied with trail conditions and appropriate trail facilities.
	Resource Knowledge	Not a selected vital sign or measure	By September 30, 2005, 14 (100%) of 14 natural heritage inventories of rare, threatened and endangered vascular plants and some animal classes will be completed within the A.T. corridor in the 14 A.T. states.

Notes:

[1] Vital signs and measures were identified by park staff, network staff, and cooperators to fulfill the objectives of the National Park Service Inventory and Monitoring program, and may not directly parallel the needs and/or requirements of any established GPRA goals.

2 GPRA Goals may not exist for all vital signs and/or measures, and not all GPRA Goals are identified on this list.

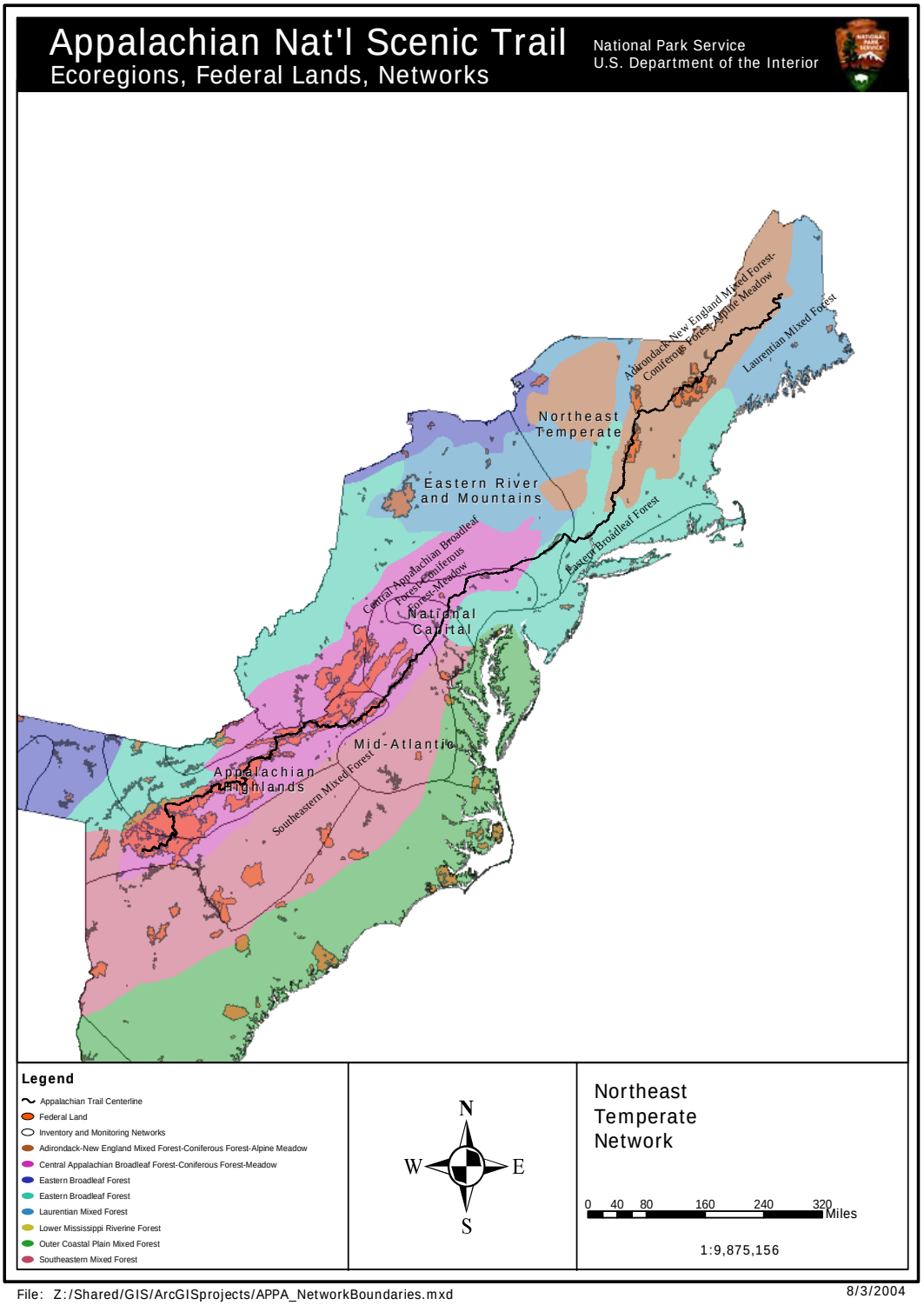


Figure B.2. Ecoregions and federal lands associated with the Appalachian Trail. The AT crosses 6 NPS units, 1 USFWS Refuge, 8 National Forests, and 67 state parks, forests and other lands.

Boston Harbor Islands, a National Park Area (BOHA) Boston, Massachusetts

Background

The Boston Harbor Islands became a unit of the National Park System in November 1996. The 34 islands (and former islands) of Boston Harbor, range in size from less than 1 acre to 214 acres and together encompass 1,600 acres of upland and another 1,500 acres of intertidal area throughout the harbor's 50 square miles. The Boston Harbor Islands are part of the only drumlin field in the United States that intersects a coastline. The islands have served numerous public and private uses and are a unique example of an island cluster intimately tied to the life of a city. Although within sight of a vibrant and densely populated city of Boston, Massachusetts, the islands offer the visitor a sense of isolation.

Located in the Northeastern Coastal Zone ecoregion at 42 degrees north latitude in Massachusetts Bay (part of the Gulf of Maine), the Boston Harbor Islands have a humid maritime climate characterized by a moderate annual range of temperatures and definite summer and winter seasons. The Massachusetts Bay was named an Estuary of National Significance in 1990, making programs to enhance the natural and scenic resources of the bay possible. The islands are located in a Class II Air Quality area, indicating that the state may permit a moderate amount of new air pollution as long as these increases do not exceed established baseline concentrations.

Despite massive human and natural alteration, the islands feature freshwater and saltwater marshes, dunes, numerous “heads” (the existing drumlins), ledges and cliffs, tidal flats and dense forest on larger islands, and nesting habitat as well as “haul out” habitat for marine bird and mammals. The flora and fauna of the islands reflect a long history of human use and alterations. Historically, the islands are thought to have been covered with mature forests of hemlock, maple, oak, pine, and hickory but presently, most of the islands are considered to be dominated by exotic, early successional vegetation.

Mission

The mission of the Boston Harbor Islands, a national park area, is to protect the islands as a resource of national significance and to make the island system an integral part of the life of the surrounding communities and region, while improving public knowledge and access for education, recreation, and tranquility within an urban area.

Legislation

Document	Description
General Management Plan, 2002	“…to preserve and protect a drumlin island system within Boston Harbor, along with associated natural, cultural, and historic resources; to tell the islands’ individual stories and enhance public understanding and appreciation of the island system as a whole; and to provide public access, where appropriate, to the islands and surrounding waters for the education, enjoyment, and scientific and scholarly research of this and future generations.”
Resource Management Plan	In progress

APPENDIX B: Summary of parks in the Northeast Temperate Network

Document	Description
Enabling Legislation, 1996	"to provide education and visitor information programs to increase public understanding of and appreciation for the natural and cultural resources of the Boston Harbor Islands." • 1996: Public Law 104-333 • 1998: Public Law 105-355, Park legislation amended authorization to acquire, in partnership with other entities, a conservation easement at Thompson Island. • 2000: Public Law 106-176, technical corrections to park enabling legislation. The park's legislation is codified to Title 16, United States Code, Section 460 kkk: Boston Harbor Islands National Recreation Area.

Natural Resources

Intertidal habitat	Terrestrial habitat	Aquatic/wetland habitat	Resource Issues
• Tidal flat - 873 acres • Aquatic bed - 120 acres • Mussel reef - 87 acres • Rocky intertidal - 83 acres • Estuarine marsh - 82 acres	• Maritime shrub - 128 acres • Woodland, pioneer & mature - 110 ac. • Maritime forest - 72 acres • Scrubland - 23 acres • Old field - 11 acres • Cliffs - 8 acres	• Ponds - 23 acres • Vegetated wetlands - 8 acres • Springs/seeps	• Coastal erosion/sea level rise • Invasive exotic species • Boats • Atmospheric deposition/ozone • Water quality • Contamination • Visitor impacts • Feral animals • Climate change

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
Air and Climate	Air Quality	Ozone, acidic deposition and stress, air contamination	None established
	Weather and Climate	Air temperature, precipitation by type, relative humidity, total solar radiation, wind speed and direction, snow water equivalent and depth	None established
Geology and Soils	Geomorphology	Intertidal substrate composition, shoreline change and sea level rise	None established
Water	Hydrology	Water depth and duration	None established
	Water Quality	Water chemistry, nutrient enrichment, contamination, aquatic macroinvertebrates	None established
Ecosystem Pattern and	Land Use/Land Cover	Monitor changes within and adjacent to park	None established

APPENDIX B: Summary of parks in the Northeast Temperate Network

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
Process	Extreme Disturbance	Harmful algal blooms	None established
Biological Integrity	Species of Special Concern	Intertidal, wetland, and forest communities; forest vegetation; mammals, and birds	None established
	Exotic Plant Species	Early detection of exotic species	None established
	T&E Species	Not a selected vital sign or measure	None established
Human Use	Visitor Usage	Identify and monitor impacts associated with increased visitation	None established
	Visitor Satisfaction	Not a selected vital sign or measure	Visitor Satisfaction: : By September 30, 2005, 95% of park visitors are satisfied with appropriate park facilities, services, and recreational opportunities.
	Consumptive Use	Intertidal harvesting	None established
	Resource Knowledge	Not a selected vital sign or measure	Sensitive habitats and species of special concern are identified on digitized maps for 30 park islands.

Notes:

[1] Vital signs and measures were identified by park staff, network staff, and cooperators to fulfill the objectives of the National Park Service Inventory and Monitoring program, and may not directly parallel the needs and/or requirements of any established GPRA goals.

2 GPRA Goals may not exist for all vital signs and/or measures, and not all GPRA Goals are identified on this list.

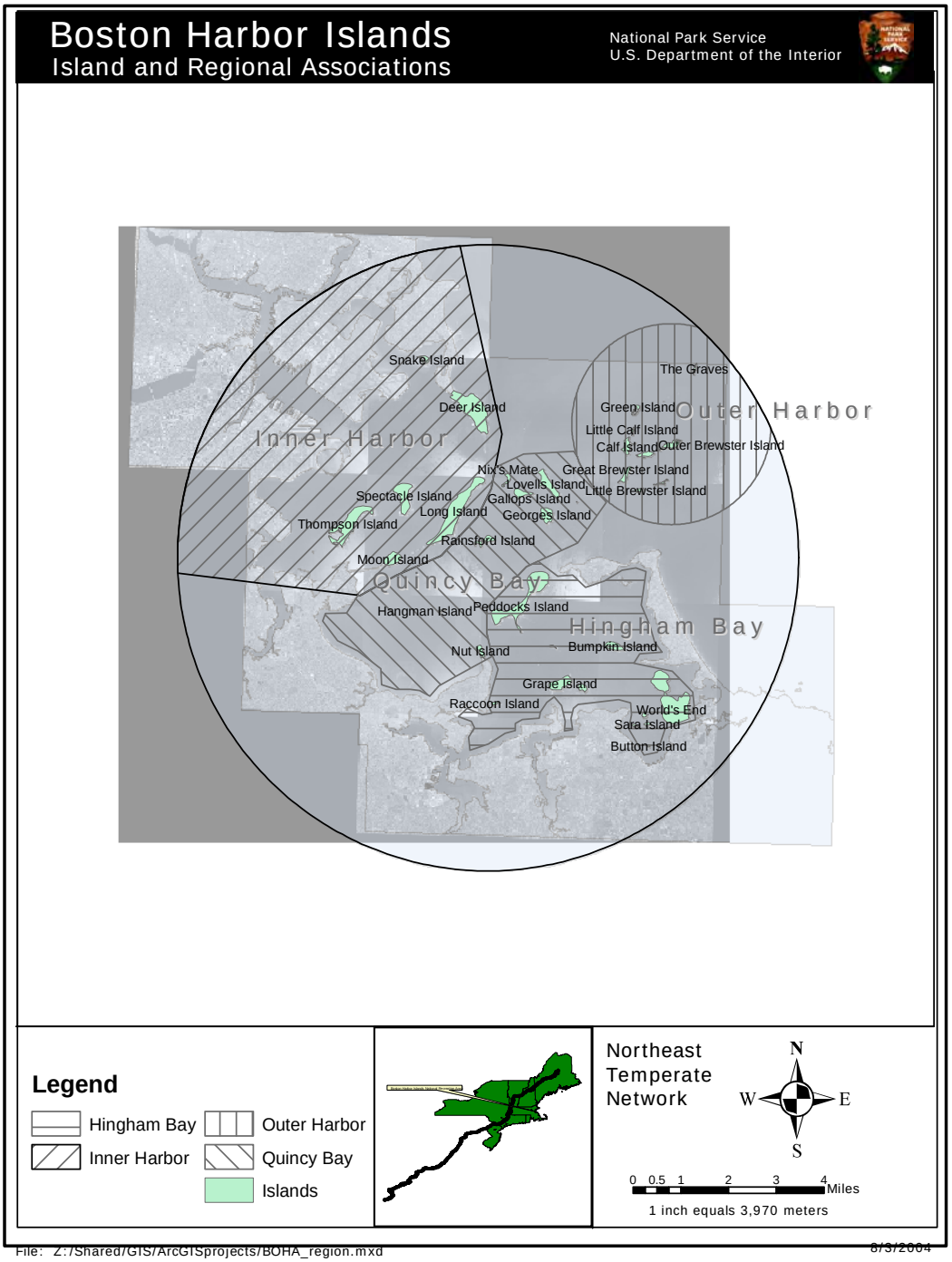


Figure B.3. Boston Harbor Islands and vicinity.

Marsh-Billings-Rockefeller National Historical Park (MABI) Woodstock, Vermont

Background

Marsh-Billings-Rockefeller NHP is the first unit of the National Park system to focus on the history of conservation and land stewardship in America. The park was gifted to the National Park Service by Laurence S. and Mary F. Rockefeller, established as a National Park in 1992, and opened to the public in June, 1998. The Park, named for George Perkins Marsh, one of the nation's first global environmental thinkers and author of "Man and Nature," is located in the Green Mountains of Central Vermont. The Park interprets the history of conservation with tours of the mansion and the surrounding 550-acre forest. The Park includes the Mt. Tom woodland, one of the earliest surviving examples of scientifically informed reforestation and forest management in the United States. The establishment of the Park directed that the tradition of professional forestry practiced on Mt. Tom for almost 125 years be continued by the National Park Service as an educational demonstration of forest stewardship and to preserve the cultural landscape.

Marsh-Billings-Rockefeller NHP is located in the Northeastern Highlands ecoregion and includes northern hardwoods, conifer plantations, cliff/rocky outcrop communities, open fields, streams, pond, vernal pools, and seeps. The mansion is a National Historic Landmark and the residential complex and farmland are part of a National Historic District.

The Park represents one of the earliest examples in New England of active reforestation efforts. Coniferous plantations of both native and non-native species were established beginning in the 1880s and presently comprise 26% of the Park's area. Reforestation also occurred in many areas of the forest as a result of agricultural abandonment, resulting in naturally regenerated northern hardwood, hemlock, and mixed forests. The Park's "patchy" forest mosaic reflects this history of alternate reforestation approaches and varied successional trajectories.

The Park includes a diversity of stand types as well as pronounced visual contrasts and view corridors created by open pastures and fields surrounded by dense forest plantations. Visitor experience of alternating openness and enclosure is further enhanced by the 14-mile system of 19th century carriage roads winding through the forest and over Mt. Tom.

Mission

Marsh-Billings-Rockefeller National Historical Park is the only national park to focus on conservation history and the evolving nature of land stewardship in America.

Legislation

Document	Description
General Management Plan, 1998	Marsh-Billings-Rockefeller NHP is a combination of a "cultural landscape with a high degree of historical integrity" that includes within its boundaries an "actively managed woodlands and a working farm that were historically part of a single estate." The park "reflects the continuity of more than a century of careful management "and is the "first unit of the national park system to focus on the history and evolution of conservation stewardship in America."
Resource Management Plan	In progress

Document	Description
Enabling Legislation, 1992	"…to interpret the history and evolution of conservation stewardship in America…" 1992: Public Law 102-350

Natural Resources

Terrestrial habitat	Aquatic/wetland habitat	Natural Resource Issues
• Hemlock no. hardwood forest - 171 acres • Northern hardwood forest - 80 acres • Hemlock forest - 62 acres • Native conifer plantations - 112 acres • Exotic conifer plantations - 40 acres • Maintained fields/pasture - 43 acres • Landscaped grounds - 9 acres • Cliffs - 1 acre	• The Pogue - 15 acre pond • Forested wetlands - 9 acres • Additional wetlands - 22 acres • Perennial stream, intermittent streams • Vernal pools • Springs/seeps	• Land management • Invasive exotic species • Atmospheric deposition/ozone • Water quality • Visitor impacts • External landuse/development • Deer, beaver • Climate change

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
Air and Climate	Air Quality	acidic deposition and stress, air contamination	None established
	Weather and Climate	Air temperature, precipitation by type, relative humidity, total solar radiation, wind speed and direction, snow water equivalent and depth	None established
Geology and Soils	Geomorphology	stream geomorphology and lake morphometry	None established
Water	Hydrology	Water depth and duration	None established
	Water Quality	Water chemistry, nutrient enrichment, contamination, aquatic macroinvertebrates	None established
Ecosystem Pattern and Process	Land Use/Land Cover	Monitor changes within and adjacent to park	None established
Biological Integrity	Species of Special Concern	wetland, forest, and freshwater communities; forest vegetation; mammals, fish, and birds	None established
	Exotic Plant Species	Early detection of exotic species	None established
	T&E Species	Not a selected vital sign or measure	None established
Human Use	Visitor Usage	Identify and monitor impacts associated with increased visitation	None established

APPENDIX B: Summary of parks in the Northeast Temperate Network

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
	Visitor Satisfaction	Not a selected vital sign or measure	By September 30, 2005, 100% of park visitors are satisfied with appropriate park facilities, services, and recreational opportunities.
	Resource Knowledge	Not a selected vital sign or measure	By September30, 2005, 11 (92%) of 12 primary Marsh-Billings-Rockefeller NHP natural resource inventories are completed.

Notes:

[1] Vital signs and measures were identified by park staff, network staff, and cooperators to fulfill the objectives of the National Park Service Inventory and Monitoring program, and may not directly parallel the needs and/or requirements of any established GPRA goals.

2 GPRA Goals may not exist for all vital signs and/or measures, and not all GPRA Goals are identified on this list.

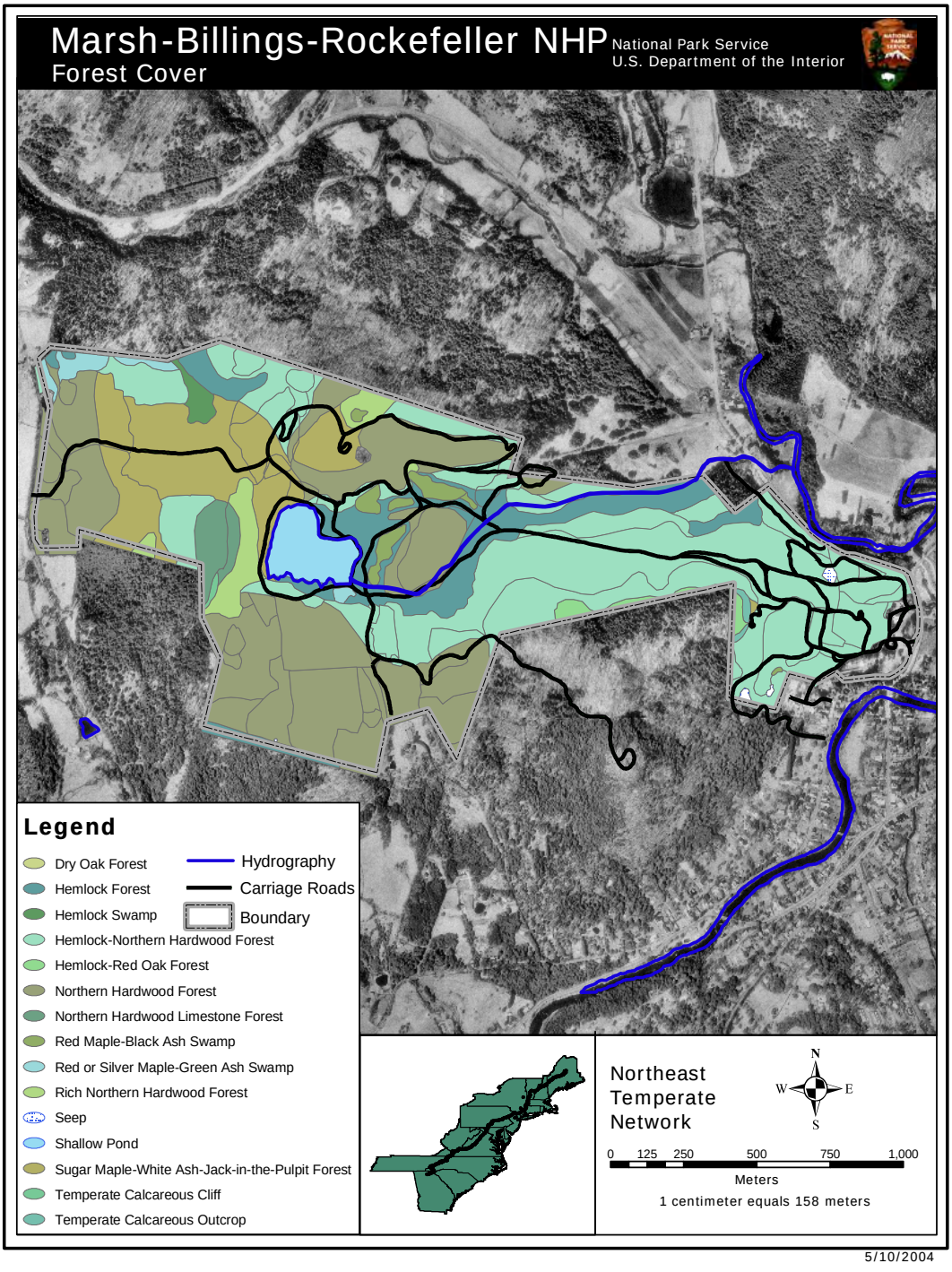


Figure B.6. Forest Cover Types at Marsh-Billings-Rockefeller NHP.

Minute Man National Historical Park (MIMA), Concord/Lexington, Massachusetts

Background

Minute Man NHP was established in 1959 to consolidate, preserve, and selectively restore and interpret portions of the Lexington-Concord Battle Road in Concord, Lincoln, and Lexington Massachusetts. The entire park is listed as a National Historic District on the National Register of Historic Places. The 750 acre park is comprised of 3 units (Battle Road, North Bridge, and Wayside units) where the opening battle of the American Revolution was initiated, and contains the site of "the shot heard around the world" at the North Bridge.

The Park, located in the Northeastern Coastal Zone ecoregion, is characterized by flat plains and low-rolling hills varying in elevation from 120' to 307' above sea level. The Park lies along the watershed boundaries of the Concord River flowing north, the Shawsheen River flowing south, and the Charles River flowing east. The primary resource management objectives of the Park are to preserve the cultural resources and reestablish the historic landscape. The cultural resources consist of 17 buildings, numerous monuments and archaeological sites, and the historic landscape consists of fields, forest, and wetlands. About one third of the park is wetlands, including forested wetland, shrub swamp, emergent wetlands, river/stream, ponds, vernal pools, and approximately one third is upland forests. Remaining lands include 150-200 acres agricultural lands (row crops, hay fields, orchards), meadow, lawn, structures, and roads and trails. Invasive exotic plants are a primary natural and cultural resource management concern due to their impacts on natural communities and cultural landscapes.

Mission

At Minute Man National Historical Park, the Battles of Lexington and Concord are brought to life through the preservation, restoration and interpretation of significant sites from "that famous day and year" when Colonists took up arms in defense of liberty and touched off the American Revolution.

Legislation

Document	Description
General Management Plan, 1989	"…ensure the protection of the park's significant cultural resources, provide better opportunities for visitor understanding of the events of the first day of the Revolutionary War-April 9, 1775, evoke the 1775 cultural landscape, and provide facilities needed fro visitors to appreciate the park's unique resources."
Resource Management Plan	A primary resource management objective is the reestablishment of the historic landscape. "The historic landscape within the park consist of fields, forest, wet lands and examples of local flora and fauna."
Enabling Legislation, 1959	"..to preserve for the benefit of the American people certain historic structures and properties of outstanding national significance associated with the opening of The War of the American Revolution, . . ." including "the road and road sites between Lexington and Concord…" 1959: Public Law 86-321

Natural Resources

Terrestrial habitat	Aquatic/wetland habitat	Natural Resource Issues
• Deciduous forest - 193 acres • Mixed & coniferous forest - 135 acres • Old fields - 153 acres • Agricultural fields - 104 acres • Cultural lands - 34 acres	• Forested wetlands - 150 acres • Shrub/open wetlands - 104 acres • Peatland - 4 acres • Ponds • Concord River, Elm Brook, Mill Brook • Vernal pools • Springs/seeps	• Invasive exotic species • Land management/agriculture • Visitor impacts • External land-use/development • Roads • Atmospheric deposition/ozone • Water quality • Deer, beaver, feral animals/pets • Climate change

•

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
Air and Climate	Air Quality	Ozone, acidic deposition and stress, air contamination	None established
	Weather and Climate	Air temperature, precipitation by type, relative humidity, total solar radiation, wind speed and direction, snow water equivalent and depth	None established
Geology and Soils	Geomorphology	stream geomorphology	None established
Water	Hydrology	Water depth and duration	None established
	Water Quality	Water chemistry, nutrient enrichment, contamination, aquatic macroinvertebrates	Water Quality - By September 30, 2005, Minute Man NHP has unimpaired water quality.
Ecosystem Pattern and Process	Land Use/Land Cover	Monitor changes within and adjacent to park	None established
Biological Integrity	Species of Special Concern	Wetland and forest communities; forest vegetation; mammals, fish, and birds	None established
	Exotic Plant Species	Early detection of exotic species	By September 30, 2005, 16 (4.7%) of 337 acres of Minute Man NHPs lands impacted by exotic vegetation targeted by September 30, 1999, is contained.
	T&E Species	Not a selected vital sign or measure	None established
Human Use	Visitor Usage	Identify and monitor impacts associated with increased visitation	None established

APPENDIX B: Summary of parks in the Northeast Temperate Network

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
	Visitor Satisfaction	Not a selected vital sign or measure	Visitor Satisfaction - By September 30, 2005, 99% of all park visitors to Minute Man NHP are satisfied with appropriate park facilities, services, and recreational opportunities.
	Resource Knowledge	Not a selected vital sign or measure	None established

Notes:

[1] Vital signs and measures were identified by park staff, network staff, and cooperators to fulfill the objectives of the National Park Service Inventory and Monitoring program, and may not directly parallel the needs and/or requirements of any established GPRA goals.

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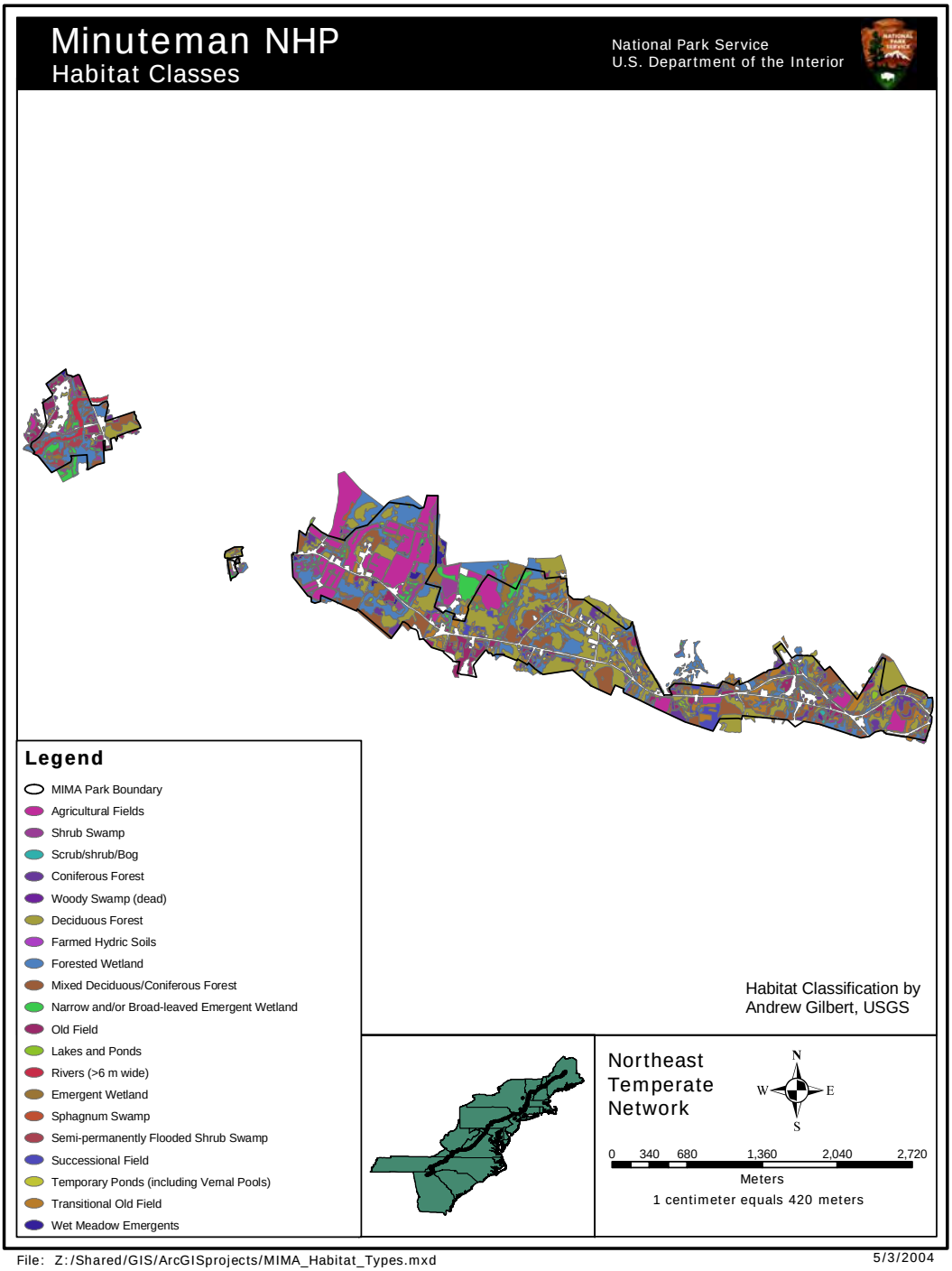


Fig. B. . Habitat Classes in Minuteman National Historic Park

Morristown National Historical Park (MORR) Morristown, New Jersey

Background

Morristown National Historic Park, the first national historic park, was established in 1933 to preserve the lands and resources associated with the winter encampments of the Continental Army during the War for Independence. Historical sites within the park include the historic Jacob Ford Mansion (General Washington's military headquarters during the winter of 1779-1780); the Upper Redoubt site (built in 1777 following the battles of Princeton and Trenton) in the Fort Nonsense Unit of the park; the historic Wick House & Farm (headquarters of General Arthur St. Clair); the 18th century Guerin house (home of local farmer, Joshua Guerin).

Morristown NHP is located on the border between the Northeastern Highlands and the Northern Piedmont ecoregions and is comprised of 1,685 acres distributed across 4 geographically separate units. Washington's Headquarters occupies 10 acres, the Fort Nonsense Unit occupies 35 acres, the Jockey Hollow Encampment, the largest unit, occupies 1,320 acres, and the New Jersey Brigade Unit occupies 321 acres. Vegetation is dominated by a mix of mowed fields, orchards, planted gardens, and forest stands. Changing land use patterns have dramatically altered the character of the local area from farmed or hardwood forested areas intersected by streams to low density residential development, expanding networks of roads, commercial development and recreational development. More than half a million visitors use the park in a year.

Mission

To protect the landscape and historic resources of the Continental Army's winter encampments and other nearby Revolutionary War military and civilian sites for the benefit and inspiration of all. To interpret the extraordinary fortitude of the officers and enlisted men under Washington's leadership and the important subsequent commemoration of these crucial events of the American Revolution.

Legislation

Document	Description
General Management Plan, 2003	The new GMP addresses many issues, including protection of museum collections, sustainable management of park forests, direct management of the park's cultural landscape, and support the enhanced interpretation of the historical aspects of the park.
Resource Management Plan, 2003	"The park's landscapes will be maintained through management of plant and animal communities." Actively managed sites include mowed fields, orchards, and planted gardens. Passively managed sites include a variety of forested stands, including successional and mature stands. There are a variety of mammals, fish, and birds present, in addition to aquatic resources.
Enabling Legislation, 1933	To commemorate the sight that General George Washington used as a winter encampment in 1779-1780 and gain "title to all the lands, structures, and other property in the military campground areas…" • 1933: Public Law 72-409 • March 2, 1933: Public Law 72-409, 47 Stat. 1421, establishes Morristown National Historical Park, the first NHP, 1051.38 acres authorized. Land includes Jockey Hollow, Ft. Nonsense, and Washington's Headquarters. Washington Association of New Jersey named advisor to park. Museum

Document	Description
	collection highlighted. • Sept. 18, 1964: Public Law 88-601, authorized the addition of 281 acres by donation, purchase or otherwise. 259.71 acquired. • Public Law 93-477 authorized 465 acres, 466.98 acquired. • Public Law 94-578 authorized 600 acres, 593.44 acquired. • Public Law 102-118 authorized 615 acres, 606.44 acquired. • Public Law 105-355 authorized 15 acres of Warren property in addition to the earlier 615 acres authorized.

Natural Resources

Terrestrial habitat	Aquatic/wetland habitat	Natural Resource Issues
• Mixed oak forest - 565 acres • Mixed successional forest - 476 acres • Mixed hardwood forest - 109 acres • Fields - 60 acres	• Wetlands - 22 acres • Rivers, streams • Cat Swamp Pond (artificial) • Springs/seeps	• Invasive exotic species • Deer, feral animals/pets • External land-use/development • Roads • Atmospheric deposition/ozone • Water quality • Land management • Visitor impacts • Climate change

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
Air and Climate	Air Quality	Ozone, acidic deposition and stress, air contamination	None established
	Weather and Climate	Air temperature, precipitation by type, relative humidity, total solar radiation, wind speed and direction, snow water equivalent and depth	None established
Geology and Soils	Geomorphology	stream geomorphology	None established
Water	Hydrology	Water depth and duration	None established
	Water Quality	Water chemistry, nutrient enrichment, contamination, aquatic macroinvertebrates	By September 30, 2005, Morristown NHP has unimpaired water quality.
Ecosystem Pattern and Process	Land Use/Land Cover	Monitor changes within and adjacent to park	None established
Biological Integrity	Species of Special Concern	Wetland and forest communities; forest vegetation; mammals, fish, and birds	None established

APPENDIX B: Summary of parks in the Northeast Temperate Network

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
	Exotic Plant Species	Early detection of exotic species	By September 30, 2005, 15 (7%) of 220 acres of Morristown NHP lands impacted by exotic vegetation targeted by September 30, 1999, are contained.
	T&E Species	Not a selected vital sign or measure	None established
Human Use	Visitor Usage	Identify and monitor impacts associated with increased visitation	None established
	Visitor Satisfaction	Not a selected vital sign or measure	By September 30, 2005, 98% of park visitors at Morristown NHP are satisfied with appropriate park facilities, services, and recreational opportunities
	Resource Knowledge	Not a selected vital sign or measure	By September 30, 2005, 5 (50%) of 10 primary Morristown NHP natural resource inventories identified in a Resource Management Plan and General Management Plan are completed.

Notes:

[1] Vital signs and measures were identified by park staff, network staff, and cooperators to fulfill the objectives of the National Park Service Inventory and Monitoring program, and may not directly parallel the needs and/or requirements of any established GPRA goals.

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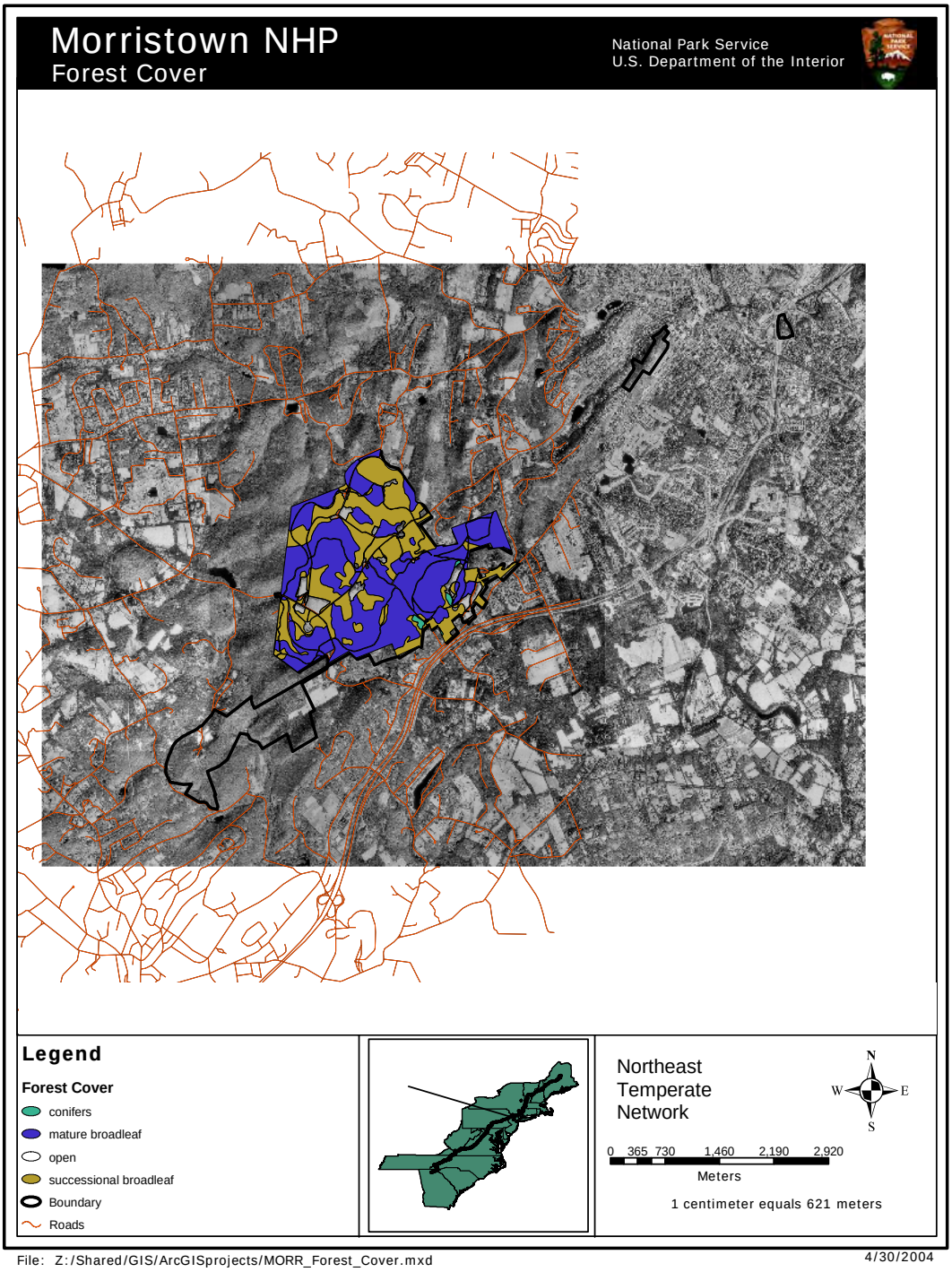


Figure A.10. Forest Cover and roads in Morristown NHP boundary (Fort Nonsense Unit not shown)

Roosevelt-Vanderbilt National Historical Sites (ROVA) Hyde Park, New York

Background

Roosevelt-Vanderbilt National Historic Sites consists of three sites in Hyde Park, New York, totaling 682 acres (Eleanor Roosevelt Mansion, Home of Franklin D. Roosevelt, and the Vanderbilt Mansion). The sites are within three miles of each other, in western Dutchess County, and host about 500,000 visitors per year.

The Roosevelt-Vanderbilt National Historic Sites host a broad array of natural resources located in the Eastern Great Lakes and Hudson Lowlands ecoregion. Both the Home of Franklin D. Roosevelt NHS and Vanderbilt Mansion NHS border on the Hudson River, a brackish-water estuary until it reaches a dam at Troy, New York 75 miles to the north. The presence of the river brings a marine influence far inland, resulting in unique plant communities and animal species otherwise uncommon to the region.

The lands are primarily (55%) forested and include nearly 30% wetlands (open water, Hudson River and freshwater tidal marshes). A 25-acre tidal marsh lies between the Home of Franklin D. Roosevelt NHS and the Hudson River, and a dam built by the Roosevelt family in 1925 across the Fall-Kill Creek created an extensive wetlands complex at the Eleanor Roosevelt NHS. In addition, the parks contain approximately 4.4 miles of streams, 14-acres of permanent ponds, 40-acres of non-tidal wetlands, numerous unmapped vernal pools and intermittent streams, mature second-growth hardwood forests, numerous rock outcrops, a sphagnum swamp, and a wet sedge meadow. Regionally significant amphibian, reptile, and plant populations are found in the parks, including State Threatened Blanding's turtle (*Emydoidea blandingii*) and a rare northern population of prickly pear cactus (*Opuntia humiifusa*). Significant threats from exotic species are affecting natural and cultural landscapes, especially Japanese barberry, Japanese knotweed, garlic mustard, tree-of heaven, and black locust.

Mission

General

- ". . . explain the significance of these wealthy Americans and the era they represent in the economic, sociological, and cultural history of the United States . . ."
- ". . . to let present and future generations know what mansion-living was like . . ."
- ". . . to illustrate a phase of man's relationship with his environment."

Eleanor Roosevelt Mansion

Commemorate the life of an outstanding woman in American history and her work on issues and humanitarian concerns to which she devoted her considerable intellect by preserving the site from which she drew much of her inspiration.

Home of Franklin D. Roosevelt

Preserve the estate and memorial gravesite of the only four term President of the United States and one of the pivotal figures of the 20th Century.

Vanderbilt Mansion

Preserve the estate of Frederick W. Vanderbilt which is representative and illustrative of the Gilded Age and significant in the economic, sociological and cultural history of the United States.

Legislation

Document	Description
General Management Plan	In progress
Resource Management Plan, 1999	"…the preservation of natural resources, cultural landscapes, and maintained viewsheds," are goals of the RMP. The site is bordered by the Hudson River, and has an extensive wetlands complex (home of the State-threatened Blanding's Turtle), seasonal and permanent woodlands ponds, second-growth hardwood forests, rock outcrops, a sphagnum swamp, and wet sedge meadow.
Enabling Legislation	**Eleanor Roosevelt Mansion:** • 1977: Public Law 95-32, establishing Eleanor Roosevelt National Historic Site. • 1998: Authorizes the acquisition of property within the historic Roosevelt lands to be acquired by means other than donation and administered as a part of the Home of FDR or Eleanor Roosevelt National Historic Site. **Home of Franklin D. Roosevelt:** • 1939: Congressional Resolution establishing President Roosevelt's intent to donate his residence to the United States upon his death. • 1944: Federal Register Notice of Secretary of the Interior Harold Ickes designating the Franklin D. Roosevelt Home a National Historic Site. • 1975: Authorized the acquisition of any lands contiguous to the Roosevelt estate to be acquired by donation. • 1998: Authorizes the acquisition of property within the historic Roosevelt lands to be acquired by means other than donation and administered as a part of the Home of FDR or Eleanor Roosevelt National Historic Site. • 1999: Authorized the transfer of administrative jurisdiction of up to one acre from the NPS to the National Archives and Records Administration for the purpose of building a joint visitor center **Vanderbilt Mansion:** • 1940: Designation Order establishes the Vanderbilt Mansion National Historic Site as a monument to the Gilded Age.

Natural Resources

Terrestrial habitat	Aquatic/wetland habitat	Natural Resource Issues
• Hemlock no. hardwood - 191 acres • Northern hardwood forest - 168 acres • Successional forest/old field - 74 acres • Conifer plantation - 29 acres • Mowed/landscaped - 124 acres • Agricultural fields - 21 acres	• Tidal marsh - 25 acres • Palustrine wetlands - 40 acres • Ponds and reservoirs -15 acres • Fall Kill, Meriches Kill, Crum Elbow Creek • Streams • Vernal pools • Springs/seeps	• Atmospheric deposition/ozone • Water quality • Contamination • External land-use/development • Roads • Land management

APPENDIX B: Summary of parks in the Northeast Temperate Network

Terrestrial habitat	Aquatic/wetland habitat	Natural Resource Issues
		• Visitor impacts • Deer, beaver, feral animals/pets • Invasive exotic species • Climate change

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
Air and Climate	Air Quality	Ozone, acidic deposition and stress, air contamination	None established
	Weather and Climate	Air temperature, precipitation by type, relative humidity, total solar radiation, wind speed and direction, snow water equivalent and depth	None established
Geology and Soils	Geomorphology	stream geomorphology	None established
Water	Hydrology	Water depth and duration	None established
	Water Quality	Water chemistry, nutrient enrichment, contamination, aquatic macroinvertebrates	By September 30, 2005, Roosevelt-Vanderbilt National Historic Sites have unimpaired water quality.
Ecosystem Pattern and Process	Land Use/Land Cover	Monitor changes within and adjacent to park	None established
Biological Integrity	Species of Special Concern	Wetland and forest communities; forest vegetation; mammals, fish, and birds	By September 30, 2005, 21 of 23 (90%) of Roosevelt-Vanderbilt National Historic Site's populations of plant and/or animal species of special concern are at scientifically acceptable levels.
	Exotic Plant Species	Early detection of exotic species	By September 30, 2005, exotic vegetation (Black Locust, barberry, ailanthus and other alien vegetation species) on 75 (67%) of 111 targeted acres of park land is contained.
	T&E Species	Not a selected vital sign or measure	None established
Human Use	Visitor Usage	Identify and monitor impacts associated with increased visitation	None established

APPENDIX B: Summary of parks in the Northeast Temperate Network

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
	Visitor Satisfaction	Not a selected vital sign or measure	By September 30, 2005, at Eleanor Roosevelt NHS, 95 percent of visitors will be satisfied with appropriate park facilities, services and recreational opportunities. By September 30, 2005, at Home of FDR, 95 percent of visitors will be satisfied with appropriate park facilities, services and recreational opportunities. By September 30, 2005, At Vanderbilt Mansion, 95% of visitors will be satisfied with appropriate park facilities, services and recreational opportunities.
	Resource Knowledge	Not a selected vital sign or measure	None established

Notes:

[1] Vital signs and measures were identified by park staff, network staff, and cooperators to fulfill the objectives of the National Park Service Inventory and Monitoring program, and may not directly parallel the needs and/or requirements of any established GPRA goals.

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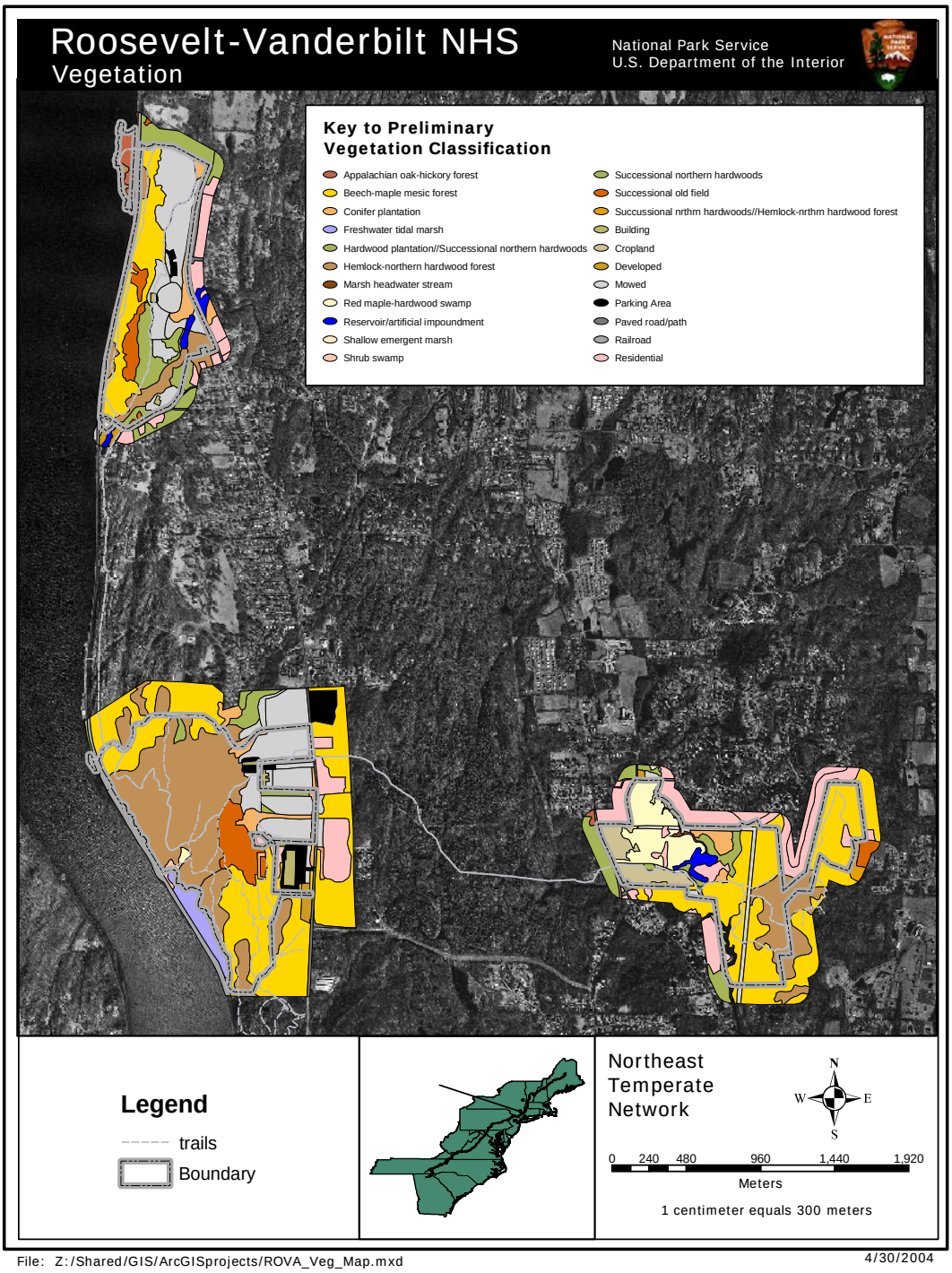


Figure A.12. Vegetation at Roosevelt-Vanderbilt NHS.

Saint-Gaudens National Historic Site (SAGA) Cornish, New Hampshire

Background

Saint-Gaudens National Historic Site consists of 148-acres that include the home, gardens and studios of Augustus Saint-Gaudens (1848-1907), one of America's foremost sculptors. This was his summer residence from 1885-1897, and his permanent home from 1900 until his death in 1907. During this time, Saint-Gaudens lived and worked as an artist in the Cornish Colony from 1885 to 1907. Saint-Gaudens National Historic Site was formally established in 1964.

The park occurs within the Northeastern Highlands ecoregion. This region is primarily dominated by hemlock and hemlock-beech transitional forest with pockets of semi-rich to rich mesic forest. The park borders a strip of rich sugar maple-ash-oak-hickory forest on river terrace slopes that were formed from lake-bottom sediments of the former glacial Lake Hitchcock along the Connecticut River Valley. Much of the site's 150 acres is on the lower slopes next to the river bottom and is covered with a coniferous and mixed deciduous forest (Gilman, 1997).

Natural resource inventories in 1980, 1986 and 1994 documented many vascular plant and vertebrate species, except birds. A long-term USFS forest health monitoring program station operates in the park. The park is experiencing a decline in white ash and near extirpation of butternut, and Hemlock Woolly Adelgid poses a potential threat to forest resources. Proliferation of purple loosestrife and potential introduction of other exotics are management concerns for the park's wetlands. The park supports a diverse amphibian and reptile community, and is developing long-term monitoring protocols and vernal pool protection strategies.

Significant resources inside the park boundaries include Blow-Me-Down Brook, Blow-Me-Up Brook, Blow-Me-Down Pond, wetlands surrounding Blow-Me-Down Pond, and a farm Pond. Roughly half of the park is bordered by stream and pond habitats. Blow-Me-Up Brook winds along the northern edge of the property through steep ravines before it merges with the larger Blow-Me-Down Brook which then flows into Blow-Me-Down Pond. Both Blow-Me-Down Pond and the farm pond are manmade and have control structures at their outlets. Blow-Me-Down Pond is 5-acre body of water with maximum depths of 7 – 8 feet by the dam, and an average depth of approximately 3.8 ft.

Mission

Preserve, protect, and interpret historically significant properties associated with the life and cultural achievements of Augustus Saint-Gaudens (1848-1907), the foremost American sculptor of the late 19th and early 20th centuries. In order that the Saint-Gaudens NHS may achieve more effectively its purpose as a living memorial, the park is directed to promote the arts through events in the spirit of those conducted by Augustus Saint-Gaudens and the Saint-Gaudens Memorial. Saint-Gaudens National Historic Site also commemorates the "Cornish Art Colony," a community of approximately sixty visual and performing artists, writers and patrons which surrounded Saint-Gaudens and continued after his death until the early 1930's.

Legislation

Document	Description
General Management	Saint-Gaudens NHS contains the home and studios of one of American's foremost sculptors. Preservation of the art, house, and studios is a top priority. Furthermore, "the gardens and landscape have special significance in their own

Plan, 1995	right, having survived nearly intact from the first quarter of the century".
Resource Management Plan	The site contains woodlands, meadows, a pond, stream, and formal gardens. The maintenance of these areas in preserving their historical and aesthetic value are goals of the RMP.
Enabling Legislation, 1964	"In order to preserve in public ownership historically significant properties associated with the life and cultural achievements of Augustus Saint-Gaudens" from "the sites and structures comprising the Saint-Gaudens Memorial…" 1964: Public Law 88-543

Natural Resources

Terrestrial habitat	Aquatic/wetland habitat	Natural Resource Issues
• Mixed forest - 104 acres • Fields - 16 acres • Landscaped - 5 acres	• Wetlands - 18 acres • Blow-me-down Pond - 5 acres • Blow-me-down, Blow-me-up Brooks • Vernal pools • Springs/seeps	• Atmospheric deposition/ozone • Water quality • External land-use/development • Roads • Visitor impacts • Land management • Deer, feral animals/pets • Invasive exotic species • Climate change

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
Air and Climate	Air Quality	Acidic deposition and stress, air contamination	None established
	Weather and Climate	Air temperature, precipitation by type, relative humidity, total solar radiation, wind speed and direction, snow water equivalent and depth	None established
Geology and Soils	Geomorphology	stream geomorphology	None established
Water	Hydrology	Water depth and duration	None established
	Water Quality	Water chemistry, nutrient enrichment, contamination, aquatic macroinvertebrates	By September 30, 2005, Saint-Gaudens NHS has unimpaired water quality.
Ecosystem Pattern and Process	Land Use/Land Cover	Monitor changes within and adjacent to park	None established
Biological Integrity	Species of Special Concern	wetland and forest communities; forest vegetation; mammals, fish, and birds	None established

APPENDIX B: Summary of parks in the Northeast Temperate Network

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
	Exotic Plant Species	Early detection of exotic species	By September 30, 2005, exotic vegetation [purple loosestrife and other alien vegetation species] on 8 of 125 targeted acres (6.5%)of parkland in Saint-Gaudens NHS are contained.
	T&E Species	Not a selected vital sign or measure	None established
Human Use	Visitor Usage	Identify and monitor impacts associated with increased visitation	None established
	Visitor Satisfaction	Not a selected vital sign or measure	By September 30, 2005, 85% of visitors to Saint-Gaudens NHS are satisfied with appropriate facilities, services, and recreational opportunities.
	Resource Knowledge	Not a selected vital sign or measure	By September 30, 2005, Saint-Gaudens NHS will have acquired 80% of the outstanding 10 of 12 data sets as called for in the NPS Inventory & Monitoring program.

Notes:

[1] Vital signs and measures were identified by park staff, network staff, and cooperators to fulfill the objectives of the National Park Service Inventory and Monitoring program, and may not directly parallel the needs and/or requirements of any established GPRA goals.

2 GPRA Goals may not exist for all vital signs and/or measures, and not all GPRA Goals are identified on this list.

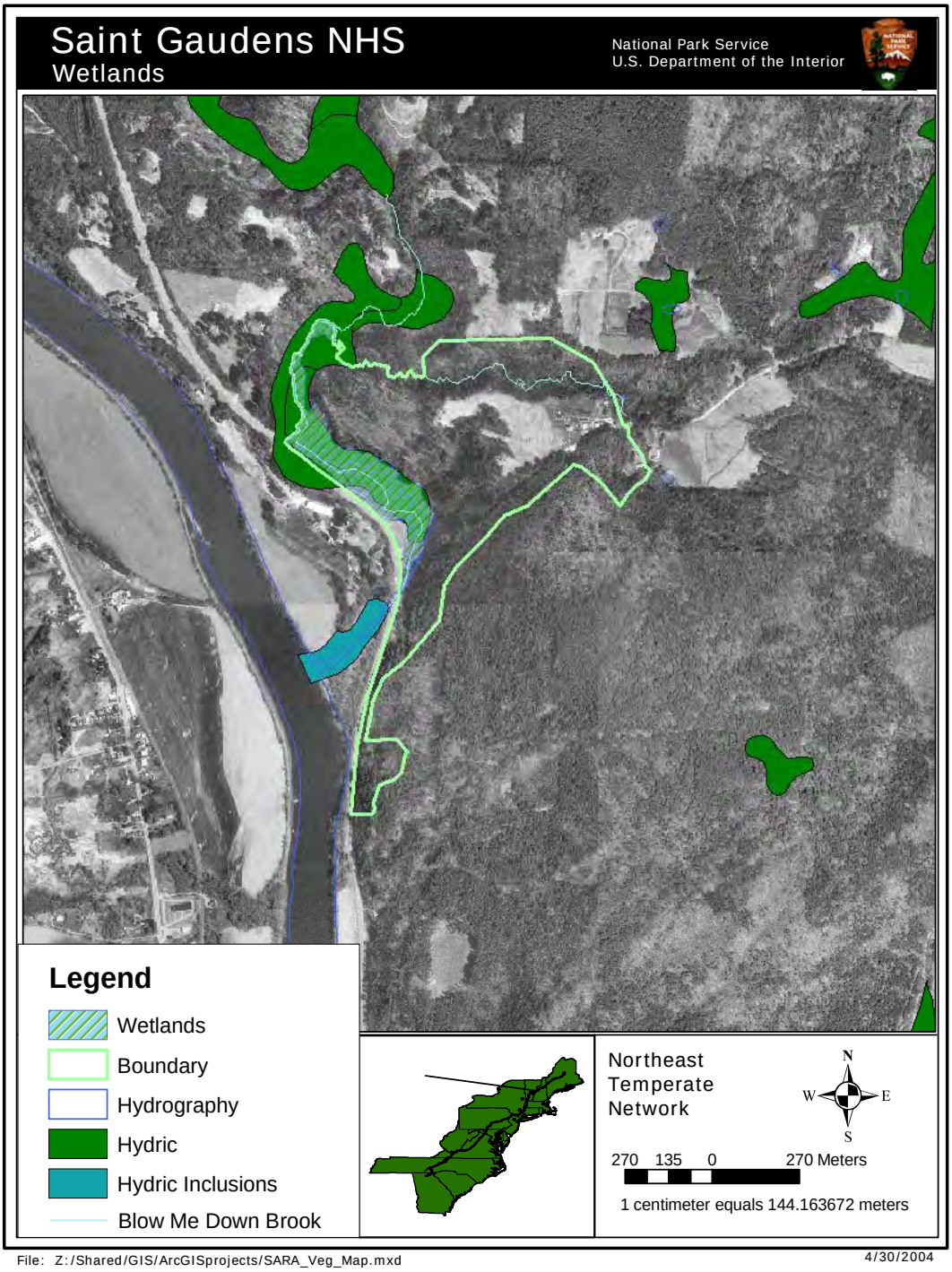


Figure A.15. Wetlands at Saint Gaudens NHP.

Saratoga National Historical Park (SARA) Schuylerville, New York

Background

Saratoga National Historic Park was established in 1938 to commemorate the first significant American military victory during the Revolution. The Battles of Saratoga are considered by some to rank among the fifteen most decisive battles in world history. Here in 1777 American forces met, defeated and forced a major British army to surrender, an event which led France to recognize the independence of the United States and enter the war as a decisive military ally of the struggling American forces.

Saratoga National Historical Park preserves and protects the battlefield and the sites associated with the 1777 surrender of British forces at Saratoga, which was a decisive event in the winning of American independence, and interprets these and other sites, events, and people related to the military campaigns in the Champlain-Hudson and Mohawk valleys.

The Park, located in the Eastern Great Lakes and Hudson Lowlands, comprises three separate units: the 4 square mile Battlefield in Stillwater, New York; the General Philip Schuyler House eight miles north of the battlefield in Schuylerville, New York; and, the Saratoga Monument in the nearby village of Victory. Saratoga is near the southern extent of the Adirondack Mountain region and is characterized by cool summers and relatively long cold winters. Snow often covers the ground from November through March.

The majority of the park consists of the Battlefield Unit which lies on rolling hills rising from the alluvial floodplain along the Hudson River. Elevations range from 26 m above sea level along the river to 124 m at the top of Fraser Hill. Numerous glacial ridges and ravines drain east into the Hudson River. A relatively low but steep escarpment marks the boundary between the hills and the alluvial floodplain of the Hudson River. Forests cover the largest percentage of park lands, comprising 2145 acres. Grasslands comprise 800 acres of the park and are dominated by grasses and forbs and contain the largest number of species in the park. The grasslands are maintained through prescribed fire and mowing. Brush/shrub areas (416 acres) and wetlands (45acres) make up the rest of the park landscape. The Hudson River floodplain, streams and wet meadows support unique habitats within and around the park. State listed threatened or special concern species found within the park include: two sedges; an iris (blue-eyed grass); running pine; and, woodland agrimony. Wildlife species typical for the region include the white-tailed deer, eastern coyote, eastern wild turkey, eastern meadowlark, northern harrier, snapping turtle, American toad, and meadow vole. Of the wildlife species known to utilize the park, 23 bird species are either federally or state listed as endangered, threatened, or of special concern. Vegetation plays a prominent role in the interpretation of the park. The historic configuration of the fields and forests at Saratoga was important in the overall battle strategy of 1777. The sequence of the park's land acquisition and land use history has produced a mosaic of old field, shrub, and forest communities.

Mission

Saratoga National Historical Park was established to preserve and protect the battlefield and sites associated with the 1777 surrender of British forces at Saratoga during the American Revolution, and to interpret the sites and events related to the military campaigns in the northern theater of operations from 1775 to 1777.

Legislation

Document	Description
General Management Plan, 2003	The goals of the GMP are to protect, preserve, and maintain the cultural and natural resources associated with the battles, siege, and surrender of 1777 at Saratoga. Furthermore, protect the natural resources "in the context of a cultural park to foster healthy ecosystems." Lastly, help the public understand the sacred and commemorative nature of the park's landscape and the significance of the military events that occurred at the site and how they impacted the outcome of the American Revolution.
Resource Management Plan, 1992	"The vegetation of the historic/cultural landscape is the Park's primary natural feature." During the battles of Saratoga the topography and vegetation played an important role. An awareness of this and an effort to restore the native vegetation is a primary goal.
Enabling Legislation, 1938	Saratoga was designated as a National Historic Park in 1938 to commemorate the battle, siege, and surrender of Saratoga in 1777. This battle is ranked among the top fifteen battles in world history and helped in the winning of American Independence • 1938: Public Law 576 authorizes Saratoga National Historical Park, incorporating the existing New York State Battlefield.. • June 22, 1948: Public Law 734 establishes Saratoga National Historical Park, with a limit of 5,500 acres. The Secretary of the Interior is authorized to accept all or any portion of the Philip Schuyler estate property, real or personal, in Schuylerville, NY, which occurs on March 30, 1950. • January 12, 1983: Public Law 97-460 establishes a permanent legislative park boundary enclosing 3406 acres. Saratoga Monument and Victory Woods are incorporated into park.

Natural Resources

Terrestrial habitat	Aquatic/wetland habitat	Natural Resource Issues
• Hemlock no. hardwood forest - 1067 ac. • Northern hardwood forest - 83 acres • Successional no. hardwood - 593 acres • Successional shrubland - 90 acres • Old field - 310 acres • Agricultural fields - 508 acres • Landscaped - 13 acres	• Wetlands - 175 acres • 4 Streams, Champlain Canal • 2 Ponds (artificial) • Springs/seeps	• Atmospheric deposition/ozone • Water quality • Contamination • Hydrologic alteration • External land-use/development • Roads • Land management • Visitor impacts • Deer, beaver, feral animals/pets • Invasive exotic species • Climate change

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
Air and Climate	Air Quality	Ozone, acidic deposition and stress, air contamination	None established

APPENDIX B: Summary of parks in the Northeast Temperate Network

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
	Weather and Climate	Air temperature, precipitation by type, relative humidity, total solar radiation, wind speed and direction, snow water equivalent and depth	None established
Geology and Soils	Geomorphology	morphometry	None established
Water	Hydrology	Water depth and duration	None established
	Water Quality	Water chemistry, nutrient enrichment, contamination, aquatic macroinvertebrates	By September 30, 2005, Saratoga NHP has unimpaired water quality.
Ecosystem Pattern and Process	Land Use/Land Cover	Monitor changes within and adjacent to park	None established
	Restoring Formerly Developed Lands		Restoring Formerly Developed Lands: By September 30, 2005, 10.1% of targeted parklands, disturbed by development or agriculture, as of 1999 (22,500 of 222,300 acres), are restored.
Biological Integrity	Species of Special Concern	Wetland and forest communities; forest vegetation; mammals, fish, and birds	None established
	Exotic Plant Species	Early detection of exotic species	By September 30, 2005, exotic vegetation on 1% of targeted acres of parkland is contained (10 of 800 Acres).
	T&E Species	Not a selected vital sign or measure	None established
Human Use	Visitor Usage	Identify and monitor impacts associated with increased visitation	None established
	Visitor Satisfaction	Not a selected vital sign or measure	By September 30, 2005, 96% of Saratoga NHP's visitors are satisfied with the appropriate park facilities, services and recreational opportunities.
	Resource Knowledge	Not a selected vital sign or measure	None established

Notes:

[1] Vital signs and measures were identified by park staff, network staff, and cooperators to fulfill the objectives of the National Park Service Inventory and Monitoring program, and may not directly parallel the needs and/or requirements of any established GPRA goals.

2 GPRA Goals may not exist for all vital signs and/or measures, and not all GPRA Goals are identified on this list.

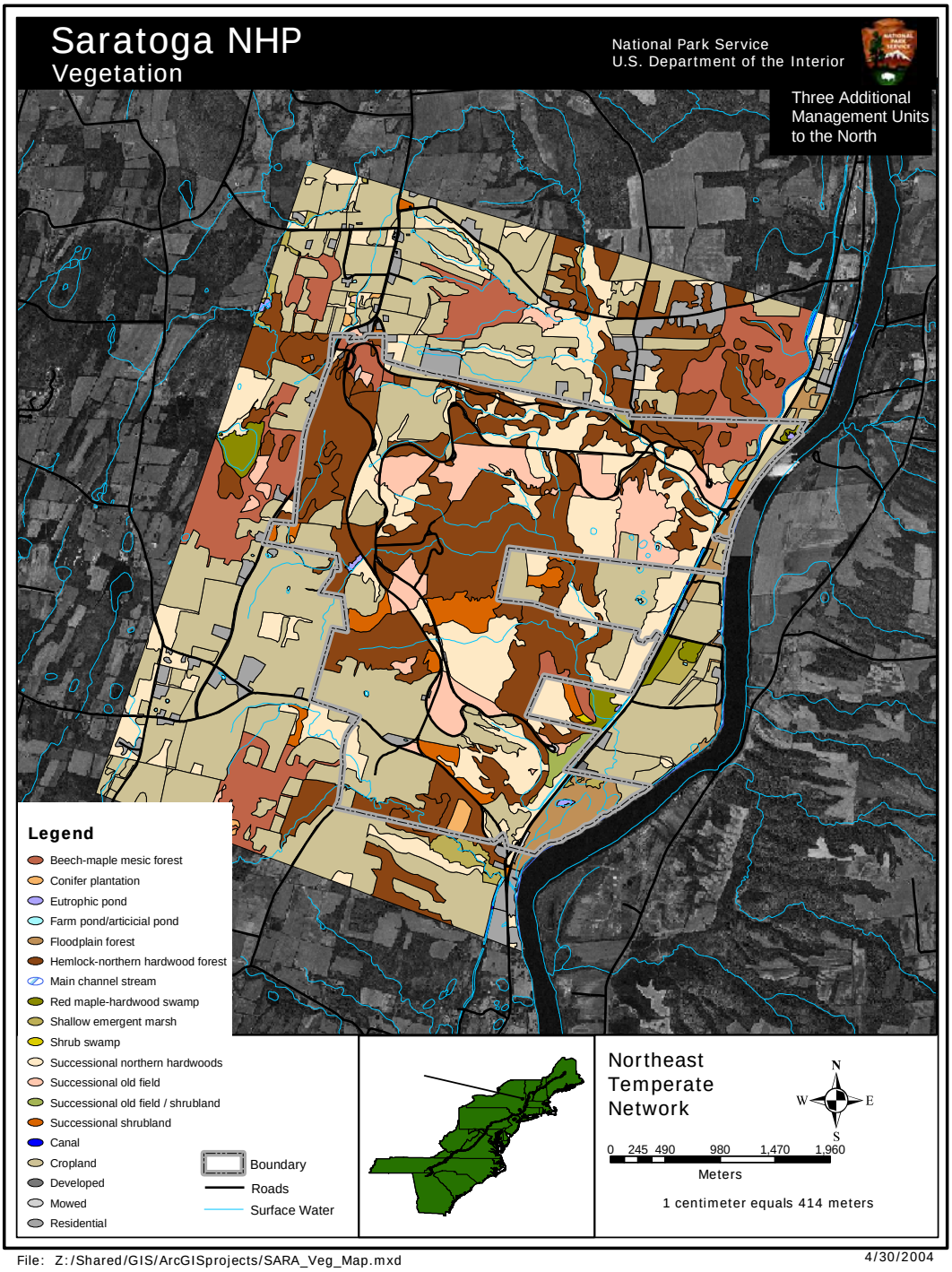


Figure A.17. Vegetation cover at Saratoga NHP.

Saugus Iron Works National Historic Site (SAIR) Saugus, Massachusetts

Background

Saugus Iron Works National Historic Site, established in 1968, is the site of the first integrated ironworks in North America (1646-1668), and hosts 25,000 visitors annual. The site includes a reconstructed blast furnace, forge, rolling mill, and a restored seventeenth century house. With the archeological site of the seventeenth-century iron-making plant, the museum collection, the seventeenth-century Iron Works House, and the reconstructed iron works complex, Saugus Iron Works National Historic Site illustrates the critical role of iron making to seventeenth-century settlement and its legacy in shaping the early history of the nation. The site's enclave setting on the Saugus River, featuring an open-air museum with working waterwheels evokes a unique experience for park visitors. These resources demonstrate seventeenth-century engineering and design methods, iron-making technology and operations, local and overseas trade, and life and work in the Massachusetts Bay Colony.

The site is a southern gateway to the Essex National Heritage Area, linking thousands of historic places in Essex County related to three primary historic themes: colonial settlement, maritime trade, and early industrialization.

The site is approximately 8-acres, and is located on the Saugus River in the Northeastern Coastal Zone ecoregion. Noteworthy natural resources include a floodplain, an emergent marsh wetland, riparian woodland, and the Saugus River. A total of 160 plants species are reported for the site. Exotic species are an issue for maintaining the marsh and the cultural landscape. The invading plants dominate the marsh and adjoining areas. The most abundant is Common Reed (*Phragmites australis*), but Purple Loosestrife (*Lythrum salicaria*), Japanese Knotweed (*Polygonum cuspidatum*), Multiflora rose (*Rosa multiflora*), and Curly Pondweed (*Potamogeton crispus*) are also present.

Prominent landscape features were dramatically altered in 1957 when an upstream dam was breached and caused a massive in-fill of silt to the site’s harbor. The aforementioned wetland marsh, dominated by invasive species, has since become established around the now channelized river, obscuring the recently reconstructed harbor and its role in the original iron making operation.

Mission

To preserve and interpret the archeological sites and features, the historic and reconstructed structures and scene, and the museum collections associated with America's first sustained, integrated, and successful iron works venture, which operated at this site from 1646 to about 1670.

- To assist in the interpretation of the Essex National Heritage Area, especially the theme of early settlement.

Legislation

Document	Description
General Management Plan, 2002	There are three fundamental objectives: "to preserve the distinctive character of park resources, to provide for quality visitor experiences, and to ensure organizational effectiveness." These goals support the mission to "preserve and interpret the archeological sites and features, the historic and reconstructed structures and scene, and the museum collections associated with America's first sustained, integrated, and successful iron works venture."
Resource Management Plan, 2003	The four resource areas identified are: landscaped areas, the Saugus River, wetlands, and riparian woodlands. Some of the goals of the RMP are to increase awareness of the park's natural resources and determine "how ecosystem stressors affect these natural resources."
Enabling Legislation, 1968	"Preserve in public ownership the first sustained integrated iron works in the Thirteen Colonies." • 1968: Public Law 90-282, an act to authorize the Secretary of the Interior to acquire the Saugus Iron Works and administer it as a National Historic Site. • November 12, 1996: Public Law 104-333, an act to establish the Essex National Heritage Area to recognize, preserve, promote, interpret, and make available for the benefit of the public resources that encompass the primary themes of the Salem Maritime National Historic Site and Saugus Iron Works National Historic Site.

Natural Resources

Habitat/land-use	Natural Resource Issues
• Saugus River (non-tidal) • Riparian marsh - 4 acres • Riparian woodland - 1 acre • Developed land - 3 acres • Landscaping - 1 acre • Seeps/springs	• Invasive exotic species • Wetland restoration • Sedimentation • Hydrologic alteration • Water quality • Contamination • Atmospheric deposition/ozone • External land-use/development • Roads • Visitor impacts • Canada geese • Climate change

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
Air and Climate	Air Quality	Acidic deposition and stress, air contamination	None established

APPENDIX B: Summary of parks in the Northeast Temperate Network

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
	Weather and Climate	Air temperature, precipitation by type, relative humidity, total solar radiation, wind speed and direction, snow water equivalent and depth	None established
Geology and Soils	Geomorphology	stream geomorphology	None established
Water	Hydrology	Water depth and duration	None established
	Water Quality	Water chemistry, nutrient enrichment, contamination, aquatic macroinvertebrates	By September 30, 2005, the Saugus River which runs through the Saugus Iron Works National Historic Site will continue to have impaired water quality.
Ecosystem Pattern and Process	Land Use/Land Cover	Monitor changes within and adjacent to park	None established
Biological Integrity	Species of Special Concern	wetland and forest communities; forest vegetation; mammals, fish, and birds	None established
	Exotic Plant Species	Early detection of exotic species	By September 30, 2005, 1 (25%) of 4 acres of Saugus Iron Works' lands impacted by exotic vegetation targeted by September 30, 1999, are contained.
	T&E Species	Not a selected vital sign or measure	None established
Human Use	Visitor Usage	Identify and monitor impacts associated with increased visitation	None established
	Visitor Satisfaction	Not a selected vital sign or measure	By September 30, 2005, 100% of visitors to Saugus Iron Works National Historic Sites are satisfied with appropriate park facilities, services, and recreational opportunities.
	Resource Knowledge	Not a selected vital sign or measure	None established
	Vital Signs		By September 30, 2005, Saugus Iron Works National Historic Site have identified Saugus' vital signs for natural resource monitoring.

Notes:

[1] Vital signs and measures were identified by park staff, network staff, and cooperators to fulfill the objectives of the National Park Service Inventory and Monitoring program, and may not directly parallel the needs and/or requirements of any established GPRA goals.

2 GPRA Goals may not exist for all vital signs and/or measures, and not all GPRA Goals are identified on this list.

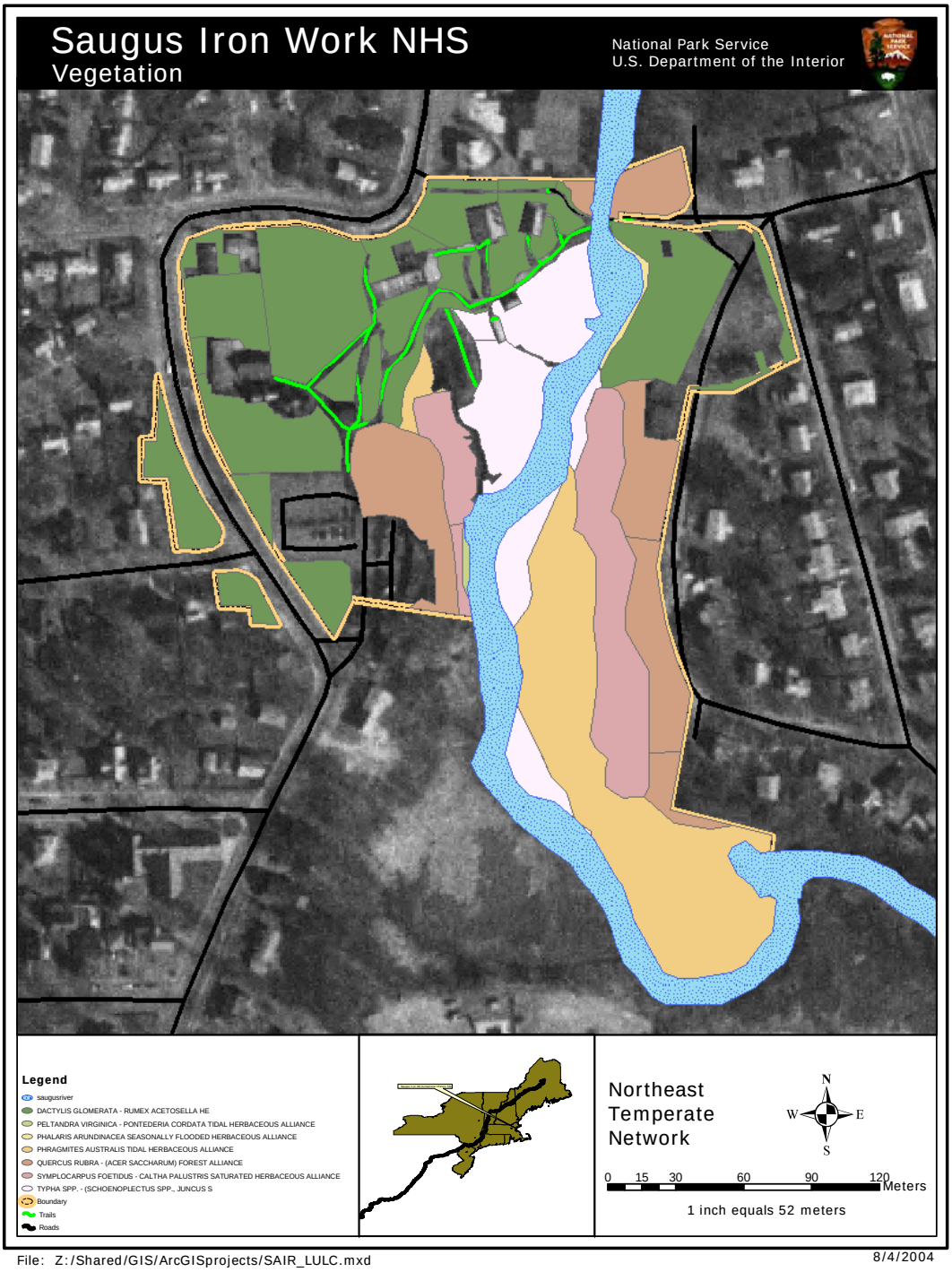


Figure A.19. Vegetation at Saugus Iron Works NHP.

Weir Farm National Historic Site (WEFA) Wilton, Connecticut

Background

Weir Farm preserves the home of nineteenth century American Impressionist Julian Alden Weir. Established as a national historic site in 1990, it protects one of the last intact landscapes associated with American Impressionism and maintains the integrity of an area that has inspired artistic expression.

The 75-acre park is located in the Northeastern Coastal Zone ecoregion in the southern part of Connecticut, and is within 25-miles of the Atlantic coast (Long Island Sound). The park contains open fields, successional forest and several wetland complexes and ephemeral surface streams. The ecological value of this small park is enhanced by adjacent forested land protected by The Nature Conservancy.

Weir Pond, a 4-acre, stream and groundwater fed, manmade pond is a prominent component of the Park landscape. The Weir Pond Dam, built to create the pond in 1896, has deteriorated and now presents an important management issue. In 1998, the Brooklyn Botanical Garden located five state listed plant species within the park. A number of invasive species at the site, including black swallowort (*Vincetoxicum nigrum*), Asiatic bittersweet (*Celastrus orbiculatus*), Japanese Barberry (*Berberis thunbergii*) and Garlic Mustard (*Allaria officinalis*) threaten the park's natural communities.

Mission

"…to maintain the integrity of a setting that inspired artistic expression…"

Preserve, and interpret the landscapes, buildings and objects which together form a place of central importance to the art of Julian Alden Weir and the American Impressionist movement, and to provide for the continuation of the site's artistic tradition. Maintain the integrity of the setting and to offer opportunities for the inspirational benefit and education of the American people.

Legislation

Document	Description
General Management Plan, 1995	The goals of the GMP are to preserve the integrity of Weir Farm and the "artistic legacy that is preserved throughout the site." This will be done through the preservation of the buildings, landscape, gardens, and pond.
Resource Management Plan, 1995	Weir Farm has a dam, pond, wetlands, forest land, and meadows. "WEFA will continue to provide a valuable picture of the past state of natural resources in the area." Objectives of the RMP include maintaining, restoring, or simulating the natural terrestrial, aquatic and atmospheric ecosystem conditions, in addition to maintaining or restoring indigenous flora, fauna, and natural communities of the "natural zones."
Enabling Legislation, 1990	"…to maintain the integrity of a setting that inspired artistic expression…" • 1990: Public Law 101-485, established Weir Farm National Historic Site. • 1994: Public Law 103-449, Title II, The Weir Farm National Historic Site Expansion Act, added the "last remaining undeveloped parcels of the historic Weir Farm still in private ownership" to the site. • 1998: Public Law 105-363, authorized the addition of up to 15 acres for visitor

Document	Description
	and administrative facilities

Natural Resources

Terrestrial habitat	Aquatic/wetland habitat	Springs/seeps
• Deciduous forest - 30 acres • Fields -15 acres • Developed - 5 acres	• Wetlands - 7 acres • Weir Pond - 4 acres • Streams • Vernal pools	• Natural Resource Issues • Invasive exotic species • External land-use/development • Roads • Land management • Atmospheric deposition/ozone • Water quality • Visitor impacts • Deer, feral animals/pets • Climate change

•

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
Air and Climate	Air Quality	Ozone, acidic deposition and stress, air contamination	None established
	Weather and Climate	Air temperature, precipitation by type, relative humidity, total solar radiation, wind speed and direction, snow water equivalent and depth	None established
Geology and Soils	Geomorphology	lake morphometry	None established
Water	Hydrology	Water depth and duration	None established
	Water Quality	Water chemistry, nutrient enrichment, contamination, aquatic macroinvertebrates	By September 30, 2005, Weir Farm NHS has unimpaired water quality. Baseline Year: 2000 Target Year: 2005
Ecosystem Pattern and Process	Land Use/Land Cover	Monitor changes within and adjacent to park	None established
Biological Integrity	Species of Special Concern	Wetland, forest, and freshwater communities; forest vegetation; mammals, fish, and birds	None established

APPENDIX B: Summary of parks in the Northeast Temperate Network

Vital Signs and Related GPRA Goals			
Category (Level 1)	**Element (Level 2)**	**Vital Signs and Measures[1]**	**GPRA Goal[2]**
	Exotic Plant Species	Early detection of exotic species	By September 30, 2005: Exotic vegetation on 8 of 30 targeted acres is contained. Baseline Year: 1999 Target Year: 2005
Human Use	Visitor Usage	Identify and monitor impacts associated with increased visitation	None established
	Visitor Satisfaction	Not a selected vital sign or measure	None established
	Resource Knowledge	Not a selected vital sign or measure	By September 30, 2005: 7 of 9 (78%) primary Weir Farm NHS natural resource inventories identified in the Resource Management Plan and General Management Plan are completed. Baseline Year: 1999 Target Year: 2005

Notes:

[1] Vital signs and measures were identified by park staff, network staff, and cooperators to fulfill the objectives of the National Park Service Inventory and Monitoring program, and may not directly parallel the needs and/or requirements of any established GPRA goals.

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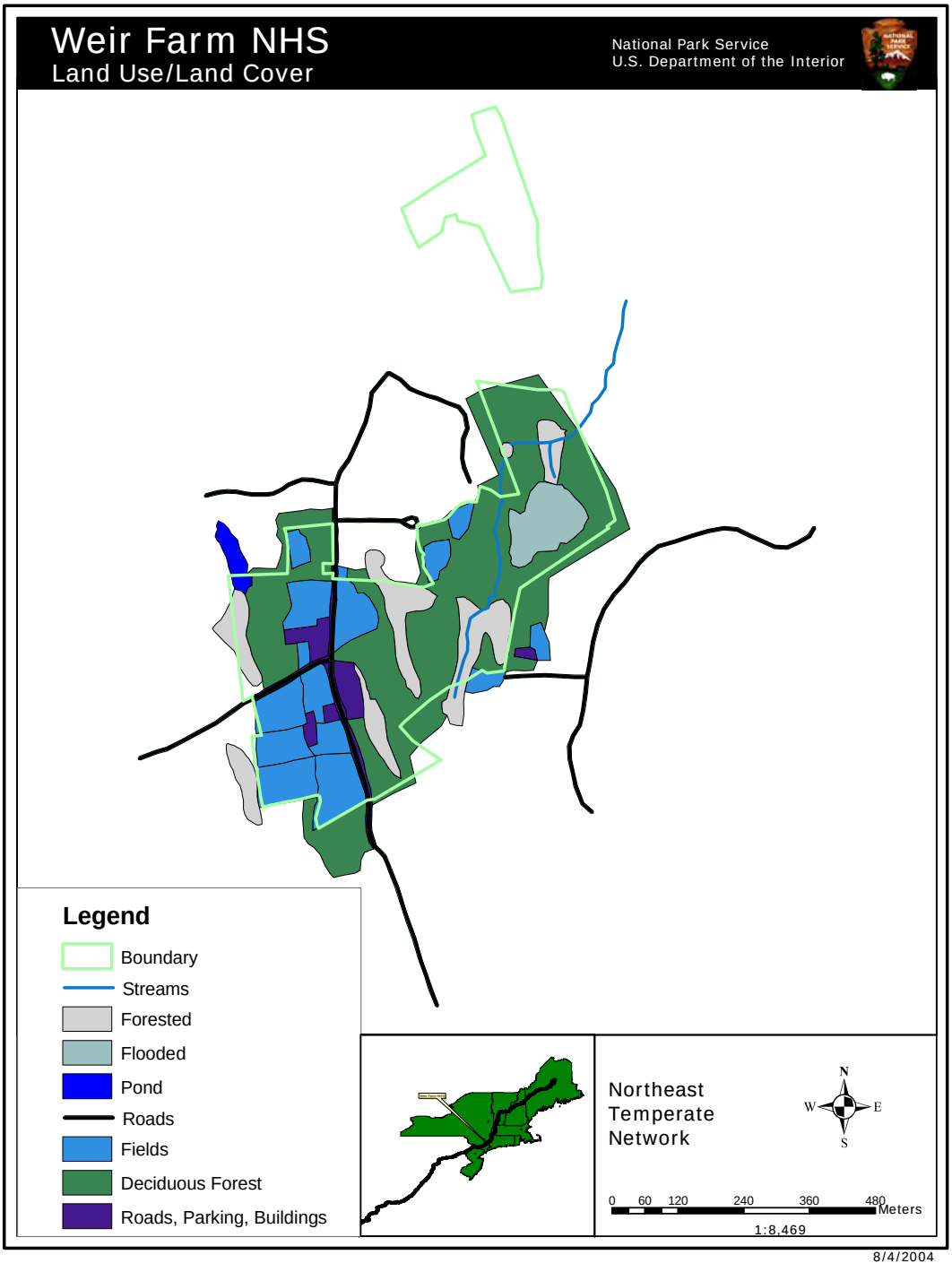


Figure A.22. Basic land cover at Weir Farm NHP.

APPENDIX C: Definitions of ecological systems in Northeast Temperate Network Parks

CES103.020 Boreal Aspen-Birch Forest 2
Division 103, Forest and Woodland 2
CES103.021 Boreal White Spruce-Fir-Hardwood Forest 3
Division 103, Forest and Woodland 3
CES201.565 Acadian Lowland Spruce-Fir-Hardwood Forest 4
Division 201, Forest and Woodland 4
CES201.566 Acadian Montane Spruce-Fir-Hardwood Forest 6
Division 201, Forest and Woodland 6
CES201.571 Laurentian-Acadian Acidic Rocky Outcrop 6
Division 201, Forest and Woodland 6
CES201.564 Laurentian-Acadian Northern Hardwoods Forest 8
Division 201, Forest and Woodland 8
CES201.563 Laurentian-Acadian Pine-Hemlock-Hardwood Forest 9
Division 201, Forest and Woodland 9
CES201.719 Laurentian-Acadian White Pine-Red Pine Forest 11
Division 201, Forest and Woodland 11
CES201.567 Acadian Alpine Barrens 12
Division 201, Shrubland 12
CES201.568 Acadian Subalpine Woodland and Barrens 13
Division 201, Shrubland 13
CES201.573 Acadian-North Atlantic Rocky Coast 14
Division 201, Shrubland 14
CES201.569 Laurentian-Acadian Acidic Cliff and Talus 15
Division 201, Shrubland 15
CES201.580 Acadian Maritime Bog 16
Division 201, Woody Wetland 16
CES201.583 Laurentian-Acadian Acidic Basin Fen 17
Division 201, Woody Wetland 17
CES201.574 Laurentian-Acadian Acidic Swamp 18
Division 201, Woody Wetland 18
CES201.585 Laurentian-Acadian Alkaline Fen 20
Division 201, Woody Wetland 20
CES201.575 Laurentian-Acadian Alkaline Swamp 21
Division 201, Woody Wetland 21
CES201.578 Acadian Coastal Salt Marsh 22
Division 201, Herbaceous Wetland 22
CES201.579 Acadian Estuary Marsh 23
Division 201, Herbaceous Wetland 23
CES201.577 Laurentian-Acadian Wet Meadow-Shrub Swamp and Marsh 24
Division 201, Herbaceous Wetland 24
CES201.048 North Atlantic Rocky Intertidal 26
Division 201, Herbaceous Wetland 26
CES201.587 Laurentian-Acadian Floodplain Forest 27

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Division 201, Mixed Upland and Wetland 27
CES201.570 Laurentian-Acadian Calcareous Cliff and Talus 28
Division 201, Barren 28
CES201.586 Laurentian-Acadian Rocky Lakeshore 29
Division 201, Barren 29
CES201.051 North Atlantic Cobble Shore 30
Division 201, Barren 30
CES201.050 North Atlantic Intertidal Mudflat 31
Division 201, Barren 31
CES201.049 North Atlantic Tidal Sand Flat 32
Division 201, Barren 32
CES202.593 Appalachian Hemlock-Hardwood Forest 32
Division 202, Forest and Woodland 32
CES202.591 Central Appalachian Oak and Pine Forest 35
Division 202, Forest and Woodland 35
CES202.600 Central Appalachian Pine-Oak Rocky Woodland 36
Division 202, Forest and Woodland 36
CES202.592 Northeastern Interior Dry Oak Forest 38
Division 202, Forest and Woodland 38
CES202.604 North-Central Appalachian Acidic Swamp 40
Division 202, Woody Wetland 40
CES202.606 North-Central Interior and Appalachian Acid Peatland 41
Division 202, Woody Wetland 41
CES202.605 North-Central Interior and Appalachian Rich Swamp 43
Division 202, Woody Wetland 43
CES202.608 Central Appalachian Floodplain 44
Division 202, Mixed Upland and Wetland 44
CES202.609 Central Appalachian Riparian 46
Division 202, Mixed Upland and Wetland 46
CES202.601 North-Central Appalachian Acidic Cliff and Talus 47
Division 202, Barren 47
CES202.603 North-Central Appalachian Circumneutral Cliff and Talus 48
Division 202, Barren 48

CES103.020 Boreal Aspen-Birch Forest

Division 103, Forest and Woodland

Spatial Scale & Pattern: Matrix
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Forest and Woodland (Treed), Boreal [Boreal Continental], Intermediate Disturbance Interval
Concept Summary: These early-successional boreal hardwood forests and woodlands are widespread throughout the boreal region of Canada, extending into parts of the Laurentian-Acadian region, but more localized eastward. They originate naturally after fires and blowdowns, but more commonly originate after logging of conifer or mixed conifer-hardwood systems. *Populus tremuloides* and *Betula papyrifera* are the most important tree species. This system is maintained by repeated disturbance within 50 year return intervals and would

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otherwise succeed to conifer systems. Localized stands of mixed conifer-hardwoods (pines and spruces) can occur in this type, but are more typically part of conifer systems.
Comments: As defined here, these are deciduous forest-dominated systems. Mixed conifer-hardwoods areas will go in the appropriate conifer forest system.

DISTRIBUTION

Range: Upper Great Lakes and southern Canada east to Maine and the Canadian Maritimes.
Ecological Divisions: 103, 201
TNC Ecoregions: 47:, 48:, 63:
Subnations/Nations: MB:, ME:, MI:, MN:, NB:, NH:, NS:, NY:, ON:, PE:, WI:

CONCEPT

Associations:
Betula papyrifera / Diervilla lonicera - (Abies balsamea) Forest (H, G4?, Paper Birch / Fir Forest, CEGL002463)
Pinus banksiana - Populus tremuloides / Diervilla lonicera Forest (M, G4G5, Jack Pine - Aspen / Bush-honeysuckle Forest, CEGL002518)
Populus (tremuloides, balsamifera) - (Betula papyrifera) - Picea mariana / Alnus viridis Forest (L, G?, Aspen - Birch - Black Spruce / Green Alder Forest, CEGL002514)
Populus (tremuloides, grandidentata) - Betula (populifolia, papyrifera) Woodland (H, G5, Early Successional Woodland/Forest, CEGL006303)
Populus tremuloides - Betula papyrifera - (Acer rubrum, Populus grandidentata) Forest (H, G5, Aspen - Birch - Red Maple Forest, CEGL002467)
Populus tremuloides - Betula papyrifera / (Abies balsamea, Picea glauca) Forest (L, G5, Aspen - Birch / Boreal Conifer Forest, CEGL002466)

SOURCES

References: Eyre 1980
Last updated: 25 Mar 2003 **Stakeholders:** MCS, ECS, CAN
Concept Author: D. Faber-Langendoen **LeadResp:** MCS

CES103.021 Boreal White Spruce-Fir-Hardwood Forest

Division 103, Forest and Woodland

Spatial Scale & Pattern: Matrix
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Lowland, Forest and Woodland (Treed), Mesotrophic Soil, Oligotrophic Soil, Picea (glauca, mariana, rubens) - Abies
Concept Summary: This system represents the southern edge of the boreal forest, ranging from eastern Alberta to eastern Canada and southward into Minnesota and the Great Lakes region, and possibly northern New England. The low-elevation forests are dominated by *Picea glauca* and *Abies balsamea*. *Picea mariana* is often present, along with occasional *Pinus banksiana*. Codominant boreal hardwoods include *Populus tremuloides* and *Betula papyrifera*. Northern hardwoods are relatively minor. Soils are acidic and usually rocky, and range from well-drained to somewhat poorly drained. This is the matrix forest type of this division. This system may include earlier successional patches in which *Populus* spp. and *Betula* spp. are dominant or mixed with *Picea* and *Abies*, that will develop into spruce-fir forests. Blowdowns with

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subsequent gap regeneration are the most frequent form of natural disturbance, with large-scale fires important at longer return intervals.

DISTRIBUTION

Range: This system ranges from eastern Alberta to eastern Canada and southward into Minnesota and the Great Lakes region, and possibly northern New England.
Ecological Divisions: 103, 201, 205?
TNC Ecoregions: 47:C, 48:C, 63:C, 66:?
Subnations/Nations: AB:c, MB:c, ME:?, MI:c, MN:c, NB:?, ON:c, QC:c, SK:c, WI:c

CONCEPT

Associations:
Abies balsamea - Betula papyrifera / Diervilla lonicera Forest (H, G5, Balsam Fir - Paper Birch Forest, CEGL002474)
Picea glauca - Abies balsamea - Populus tremuloides / Mixed Herbs Forest (H, G5, Spruce - Fir - Aspen Forest, CEGL002475)
Picea glauca - Abies balsamea / Acer spicatum / Rubus pubescens Forest (H, G4G5, Spruce - Fir / Mountain Maple Forest, CEGL002446)
Picea mariana - Populus tremuloides / Mixed Herbs Forest (M, G4G5, Black Spruce - Aspen Rich Forest, CEGL002516)
Picea mariana / Pleurozium schreberi Forest (M, G5, Black Spruce / Feathermoss Forest, CEGL002447)

SOURCES

Last updated: 25 Mar 2003 **Stakeholders:** MCS, ECS, CAN
Concept Author: D. Faber-Langendoen **LeadResp:** MCS

CES201.565 Acadian Lowland Spruce-Fir-Hardwood Forest

Division 201, Forest and Woodland

Spatial Scale & Pattern: Matrix
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Lowland, Forest and Woodland (Treed), Mesotrophic Soil, Oligotrophic Soil, Picea (glauca, mariana, rubens) - Abies
Non-Diagnostic Classifiers: Sideslope, Toeslope/Valley Bottom, Glaciated, Acidic Soil, Mineral: W/ A-Horizon >10 cm, Sand Soil Texture, Loam Soil Texture, Udic, Long Disturbance Interval, W-Patch/Medium Intensity, Needle-Leaved Tree, Moderate (100-500 yrs) Persistence
Concept Summary: This system represents the Acadian and northern Appalachian red spruce-fir forest that extends to the southern boreal region of southeastern Canada. The low- to mid-elevation forests are dominated by *Picea rubens* and *Abies balsamea*. *Picea mariana* and *Picea glauca* are often present. *Betula alleghaniensis* is the most common codominant, and *Acer rubrum, Acer saccharum,* and *Fagus grandifolia* are often present. Soils are acidic and usually rocky, and range from well-drained to somewhat poorly drained. This is the matrix forest type in the lowland northern portions of this division. This system may include earlier successional patches in which *Populus* spp. and *Betula* spp. are dominant or mixed with *Picea* and *Abies,* that will develop into spruce-fir forests. Blowdowns with subsequent gap regeneration are the most frequent form of natural disturbance, with large-scale fires important at longer return intervals.

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Comments: An east-west separation may be warranted between the white spruce-balsam-northern hardwoods in the Laurentian region, and the red spruce-balsam fir-northern hardwoods to the east (though white spruce is also common in parts of the east). But the hardwoods component is essentially similar (though beech drops out in the most western part of this System). Further review is needed, and should be done in conjunction with the similar northern hardwood system, Laurentian-Acadian Northern Hardwoods Forest (CES201.564).

DISTRIBUTION

Range: Northern New England and northern New York and adjacent Canada; occasional southwards.
Ecological Divisions: 201, 202
TNC Ecoregions: 61:C, 63:C
Subnations/Nations: ME:c, NB:?, NH:c, NY:c, QC:?, VT:c

CONCEPT

Associations:
Picea mariana - Populus tremuloides / Mixed Herbs Forest (L, G4G5, Black Spruce - Aspen Rich Forest, CEGL002516)
Picea mariana / Pleurozium schreberi Forest (L, G5, Black Spruce / Feathermoss Forest, CEGL002447)
Picea rubens - Abies balsamea - Betula papyrifera Forest (H, G?, Low-Elevation Spruce - Fir Forest, CEGL006273)
Picea rubens - Abies balsamea - Betula spp. - Acer rubrum Forest (H, G?, Successional Spruce - Fir Forest, CEGL006505)
Picea rubens - Picea glauca Forest (H, G4G5, Maritime Spruce - Fir Forest, CEGL006151)

SOURCES

References: Lorimer 1977
Last updated: 24 Mar 2003
Concept Author: S.C. Gawler
Stakeholders: ECS, MCS
LeadResp: ECS

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CES201.566 Acadian Montane Spruce-Fir-Hardwood Forest

Division 201, Forest and Woodland

Spatial Scale & Pattern: Large Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Montane, Forest and Woodland (Treed), Ridge/Summit/Upper Slope, Picea (glauca, mariana, rubens) - Abies
Non-Diagnostic Classifiers: Glaciated, Mesotrophic Soil, Oligotrophic Soil, Acidic Soil, Mineral: W/ A-Horizon >10 cm, Loam Soil Texture, Udic, Long Disturbance Interval, W-Patch/Medium Intensity, Needle-Leaved Tree, Broad-Leaved Tree, Moderate (100-500 yrs) Persistence
Concept Summary: This is the matrix forest system in the montane spruce-fir region of the northern Appalachian Mountains, extending east through the Canadian Maritimes. It occurs mostly upwards of 1500 feet and is restricted to progressively higher elevations southward. Northward, it is often contiguous with Acadian Lowland Spruce-Fir-Hardwood Forest (CES201.565). These systems often are a mosaic of strongly coniferous patches and mixed patches, with occasional smaller inclusions of northern hardwoods. *Picea rubens* and *Abies balsamea* are the dominant conifers. Gaps formed by wind, snow, ice, and harvesting are the major replacement vectors; fires may be important but only over a long return interval.

DISTRIBUTION

Range: Higher elevations of northern New England and the Adirondacks, extending north along the mountains and higher hills into Canada.
Ecological Divisions: 201, 202
TNC Ecoregions: 60:P, 61:C, 63:C
Subnations/Nations: MA:c, ME:c, NH:c, NY:c, VT:c

CONCEPT

Associations:
Abies balsamea - (Betula papyrifera var. cordifolia) Forest (G?, Montane Fir - Birch Forest, CEGL006112)
Picea rubens - Abies balsamea - Betula spp. - Acer rubrum Forest (G?, Successional Spruce - Fir Forest, CEGL006505)
Picea rubens - Abies balsamea / Sorbus americana Forest (G3G5, Montane Spruce - Fir Forest, CEGL006128)
Picea rubens - Betula alleghaniensis / Dryopteris campyloptera Forest (G?, Red Spruce - Hardwoods Forest, CEGL006267)

SOURCES

Last updated: 14 Mar 2003
Concept Author: S.C. Gawler
Stakeholders: ECS
LeadResp: ECS

CES201.571 Laurentian-Acadian Acidic Rocky Outcrop

Division 201, Forest and Woodland

Spatial Scale & Pattern: Small Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland

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Diagnostic Classifiers: Lowland, Ridge/Summit/Upper Slope, Rock Outcrops/Barrens/Glades, Glaciated, Acidic Soil
Non-Diagnostic Classifiers: Forest and Woodland (Treed), Oligotrophic Soil, Very Shallow Soil, Mineral: W/ A-Horizon >10 cm, Mineral: W/ A-Horizon <10 cm, Sand Soil Texture, Loam Soil Texture, Udic, Consolidated, Long Disturbance Interval, F-Patch/Low Intensity, W-Landscape/Medium Intensity, Needle-Leaved Tree, Broad-Leaved Deciduous Tree, Broad-Leaved Shrub, Dwarf-Shrub, Graminoid, Nonvascular
Concept Summary: This outcrop system ranges across New England and the upper Great Lakes region and adjacent Canada, where it is found on ridges or summits of resistant acidic bedrock at low to mid elevations. The vegetation is patchy, often a mosaic of woodlands and open glades. *Quercus rubra*, *Quercus ellipsoidalis*, and various conifers including *Pinus banksiana* in the west and *Pinus rigida* or *Pinus strobus* in the east are characteristic trees, and low heath shrubs are often present. Exposure and occasional fire are the major factors in keeping the vegetation relatively open.

DISTRIBUTION

Range: New England and adjacent Canada west to the Great Lakes and northern Minnesota.
Ecological Divisions: 201
TNC Ecoregions: 47:C, 48:C, 60:P, 63:C, 64:P
Subnations/Nations: ME:c, MI:c, MN:c, NH:c, NY:c, VT:c, WI:c

CONCEPT

Associations:
(Pinus strobus, Quercus rubra) / Danthonia spicata Acid Bedrock Wooded Herbaceous Vegetation (G3G4, White Pine - Red Oak Bedrock Glade, CEGL005101)
Danthonia spicata - Poa compressa Granite Herbaceous Vegetation (G?, Poverty Grass Granite Barrens, CEGL005157)
Juniperus communis - (Quercus rubra) / Juniperus horizontalis - Arctostaphylos uva-ursi Shrubland (G3G4, Common Juniper Rocky Krummholz, CEGL005065)
Picea rubens / Vaccinium angustifolium / Sibbaldiopsis tridentata Woodland (G3G5, Spruce - Fir Rocky Ridge, CEGL006053)
Pinus banksiana - Pinus strobus - (Quercus rubra) / Cladina spp. Nonvascular Vegetation (M, G3G5, Mixed Pine - (Oak) Igneous - Metamorphic Rock Outcrop, CEGL002491)
Pinus banksiana / (Quercus rubra, Quercus ellipsoidalis) Forest (M, G4?, Jack Pine / Scrub Oak Forest, CEGL002440)
Pinus banksiana / Kalmia angustifolia - Vaccinium spp. Woodland (G3G5, Jack Pine Heath Barren, CEGL006041)
Pinus resinosa / Gaylussacia baccata - Vaccinium angustifolium Woodland (G3G5, Red Pine Woodland, cegl006010)
Pinus rigida - Quercus (coccinea, velutina) / Schizachyrium scoparium Woodland (M, G3G5, CEGL006166)
Pinus rigida / Corema conradii Woodland (M, G2, Coastal Pitch Pine Rocky Woodland, CEGL006154)
Pinus rigida / Photinia melanocarpa / Deschampsia flexuosa - Schizachyrium scoparium Woodland (G?, Pitch Pine Rocky Summit, CEGL006116)
Populus tremuloides - (Populus grandidentata) Rocky Woodland (G?, Mixed Aspen Rocky Woodland, CEGL002487)

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Quercus ellipsoidalis - Quercus macrocarpa - (Pinus banksiana) Rocky Woodland (G?, Boreal Oak - (Pine) Rocky Woodland, CEGL005246)
Quercus rubra - (Quercus prinus) / Vaccinium spp. / Deschampsia flexuosa Woodland (G3G5, Appalachian Red Oak Woodland (Northern Type), CEGL006134)
Vaccinium angustifolium - Sorbus americana / Sibbaldiopsis tridentata Dwarf-shrubland (G?, Blueberry Granite Barrens, CEGL005094)

SOURCES

Last updated: 14 Mar 2003
Concept Author: S.C. Gawler
Stakeholders: ECS, MCS
LeadResp: ECS

CES201.564 Laurentian-Acadian Northern Hardwoods Forest

Division 201, Forest and Woodland

Spatial Scale & Pattern: Matrix
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Montane, Forest and Woodland (Treed), Eutrophic Soil, Mesotrophic Soil, Broad-Leaved Tree, Acer saccharum - Betula spp.
Non-Diagnostic Classifiers: Lowland, Ridge/Summit/Upper Slope, Sideslope, Glaciated, Circumneutral Soil, Acidic Soil, Shallow Soil, Deep Soil, Mineral: W/ A-Horizon >10 cm, Loam Soil Texture, Udic, Long Disturbance Interval, W-Patch/Medium Intensity
Concept Summary: These northern hardwood forests range across New England and adjacent Canada west to Minnesota. They occur in various dry-mesic to wet-mesic settings at low to moderate elevations (generally <2000 feet) throughout the Laurentian-Acadian Division. *Acer saccharum*, *Betula alleghaniensis*, and *Fagus grandifolia* are the dominant trees (the latter only east of Lake Michigan). *Tsuga canadensis* or, in the Northeast, *Picea rubens* are common minor canopy associates. *Ostrya virginiana* is frequent but not dominant. Oak is a minor component, and absent from northern regions. Soils range from moderately nutrient-poor to quite enriched, with associated shifts in the herb flora. Blowdowns or snow and ice loading, with subsequent gap regeneration, are the most frequent form of natural disturbance.
Comments: An east-west separation may be warranted between the Laurentian and Acadian region. But the hardwoods component is essentially similar (though beech drops out in the most western part of this system). Further review is needed, and should be done in conjunction with the similar spruce-fir-northern hardwood system, Acadian Lowland Spruce-Fir-Hardwood Forest (CES201.565).

DISTRIBUTION

Range: Northern New England and northern New York west across the upper Great Lakes to northern Minnesota, and adjacent Canada; occasional southwards.
Ecological Divisions: 201, 202
TNC Ecoregions: 47:C, 48:C, 60:C, 61:C, 63:C, 64:C
Subnations/Nations: MA:c, ME:c, MI:c, MN:c, NB:?, NH:c, NY:c, ON:?, QC:?, VT:c, WI:c

CONCEPT

Associations:
Acer saccharum - (Fraxinus americana) / Arisaema triphyllum Forest (G?, Semi-rich Northern Hardwood Forest, CEGL006211)

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Acer saccharum - Betula alleghaniensis - (Tilia americana) Forest (G3G4, Maple - Yellow Birch Northern Hardwoods Forest, CEGL002457)
Acer saccharum - Betula alleghaniensis - Fagus grandifolia / Viburnum lantanoides Forest (G3G5, Northern Hardwood Forest, CEGL006252)
Acer saccharum - Betula alleghaniensis - Prunus serotina Forest (G4, Central Appalachian Northern Hardwood Forest, CEGL006045)
Acer saccharum - Fagus grandifolia - Betula spp. / Maianthemum canadense Forest (G4G5, Beech - Maple - Northern Hardwoods Forest, CEGL005004)
Acer saccharum - Fraxinus americana - Juglans cinerea / Staphylea trifolia Forest (G4?, CEGL006020)
Acer saccharum - Fraxinus americana - Tilia americana - Liriodendron tulipifera / Actaea racemosa Forest (G4?, CEGL006237)
Acer saccharum - Fraxinus americana - Tilia americana / Acer spicatum / Allium tricoccum - Caulophyllum thalictroides Forest (G4?, Sugar Maple - Ash - Basswood Northern Appalachian Rich Mesic Forest, CEGL005008)
Acer saccharum - Tilia americana / Ostrya virginiana - Carpinus caroliniana Forest (G3G4, North-central Maple - Basswood Forest, CEGL002062)
Acer saccharum - Tilia americana / Ostrya virginiana / Lonicera canadensis Forest (G3?, Northern Maple - Basswood Forest, CEGL002458)
Clay Seeps Sparse Vegetation (G?, Clay Seeps, CEGL005163)
Symplocarpus foetidus Herbaceous Vegetation (G4?, Skunk Cabbage Seepage Meadow, CEGL002385)
Thuja occidentalis - Betula alleghaniensis Forest (G2Q, Northern White-cedar - Yellow Birch Forest, CEGL002450)
Thuja occidentalis / Abies balsamea - Acer spicatum Forest (G4, White-cedar - Boreal Conifer Mesic Forest, CEGL002449)

SOURCES

References: Comer and Albert 1997, Comer et al. 1995a, Comer et al. 1998
Last updated: 14 Mar 2003 **Stakeholders:** ECS, MCS
Concept Author: S.C. Gawler **LeadResp:** ECS

CES201.563 Laurentian-Acadian Pine-Hemlock-Hardwood Forest

Division 201, Forest and Woodland

Spatial Scale & Pattern: Matrix
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Lowland, Forest and Woodland (Treed), Pinus spp. - Tsuga canadensis
Non-Diagnostic Classifiers: Sideslope, Glaciated, Mesotrophic Soil, Acidic Soil, Shallow Soil, Deep Soil, Mineral: W/ A-Horizon >10 cm, Sand Soil Texture, Loam Soil Texture, Udic, Very Long Disturbance Interval, F-Landscape/Medium Intensity, W-Patch/Medium Intensity, Needle-Leaved Tree, Broad-Leaved Deciduous Tree
Concept Summary: This north-temperate forest system ranges from the northeastern U.S. and adjacent Canada west to the Great Lakes and upper Midwest. The mesic to dry-mesic forests usually occur on low-nutrient soils at low elevations, mostly <2000 feet. Canopy dominants include *Pinus strobus, Tsuga canadensis,* and *Quercus rubra* in varying percentages. *Acer rubrum* is also quite common. *Quercus velutina* and *Quercus alba* are essentially absent from

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this system, being more representative of systems in the Central Interior-Appalachian Division to the south. This is a widespread, matrix forest type for the more temperate portions of this division. Gap replacement and infrequent fire are the major natural regeneration modes.

DISTRIBUTION

Range: New England west to the Great Lakes and northern Minnesota.
Ecological Divisions: 201
TNC Ecoregions: 47:C, 48:C, 63:C, 64:P
Subnations/Nations: ME:c, MI:c, MN:c, NH:c, NY:c, PA:c, VT:c, WI:c

CONCEPT

Associations:
(Pinus strobus, Quercus rubra) / Danthonia spicata Acid Bedrock Wooded Herbaceous Vegetation (G3G4, White Pine - Red Oak Bedrock Glade, CEGL005101)
Acer rubrum - Nyssa sylvatica - Betula alleghaniensis / Sphagnum spp. Forest (G?, Red Maple - Black Gum Basin Swamp, CEGL006014)
Acer saccharum - Pinus strobus / Acer pensylvanicum Forest (G?, Northern Hardwood - White Pine Forest, CEGL005005)
Betula alleghaniensis - Acer rubrum - (Tsuga canadensis, Abies balsamea) / Osmunda cinnamomea Forest (G4?, Hardwood - Conifer Seepage Forest, CEGL006380)
Clay Seeps Sparse Vegetation (G?, Clay Seeps, CEGL005163)
Pinus strobus - (Pinus resinosa) - Quercus rubra Forest (G4G5, White Pine - Red Oak Forest, CEGL002480)
Pinus strobus - Quercus (rubra, velutina) - Fagus grandifolia Forest (G5, White Pine - Oak Forest, CEGL006293)
Pinus strobus - Quercus alba / (Corylus americana, Gaylussacia baccata) Forest (G3, White Pine - White Oak Sand Forest, CEGL002481)
Pinus strobus - Tsuga canadensis - Picea rubens Forest (G?, White Pine - Hemlock - Red Spruce Forest, CEGL006324)
Pinus strobus - Tsuga canadensis Great Lakes Forest (G3, Great Lakes White Pine - Hemlock Forest, CEGL002590)
Pinus strobus / Acer spicatum - Corylus cornuta Forest (G3G4, White Pine / Mountain Maple Mesic Forest, CEGL002445)
Quercus rubra - Acer rubrum - Betula spp. - Pinus strobus Forest (G?, Northern Oak - Pine Forest, CEGL006506)
Quercus rubra - Acer saccharum - Fagus grandifolia / Viburnum acerifolium Forest (G?, Red Oak - Northern Hardwood Forest, CEGL006173)
Quercus rubra - Acer saccharum - Liriodendron tulipifera Forest (G?, High Allegheny Rich Red Oak - Sugar Maple Forest, CEGL006125)
Quercus rubra - Acer saccharum Forest (G4G5, Northern Red Oak - Sugar Maple Forest, CEGL002461)
Quercus rubra - Quercus alba - (Quercus velutina, Acer rubrum) / Viburnum acerifolium Forest (G?, Northern Red Oak - White Oak - (Maple) Forest, CEGL002462)
Symplocarpus foetidus Herbaceous Vegetation (G4?, Skunk Cabbage Seepage Meadow, CEGL002385)
Thuja occidentalis - (Betula alleghaniensis, Tsuga canadensis) Forest (G3?, White-cedar - (Hemlock) Mesic Forest, CEGL002595)

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Tsuga canadensis - (Betula alleghaniensis) - Picea rubens / Cornus canadensis Forest (G?, Hemlock - Spruce - Hardwood Forest, CEGL006129)
Tsuga canadensis - (Betula alleghaniensis) Forest (G3G4, Hemlock Mesic Forest, CEGL002598)
Tsuga canadensis - Acer saccharum - Betula alleghaniensis Forest (G4?, North Central Hemlock - Hardwood Forest, CEGL005044)
Tsuga canadensis - Fagus grandifolia - (Acer saccharum) Great Lakes Forest (G4G5, Great Lakes Hemlock - Beech - Hardwood Forest, CEGL005042)
Tsuga canadensis - Fagus grandifolia - Acer saccharum / (Hamamelis virginiana, Kalmia latifolia) Forest (G3?, East-central Hemlock Hardwood Forest, CEGL005043)

SOURCES

References: Comer and Albert 1997, Comer et al. 1995a, Comer et al. 1998, Whitney 1984
Last updated: 09 Jan 2003 **Stakeholders:** ECS, MCS
Concept Author: S.C. Gawler **LeadResp:** ECS

CES201.719 Laurentian-Acadian White Pine-Red Pine Forest

Division 201, Forest and Woodland

Spatial Scale & Pattern: Matrix Classification Confidence: high
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Forest and Woodland (Treed)
Concept Summary: This pine forest system is found on nutrient-poor to moderately rich soils in a variety of topographic settings. Soils are loamy to sandy, varying from thin soil over bedrock to deeper soils, sometimes sandy. Sites are xeric to subxeric, but less strongly than barrens and sandplains. The dominant fire regime varies from 100-200 years for *Pinus strobus* and *Pinus resinosa*. Other boreal conifers may occasionally be present. Canopy structure is mostly closed-canopy but can be partially open. Conifers typically dominate the canopy, but boreal hardwoods (*Populus tremuloides, Betula papyrifera*) or hardwoods (*Acer rubrum, Quercus rubra*) may codominate. The shrub and field layers can be somewhat dense to sparse.
Comments: This system is dominated by white and red pine forests, which are found primarily in the Great Lakes and sub-boreal region, but extend eastward to Acadia.

DISTRIBUTION

Ecological Divisions: 201
TNC Ecoregions: 47:, 48:, 60:, 61:?, 63:
Subnations/Nations: MB:, ME:, MI:, MN:, NB:, NH:, NS:, NY:, ON:, PE:, WI:

CONCEPT

Associations:
Pinus resinosa - Populus tremuloides / Diervilla lonicera - Vaccinium spp. Forest (H, G?, Red Pine - Aspen - Birch Forest, CEGL002520)
Pinus resinosa / Vaccinium spp. Forest (H, G3, Red Pine / Blueberry Dry Forest, CEGL002443)
Pinus strobus - Populus tremuloides / Corylus cornuta Forest (H, G4?, White Pine - Aspen - Birch Forest, CEGL002479)
Pinus strobus - Tsuga canadensis - Picea rubens Forest (M, G?, White Pine - Hemlock - Red Spruce Forest, CEGL006324)
Pinus strobus / Acer spicatum - Corylus cornuta Forest (H, G3G4, White Pine / Mountain Maple Mesic Forest, CEGL002445)

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Pinus strobus / Vaccinium spp. Forest (H, G3G4, White Pine / Blueberry Dry-Mesic Forest, CEGL002444)

SOURCES

References: Comer et al. 1995a, Comer et al. 1998, Frelich 1992, Heinselman 1973, Whitney 1986, Whitney 1987
Last updated: 24 Mar 2003 **Stakeholders:** MCS, ECS, CAN
Concept Author: D. Faber-Langendoen **LeadResp:** MCS

CES201.567 Acadian Alpine Barrens

Division 201, Shrubland

Spatial Scale & Pattern: Large Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Alpine/AltiAndino, Shrubland (Shrub-dominated), Moss/Lichen (Nonvascular), Ridge/Summit/Upper Slope
Non-Diagnostic Classifiers: Glaciated, Oligotrophic Soil, Acidic Soil, Very Shallow Soil, Aquic, Udic, Consolidated, Landslide, W-Landscape/High Intensity, Dwarf-Shrub, Graminoid, Lichen, Long (>500 yrs) Persistence
Concept Summary: Restricted to the northern Appalachians and the Gaspe Peninsula, this system encompasses vegetation above treeline on northeastern mountains. Wind, snow, and cloud-cover fog are prominent environmental factors. Most of the cover is dwarf-shrubland, lichen, or sparse vegetation; islands of taller shrubs may occur in protected spots. The dominant plants are ericads (*Vaccinium uliginosum* is diagnostic and often dominant, with several other alpine-restricted ericads such as *Phyllodoce caerulea* and *Loiseleuria procumbens*) and cushion-plants such as *Diapensia lapponica*. *Carex bigelowii* is a characteristic and, in some places, locally dominant sedge. This system includes wetland depressions, small alpine bogs, within the surrounding upland matrix.

DISTRIBUTION

Range: Higher summits of the northern Appalachian mountains, from northern New England and the Adirondacks into the Canadian Gaspe.
Ecological Divisions: 201
TNC Ecoregions: 63:C
Subnations/Nations: ME:c, NH:, NY:, QC:, VT:

CONCEPT

Associations:
Carex bigelowii Herbaceous Vegetation (G2, Bigelow's Sedge Alpine Meadow, CEGL006081)
Diapensia lapponica Dwarf-shrubland (G2G3, Windswept Alpine Ridge, CEGL006322)
Empetrum nigrum - Vaccinium uliginosum - Vaccinium oxycoccos / Rubus chamaemorus Dwarf-shrubland (G?, Black Crowberry Wet Alpine Bog, CEGL006140)
Kalmia angustifolia - Chamaedaphne calyculata / Rubus chamaemorus / Cladina spp. Dwarf-shrubland (G?, CEGL006425)
Lichen Fellfield Sparse Vegetation [Provisional] (G?, Lichen Fellfield, CEGL006420)
Trichophorum caespitosum - Calamagrostis pickeringii Herbaceous Vegetation (G?, CEGL006423)

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Trichophorum caespitosum - Carex scirpoidea - Carex bigelowii Herbaceous Vegetation (G?, CEGL006424)
Trichophorum caespitosum - Saxifraga (foliolosa, paniculata, rivularis) Herbaceous Vegetation (G?, Northern Appalachian Alpine Cliff, CEGL006428)
Vaccinium uliginosum - Harrimanella hypnoides - Loiseleuria procumbens Dwarf-shrubland (G2G3, Alpine Heath Snowbank, CEGL006155)
Vaccinium uliginosum - Rhododendron lapponicum / Juncus trifidus Dwarf-shrubland (G2G3, Alpine Heath Meadow, CEGL006298)

SOURCES

References: Bliss 1963, Kimball and Weihrauch 2000, Sperduto and Cogbill 1999
Last updated: 09 Jan 2003 **Stakeholders:** ECS
Concept Author: S.C. Gawler **LeadResp:** ECS

CES201.568 Acadian Subalpine Woodland and Barrens

Division 201, Shrubland

Spatial Scale & Pattern: Large Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Alpine/AltiAndino, Shrubland (Shrub-dominated), Ridge/Summit/Upper Slope, Picea (glauca, mariana, rubens) - Abies
Non-Diagnostic Classifiers: Montane, Forest and Woodland (Treed), Moss/Lichen (Nonvascular), Glaciated, Mesotrophic Soil, Oligotrophic Soil, Acidic Soil, Very Shallow Soil, Shallow Soil, Mineral: W/ A-Horizon >10 cm, Mineral: W/ A-Horizon <10 cm, Udic, Consolidated, Intermediate Disturbance Interval, Long Disturbance Interval, F-Patch/Medium Intensity, W-Landscape/High Intensity, Needle-Leaved Tree, Broad-Leaved Shrub, Long (>500 yrs) Persistence
Concept Summary: This system encompasses vegetation of varying physiognomy at upper elevations, near and slightly above treeline, in the northeastern U.S. and adjacent Canada. This system may be a zone between montane spruce-fir forest and alpine systems, or may cover the ridgelines and summits of lower mountains. In the Appalachians it occurs mostly above 2500 feet, but can be at much lower elevations near the Atlantic Coast. The trees become progressively stunted as exposure increases, with *Picea rubens* being replaced by *Picea mariana*. *Abies balsamea* is also a prominent tree species, and may occur as "fir-wave" forests. Vegetation structure ranges from forest to woodland to shrubland to sparsely vegetated dwarf-shrubs and herbs. Forest and woodland are most extensive, and patches of open rock support areas of shrub, dwarf-shrub or sparse vegetation. In the subalpine zone, shrublands may be extensive on the upper slopes, forming krummholz or, in somewhat more protected spots, deciduous shrub thickets. Ericads including *Kalmia angustifolia, Ledum groenlandicum,* and *Vaccinium uliginosum*, are the most characteristic shrubs; *Empetrum nigrum* and *Empetrum eamesii ssp. atropurpureum (= Empetrum atropurpureum)* are indicative of the subalpine zone. Subalpine fens, restricted to the White Mountains, are included here. These are heath-dominated and graminoid-dominated fens, often occurring in a mosaic surrounded by other subalpine vegetation. They are on gentle slopes (usually ca. 10%), usually at 2400-3000 feet. *Calamagrostis pickeringii* is dominant and characteristic in the graminoid fens, with northern sedges such as *Carex michauxiana, Carex wiegandii, Carex exilis*, etc. The montane heath fens contain *Alnus viridis ssp. crispa (= Alnus crispa), Nemopanthus mucronatus*, and ericads. Peat

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accumulation is in the 10-50 cm range. These are usually ca. 5 acres in size, but range up to about 20 acres.
Comments: Subalpine fens are considered a distinct system by NHHP (the only state where they're currently known from), but because (1) there is little information available on them yet and (2) the alpine system includes alpine wetlands as well as uplands, they are included within this system. This could be reconsidered as more information on their landscape distribution, extent and pattern becomes available.

DISTRIBUTION

Range: Higher summits of the northern Appalachian mountains, from northern New England and the Adirondacks into the Canadian Gaspe, extending south in scattered locations into southern New England.
Ecological Divisions: 201, 202
TNC Ecoregions: 61:C, 63:C
Subnations/Nations: ME:c, NB:, NH:c, NY:c, QC:, VT:c

CONCEPT

Associations:
Abies balsamea - (Betula papyrifera var. cordifolia) Forest (G?, Montane Fir - Birch Forest, CEGL006112)
Empetrum nigrum - Vaccinium uliginosum - Vaccinium oxycoccos / Rubus chamaemorus Dwarf-shrubland (G?, Black Crowberry Wet Alpine Bog, CEGL006140)
Kalmia angustifolia - Chamaedaphne calyculata / Rubus chamaemorus / Cladina spp. Dwarf-shrubland (G?, CEGL006425)
Picea mariana - Abies balsamea / Sibbaldiopsis tridentata Shrubland (G?, Black Spruce Krummholz, CEGL006038)
Picea mariana / Kalmia angustifolia Dwarf-shrubland (G?, Subalpine Summit Heath, CEGL006031)
Picea mariana / Ledum groenlandicum - Empetrum nigrum / Cladina spp. Dwarf-shrubland (G3G5, Cold Air Talus Heathland, CEGL006268)
Picea rubens / Vaccinium angustifolium / Sibbaldiopsis tridentata Woodland (G3G5, Spruce - Fir Rocky Ridge, CEGL006053)

SOURCES

References: Sperduto and Cogbill 1999
Last updated: 09 Jan 2003 **Stakeholders:** ECS
Concept Author: S.C. Gawler **LeadResp:** ECS

CES201.573 Acadian-North Atlantic Rocky Coast

Division 201, Shrubland

Spatial Scale & Pattern: Small Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Shrubland (Shrub-dominated), Moss/Lichen (Nonvascular), Rocks and Derived Substrates of the Immediate Coast
Non-Diagnostic Classifiers: Lowland, Glaciated, Very Shallow Soil, Mineral: W/ A-Horizon <10 cm, Consolidated, Unconsolidated, W-Landscape/Medium Intensity, Moderate (100-500 yrs) Persistence, Long (>500 yrs) Persistence

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Concept Summary: This system encompasses non-forested uplands along the immediate Atlantic Coast, from north of Cape Cod to the Canadian maritimes. It is often a narrow zone between the high tide line and the upland forest; this zone becomes wider with increasing maritime influence. The substrate is rock, sometimes with a shallow soil layer, and tree growth is prevented by extreme exposure to wind, salt spray, and fog. Cover is patchy shrubs, dwarf-shrubs and sparse vascular vegetation, sometimes with a few stunted trees. Many coastal islands have graminoid-shrub areas that were maintained by sheep grazing and now persist even after grazing has ceased.

DISTRIBUTION

Range: Primary range is Maine eastward into the Canadian Maritimes, with peripheral occurrences southward along the New England rocky coast.
Ecological Divisions: 201, 202
TNC Ecoregions: 62:C, 63:C
Subnations/Nations: CT:?, MA:c, ME:c, NB:, NH:p

CONCEPT

Associations:
Cakile edentula ssp. edentula - Mertensia maritima Sparse Vegetation (G?, Northern Maritime Beach Strand, CEGL006106)
Morella pensylvanica - Empetrum nigrum Dwarf-shrubland (G?, Crowberry - Bayberry Maritime Shrubland, CEGL006510)
Morella pensylvanica - Prunus maritima Shrubland (G4, Northern Bayberry Dune Shrubland, CEGL006295)
Prunus serotina - Rhus typhina Shrubland (G?, Rocky Headland, CEGL006399)
Solidago sempervirens - (Rhodiola rosea) - Juniperus horizontalis Sparse Vegetation (G?, Northern Maritime Rocky Headlands, CEGL006529)

SOURCES

Last updated: 09 Jan 2003
Concept Author: S.C. Gawler
Stakeholders: ECS
LeadResp: ECS

CES201.569 Laurentian-Acadian Acidic Cliff and Talus

Division 201, Shrubland

Spatial Scale & Pattern: Small Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Ridge/Summit/Upper Slope, Cliff (Substrate), Talus (Substrate), Acidic Soil, Landslide
Non-Diagnostic Classifiers: Montane, Lowland, Shrubland (Shrub-dominated), Moss/Lichen (Nonvascular), Glaciated, Very Shallow Soil, Mineral: W/ A-Horizon <10 cm, Intermediate Disturbance Interval [Periodicity/Polycyclic Disturbance], Moderate (100-500 yrs) Persistence
Concept Summary: This cliff system occurs at low to mid elevations, well below treeline, from New England west to the Great Lakes. It consists of vertical or near-vertical cliffs and the talus slopes below, formed on hills of granitic or otherwise acidic bedrock. Most of the substrate is dry and exposed, but small (occasionally large) areas of seepage are often present. Vegetation in seepage areas tends to be more well-developed and floristically different from the surrounding dry cliffs. The vegetation is patchy and often sparse, punctuated with patches of small trees

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(e.g., *Betula* and *Picea* spp.). Calciphilic species are absent. This system differs from the more southerly North-Central Appalachian Acidic Cliff and Talus (CES202.601) in the more boreal affinities of its flora, for example *Picea* spp. rather than *Juniperus virginiana*.

DISTRIBUTION

Range: New England and adjacent Canada west to the Great Lakes.
Ecological Divisions: 201, 202
TNC Ecoregions: 47:C, 48:C, 61:C, 63:C
Subnations/Nations: MA:?, ME:c, MI:c, MN:c, NH:c, NY:c, VT:c, WI:c

CONCEPT

Associations:
Acer spicatum - Thuja occidentalis - Betula papyrifera / Taxus canadensis Shrubland (G?, Northern (Laurentian) Igneous - Metamorphic Moist Cliff Scrub, CEGL005251)
Basalt - Diabase Northern Open Talus Sparse Vegetation (G?, Northern Basalt - Diabase Open Talus, CEGL005247)
Betula alleghaniensis - Quercus rubra / Polypodium virginianum Woodland (G3G5, Northern Hardwood - Oak Talus Slope Woodland, CEGL006320)
Betula papyrifera - Picea glauca / Acer spicatum - Alnus viridis / Polypodium virginianum Talus Shrubland [Provisional] (G?, Northern Basalt - Diabase Scrub Talus, CEGL005252)
Drosera rotundifolia - Viola spp. Cliff Sparse Vegetation (G?, Northern Appalachian Cliff Seep, CEGL006429)
Granite - Metamorphic Talus Northern Sparse Vegetation (G4G5, Northern Granite - Metamorphic Talus, CEGL002409)
Igneous - Metamorphic Northern Dry Cliff Sparse Vegetation (G?, Northern (Laurentian) Igneous - Metamorphic Dry Cliff, CEGL002300)
Picea mariana / Ledum groenlandicum - Empetrum nigrum / Cladina spp. Dwarf-shrubland (G3G5, Cold Air Talus Heathland, CEGL006268)
Picea rubens / Ribes glandulosum Woodland (G3G5, Red Spruce Talus Slope Woodland, CEGL006250)
Polypodium (virginianum, appalachianum) / Lichens Nonvascular Vegetation (G?, Northern Lichen Talus Barrens, CEGL006534)
Sandstone Dry Cliff Sparse Vegetation (G4G5, Midwest Dry Sandstone Cliff, CEGL002045)
Sandstone Midwest Moist Cliff Sparse Vegetation (G4G5, Midwest Moist Sandstone Cliff, CEGL002287)

SOURCES

Last updated: 09 Jan 2003
Concept Author: S.C. Gawler
Stakeholders: ECS, MCS
LeadResp: ECS

CES201.580 Acadian Maritime Bog

Division 201, Woody Wetland

Spatial Scale & Pattern: Large Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Wetland
Diagnostic Classifiers: Organic Peat (>40 cm), Dwarf-Shrub, Graminoid, Maritime Climate

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Non-Diagnostic Classifiers: Shrubland (Shrub-dominated), Bryophyte, Moderate (100-500 yrs) Persistence, Extensive Wet Flat, Depressional, Oligotrophic Water, Acidic Water, Saturated Soil, >180-day hydroperiod

Concept Summary: These ombrotrophic acidic peatlands occur along the north Atlantic Coast from downeast Maine east into the Canadian maritimes. When these form in basins, they develop raised plateaus with undulating sedge and dwarf-shrub vegetation. *Trichophorum caespitosum* may form sedge lawns on the raised plateau. The system may also occur as "blanket bogs" over a sloping rocky substrate in extreme maritime settings; here, dwarf-shrubs and *Sphagnum* are the dominant cover. Species characteristic of this maritime setting include *Empetrum nigrum* and *Rubus chamaemorus*. Typical bog heaths such as *Kalmia angustifolia, Kalmia polifolia, Gaylussacia baccata, Ledum groenlandicum,* and *Gaylussacia dumosa* are also present. Morphological characteristics and certain coastal species distinguish these from more inland raised bogs. The distribution is primarily Canadian, and these peatlands are rare in the U.S.

DISTRIBUTION

Range: Eastern Maine eastward into the Canadian Maritimes, near the coast.
Ecological Divisions: 201
TNC Ecoregions: 63:C
Subnations/Nations: ME:c, NB:

CONCEPT

Associations:
Empetrum nigrum - Gaylussacia dumosa - Rubus chamaemorus / Sphagnum spp. Dwarf-shrubland (G3G5, Maritime Crowberry Bog, CEGL006248)
Kalmia angustifolia - Chamaedaphne calyculata - (Picea mariana) / Cladina spp. Dwarf-shrubland (G5, Raised Dwarf-shrub Bog, CEGL006225)
Picea mariana / (Vaccinium corymbosum, Gaylussacia baccata) / Sphagnum sp. Woodland (G3G5, Black Spruce Woodland Bog, CEGL006098)
Picea mariana / Rubus chamaemorus / Sphagnum spp. Woodland (G3G5, Coastal Black Spruce Woodland Bogs, CEGL006082)
Trichophorum caespitosum - Gaylussacia dumosa / Sphagnum (fuscum, rubellum, magellanicum) Herbaceous Vegetation (G?, Maritime Peatland Sedge Lawn, CEGL006260)

SOURCES

References: Damman and French 1987
Last updated: 09 Jan 2003 **Stakeholders:** ECS
Concept Author: S.C. Gawler **LeadResp:** ECS

CES201.583 Laurentian-Acadian Acidic Basin Fen

Division 201, Woody Wetland

Spatial Scale & Pattern: Large Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Wetland
Diagnostic Classifiers: Organic Peat (>40 cm), Broad-Leaved Shrub, Dwarf-Shrub, Graminoid, Picea mariana - Larix laricina, Extensive Wet Flat, Depressional, Acidic Water
Non-Diagnostic Classifiers: Shrubland (Shrub-dominated), Moderate (100-500 yrs) Persistence, Oligotrophic Water, Shallow (<15 cm) Water

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Concept Summary: This peatland system ranges over a broad geographic area across the glaciated northeast to the Great Lakes and upper Midwest. The fens have developed in open or closed, relatively shallow basins with nutrient-poor and acidic conditions. Many occur in association with larger lakes or streams. The substrate is *Sphagnum*, and vegetation typically includes areas of graminoid dominance and dwarf-shrub dominance. *Chamaedaphne calyculata* is usually present and often dominant. Scattered stunted trees may be present. These fens often develop adjacent to open water. They lack the ribbed or reticulate microtopographical patterning of the patterned fen system.
Comments: Need to clarify the conceptual boundaries between this and the boreal fens in central and eastern Canada.

DISTRIBUTION

Range: New England and adjacent Canada west to the Great Lakes and Minnesota, north of the glacial boundary.
Ecological Divisions: 201, 202
TNC Ecoregions: 47:C, 48:P, 61:C, 63:C
Subnations/Nations: MA:c, ME:c, MI:c, MN:c, NB:, NH:c, NY:c, QC:, VT:c, WI:c

CONCEPT

Associations:
Carex (oligosperma, exilis) - Chamaedaphne calyculata Shrub Herbaceous Vegetation (G?, Few-seeded Sedge - Leatherleaf Fen, CEGL006524)
Carex lasiocarpa - Carex oligosperma / Sphagnum spp. Herbaceous Vegetation (G3G4, Northern Sedge Poor Fen, CEGL002265)
Carex oligosperma - Carex pauciflora - Eriophorum vaginatum / Sphagnum spp. Herbaceous Vegetation (G4G5, Open Graminoid / Sphagnum Bog, CEGL005256)
Chamaedaphne calyculata / Carex oligosperma / Sphagnum spp. Poor Fen Dwarf-shrubland (G5, Leatherleaf Poor Fen, CEGL005277)
Larix laricina / Chamaedaphne calyculata / Carex lasiocarpa Shrubland (G4G5, Tamarack Scrub Poor Fen, CEGL005226)
Myrica gale - Chamaedaphne calyculata / Carex (lasiocarpa, utriculata) - Utricularia spp. Shrub Herbaceous Vegetation (G4G5, Medium Fen, CEGL006302)
Myrica gale - Spiraea alba - Chamaedaphne calyculata Shrubland (G?, Sweetgale Mixed Shrub Fen, CEGL006512)
Picea mariana / Chamaedaphne calyculata / Sphagnum spp. Dwarf-shrubland (G4G5, Black Spruce / Leatherleaf Semi-treed Bog, CEGL005218)
Vaccinium corymbosum / Sphagnum spp. Shrubland (G3G5, Highbush Blueberry Bog Thicket, CEGL006190)

SOURCES

References: Damman and French 1987
Last updated: 09 Jan 2003 **Stakeholders:** ECS, MCS
Concept Author: S.C. Gawler **LeadResp:** ECS

CES201.574 Laurentian-Acadian Acidic Swamp

Division 201, Woody Wetland

Spatial Scale & Pattern: Large Patch

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Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Wetland
Diagnostic Classifiers: Picea (rubens, mariana) - Acer rubrum, Extensive Wet Flat, Acidic Water
Non-Diagnostic Classifiers: Forest and Woodland (Treed), Mineral: W/ A-Horizon <10 cm, Needle-Leaved Tree, Broad-Leaved Deciduous Tree, Moderate (100-500 yrs) Persistence, Mesotrophic Water, Oligotrophic Water, Saturated Soil, Intermittent Flooding [Intermittent interval, Irregular Flooding], Intermittent Flooding [Intermittent interval, Spring Flooding]
Concept Summary: These forested wetlands are found in temperate northeastern and north-central U.S., primarily in glaciated regions in the Laurentian-Acadian region. They occur on mineral soils that are nutrient-poor. There may be an organic epipedon, but the substrate is not deep peat. These basin wetlands remain saturated for all or nearly all of the growing season, and may have standing water seasonally. There may be some seepage influence, especially near the periphery. *Acer rubrum*, *Fraxinus* spp., *Picea rubens* (rarely *Picea mariana*), and *Abies balsamea* are the most typical trees. The herbaceous and shrub layers tend to be fairly species-poor. *Nemopanthus mucronatus* and *Osmunda* spp. are typical shrub and herb species.
Comments: Acadian Near-Boreal Spruce Flat (CES201.562) is related but is more northern and occurs on imperfectly drained but not persistently saturated soils. *Picea rubens* in the east vs. *Picea mariana* in the west and north might be a split in future with more careful scrutiny.

DISTRIBUTION

Range: New England and adjacent Canada west to the Great Lakes and northern Minnesota.
Ecological Divisions: 201
TNC Ecoregions: 47:P, 48:C, 60:P, 63:C
Subnations/Nations: ME:c, MI:c, MN:p, NB:, NH:c, NY:c, ON:, VT:c, WI:c

CONCEPT

Associations:
Acer rubrum - Fraxinus spp. - Betula papyrifera / Cornus canadensis Forest (L, G4, Red Maple - Ash - Birch Swamp Forest, CEGL002071)
Acer rubrum - Fraxinus spp. / Nemopanthus mucronatus - Vaccinium corymbosum Forest (G?, Northern Red Maple - Ash Swamp, CEGL006220)
Acer rubrum / Carex stricta - Onoclea sensibilis Woodland (L, G3G5, Red Maple - Tussock Sedge Wooded Marsh, CEGL006119)
Betula alleghaniensis - Acer rubrum - (Tsuga canadensis, Abies balsamea) / Osmunda cinnamomea Forest (G4?, Hardwood - Conifer Seepage Forest, CEGL006380)
Picea mariana / Alnus incana / Sphagnum spp. Forest (L, G5, Black Spruce / Alder Swamp, CEGL002452)
Picea rubens - Abies balsamea / Gaultheria hispidula / Osmunda cinnamomea / Sphagnum spp. Forest (G?, Northern Appalachian Spruce - Fir Swamp, CEGL006312)
Picea rubens - Acer rubrum / Nemopanthus mucronatus Forest (G?, Red Maple - Conifer Acidic Swamp, CEGL006198)

SOURCES

References: Comer and Albert 1997, Comer et al. 1995a, Comer et al. 1998
Last updated: 23 Mar 2003 **Stakeholders:** ECS, MCS
Concept Author: S.C. Gawler **LeadResp:** ECS

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CES201.585 Laurentian-Acadian Alkaline Fen

Division 201, Woody Wetland

Spatial Scale & Pattern: Small Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Wetland
Diagnostic Classifiers: Organic Peat (>40 cm), Mesotrophic Water, Alkaline Water, Circumneutral Water
Non-Diagnostic Classifiers: Shrubland (Shrub-dominated), Broad-Leaved Shrub, Dwarf-Shrub, Graminoid, Moderate (100-500 yrs) Persistence, Extensive Wet Flat, Depressional, Shallow (<15 cm) Water, Saturated Soil
Concept Summary: These fens, distributed across glaciated eastern and central North America, develop in open basins where bedrock or other substrate influence creates circumneutral to calcareous conditions. They are most abundant in areas of limestone bedrock, and widely scattered in areas where calcareous substrates are scarce. The vegetation may be graminoid-dominated, shrub-dominated, or a patchwork of the two; *Dasiphora fruticosa ssp. floribunda* is a common diagnostic shrub. The herbaceous flora is usually species-rich, and includes calciphilic graminoids and forbs. *Sphagnum* dominates the substrate; *Campylium stellatum* is an indicator bryophyte. The edge of the basin may be shallow to deep peat over a sloping substrate, where seepage waters provide nutrients.
Comments: Need to clarify the conceptual boundaries between this and the boreal fens in central and eastern Canada.

DISTRIBUTION

Range: Scattered locations from New England and adjacent Canada west to the Great Lakes and northern Minnesota.
Ecological Divisions: 201, 202
TNC Ecoregions: 47:C, 48:C, 61:C, 63:C, 64:P
Subnations/Nations: ME:c, MI:c, MN:c, NB:, NH:c, NY:c, VT:c, WI:c

CONCEPT

Associations:
Betula pumila - Dasiphora fruticosa ssp. floribunda / Carex lasiocarpa - Trichophorum alpinum Shrubland (G3G5, Bog Birch - Shrubby-cinquefoil Rich Boreal Fen, CEGL002495)
Betula pumila / Chamaedaphne calyculata / Carex lasiocarpa Shrubland (G4G5, Bog Birch - Leatherleaf Rich Fen, CEGL002494)
Carex (interior, hystericina, flava) - Trichophorum alpinum / Campylium stellatum Shrub Herbaceous Vegetation (G2G3, Northern Sloping Fen, CEGL006331)
Carex lasiocarpa - (Carex rostrata) - Equisetum fluviatile Herbaceous Vegetation (G?, Wiregrass Sedge Shore Fen, CEGL005229)
Carex lasiocarpa - Calamagrostis spp. - (Eleocharis rostellata) Herbaceous Vegetation (G3G4, Prairie Transition Rich Fen, CEGL002383)
Carex lasiocarpa - Carex buxbaumii - Trichophorum caespitosum Boreal Herbaceous Vegetation (G4G5, Boreal Sedge Rich Fen, CEGL002500)
Chamaedaphne calyculata - Myrica gale / Carex lasiocarpa Dwarf-shrubland (G4G5, Leatherleaf - Sweet Gale Shore Fen, CEGL005228)
Dasiphora fruticosa ssp. floribunda / Carex (sterilis, hystericina, flava) Shrub Herbaceous Vegetation (G2, Lower New England Sloping Fen, CEGL006326)

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Dasiphora fruticosa ssp. floribunda / Carex lasiocarpa / Campylium stellatum Shrub Herbaceous Vegetation (G?, Northern Shrubby-cinquefoil Alkaline Fen, CEGL006525)
Myrica gale - Dasiphora fruticosa ssp. floribunda / Carex lasiocarpa - Cladium mariscoides Shrub Herbaceous Vegetation (G2G3, CEGL006068)
Myrica gale / Carex lasiocarpa - Lobelia kalmii - Trichophorum alpinum Shrub Herbaceous Vegetation [Provisional] (G3G4, Rhizomatous Sedge - Sweet Gale Peatland Fen, CEGL006160)
Thuja occidentalis - (Myrica gale) / Trichophorum alpinum / Drepanocladus spp. Shrubland (G?, White-cedar - Sweet Gale Scrub Fen, CEGL005193)
Thuja occidentalis - Abies balsamea / Ledum groenlandicum / Carex trisperma Woodland (G?, Northern White-cedar Wooded Fen, CEGL006507)

SOURCES

Last updated: 09 Jan 2003 **Stakeholders:** ECS, MCS
Concept Author: S.C. Gawler **LeadResp:** ECS

CES201.575 Laurentian-Acadian Alkaline Swamp

Division 201, Woody Wetland

Spatial Scale & Pattern: Large Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Wetland
Diagnostic Classifiers: Thuja occidentalis - Fraxinus nigra, Depressional, Mesotrophic Water, Circumneutral Water
Non-Diagnostic Classifiers: Forest and Woodland (Treed), Mineral: W/ A-Horizon >10 cm, Mineral: W/ A-Horizon <10 cm, Needle-Leaved Tree, Broad-Leaved Deciduous Tree, Moderate (100-500 yrs) Persistence, Saturated Soil
Concept Summary: These forested wetlands are found across northern New England and the upper Midwest and eastern to south-central Canada in basins where higher pH and/or nutrient levels are associated with a rich flora. The substrate may be mineral soil or peat; often, there is an organic epipedon over mineral soil. *Thuja occidentalis* is a diagnostic canopy species, and may dominate the canopy or be mixed with other conifers or with deciduous trees, most commonly *Acer rubrum* or *Fraxinus nigra*. *Cornus sericea* is a common shrub. The herb layer tends to be more diverse than in acidic swamps. Small open fenny areas may occur within the wetland. Seepage may influence parts of the wetland, but the hydrology is dominated by the basin setting.

DISTRIBUTION

Range: Scattered locations from New England and adjacent Canada west to the Great Lakes and northern Minnesota.
Ecological Divisions: 201
TNC Ecoregions: 47:C, 48:C, 60:?, 63:C, 64:C
Subnations/Nations: MI:c, MN:c, NY:c, PA:c, VT:c, WI:c

CONCEPT

Associations:
Acer rubrum - Fraxinus spp. - Betula papyrifera / Cornus canadensis Forest (G4, Red Maple - Ash - Birch Swamp Forest, CEGL002071)
Fraxinus nigra - Mixed Hardwoods - Conifers / Cornus sericea / Carex spp. Forest (G4, Black Ash - Mixed Hardwood Swamp, CEGL002105)

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Larix laricina / Alnus incana Forest (G4, Northern Tamarack Rich Swamp, CEGL002471)
Picea mariana / Alnus incana / Sphagnum spp. Forest (L, G5, Black Spruce / Alder Swamp, CEGL002452)
Thuja occidentalis - (Larix laricina) Seepage Forest (G3G4, White-cedar Seepage Swamp, CEGL002455)
Thuja occidentalis - (Picea mariana, Abies balsamea) / Alnus incana Forest (G4, White-cedar - (Mixed Conifer) / Alder Swamp, CEGL002456)
Thuja occidentalis - Acer rubrum / Cornus sericea Forest (G?, Northern White-cedar - Red Maple Enriched Swamp, CEGL006199)
Thuja occidentalis - Fraxinus nigra Forest (G?, White-cedar - Black Ash Swamp, CEGL005165)
Thuja occidentalis - Larix laricina / Sphagnum spp. Forest (G?, White-cedar - Tamarack Peat Swamp, CEGL005225)
Thuja occidentalis / Sphagnum (girgensohnii, warnstorfii) Forest (G?, Northern White-cedar Peatland Swamp, CEGL006007)
Tsuga canadensis - Betula alleghaniensis Saturated Forest (L, G3, Hemlock - Yellow Birch Swamp Wet-Mesic Forest, CEGL005003)

SOURCES

References: Comer and Albert 1997, Comer et al. 1995a, Comer et al. 1998
Last updated: 01 Mar 2303 **Stakeholders:** ECS, MCS
Concept Author: S.C. Gawler **LeadResp:** ECS

CES201.578 Acadian Coastal Salt Marsh

Division 201, Herbaceous Wetland

Spatial Scale & Pattern: Small Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Wetland
Diagnostic Classifiers: Graminoid, Spartina (patens, alterniflora), Tidal / Estuarine, Saltwater (Polyhaline)
Non-Diagnostic Classifiers: Herbaceous, Organic Peat (>40 cm), Mineral: W/ A-Horizon >10 cm, Moderate (100-500 yrs) Persistence, Long (>500 yrs) Persistence
Concept Summary: This system covers marshes of the Gulf of Maine and parts of the southern New England coastline, along the immediate ocean shore and near estuary mouths, where salinity regime is polyhaline. Sometimes called "salt meadows," these marshes display strong graminoid dominance, with patchy forbs. *Spartina patens* and *Spartina alterniflora* are the major dominants. These marshes may be extensive where the local topography allows their development: this pattern is more common in the southern portion of the system's range (Merrymeeting Bay, ME, southward). Eastward, where the coastal topography becomes more dissected, they are more commonly seen as a fairly narrow fringe along tidal shorelines. These marshes are typically less extensive and with some different floristic elements than the marshes southward along the Atlantic Coast from Cape Cod to Chesapeake Bay.

DISTRIBUTION

Range: Coastline of the Gulf of Maine, from north of Cape Cod north and east to the Bay of Fundy.
Ecological Divisions: 201, 202
TNC Ecoregions: 62:C, 63:C

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Subnations/Nations: CT:c, MA:c, ME:c, NB:, NH:c

CONCEPT

Associations:
Ascophyllum nodosum - Fucus vesiculosus Tidal Algal Nonvascular Vegetation (G?, New England Rocky Intertidal Community, CEGL006341)
Ruppia maritima Acadian/Virginian Zone Temperate Herbaceous Vegetation (G?, Northern Atlantic Coast Beaked Ditch-grass Bed, CEGL006167)
Salicornia (virginica, bigelovii, maritima) - Spartina alterniflora Herbaceous Vegetation (G5, Salt Panne, CEGL004308)
Spartina alterniflora / (Ascophyllum nodosum) Acadian/Virginian Zone Herbaceous Vegetation (G5, Spartina Low Salt Marsh, CEGL004192)
Spartina patens - Distichlis spicata - (Juncus gerardii) Herbaceous Vegetation (G5, Spartina High Salt Marsh, CEGL006006)

SOURCES

Last updated: 09 Jan 2003
Concept Author: S.C. Gawler
Stakeholders: ECS
LeadResp: ECS

CES201.579 Acadian Estuary Marsh

Division 201, Herbaceous Wetland

Spatial Scale & Pattern: Small Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Wetland
Diagnostic Classifiers: Graminoid, Spartina (patens, alterniflora), Tidal / Estuarine, Brackish (Mesohaline)
Non-Diagnostic Classifiers: Herbaceous, Organic Peat (>40 cm), Mineral: W/ A-Horizon >10 cm, Moderate (100-500 yrs) Persistence
Concept Summary: These marshes are found along mesohaline reaches of estuaries of the Gulf of Maine and parts of the southern New England coastline. Emergent and submergent vegetation characterize this system. Dominance ranges from extensive grasslands (tall *Schoenoplectus* spp., etc.) to sparsely vegetated mudflats, all tidally influenced. These marshes grade into the saltmarsh system at the mouth of estuaries. They are typically less extensive and with some different floristic elements than the marshes southward along the Atlantic Coast to Chesapeake Bay.
Comments: Differences between marshes in Division 202 and Division 201 may be sufficient to distinguish them as separate systems; however, data on estuarine marshes in Division 201 (Laurentian-Acadian) is very sketchy and should be better documented before such a split is made.

DISTRIBUTION

Range: Coastline of the Gulf of Maine, southern New England north and east to the Bay of Fundy, extending upstream in estuaries to the tidal limit.
Ecological Divisions: 201, 202
TNC Ecoregions: 62:C, 63:C
Subnations/Nations: CT:c, MA:c, ME:c, NB:, NH:c

CONCEPT

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Associations:
Acer rubrum - Fraxinus pennsylvanica / Polygonum spp. Woodland (G2, Freshwater Tidal Woodland, CEGL006165)
Alnus (incana ssp. rugosa, serrulata) - Cornus amomum Shrubland (G?, North Atlantic Fresh Tidal Shrub Swamp, CEGL006337)
Amaranthus cannabinus Tidal Herbaceous Vegetation (G3G5, CEGL006080)
Cladium mariscoides - Drosera intermedia - Eleocharis rostellata Herbaceous Vegetation (G1, Sea Level Fen, CEGL006310)
Eriocaulon parkeri - Polygonum punctatum Herbaceous Vegetation (G2, Estuary Pipewort Brackish Intertidal Flat, CEGL006352)
Impatiens capensis - Peltandra virginica - Sagittaria latifolia - (Typha angustifolia) Tidal Herbaceous Vegetation (G?, Freshwater Tidal Mixed Forbs High Marsh, CEGL006325)
Nuphar lutea ssp. advena Tidal Herbaceous Vegetation (G?, CEGL004472)
Peltandra virginica - Pontederia cordata Tidal Herbaceous Vegetation (G3G4, CEGL004706)
Stuckenia pectinata - Potamogeton perfoliatus - (Zannichellia palustris) Tidal Herbaceous Vegetation (G3G5, CEGL006027)
Typha angustifolia - Hibiscus moscheutos Herbaceous Vegetation (G?, Brackish Tidal Marsh (Cattail Type), CEGL004201)
Zizania aquatica Tidal Herbaceous Vegetation (G4?, Atlantic Coast Wild Rice Tidal Marsh, CEGL004202)

SOURCES

Last updated: 09 Jan 2003 **Stakeholders:** ECS
Concept Author: S.C. Gawler **LeadResp:** ECS

CES201.577 Laurentian-Acadian Wet Meadow-Shrub Swamp and Marsh

Division 201, Herbaceous Wetland

Spatial Scale & Pattern: Large Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Wetland
Diagnostic Classifiers: Broad-Leaved Shrub, Graminoid, Depressional [Lakeshore], Riverine / Alluvial, Shallow (<15 cm) Water, >180-day hydroperiod
Non-Diagnostic Classifiers: Herbaceous, Muck, Aquatic Herb, Moderate (100-500 yrs) Persistence, Extensive Wet Flat, Depressional [Pond], Circumneutral Water, Acidic Water
Concept Summary: This system encompasses shrub swamps and herbaceous emergent to submergent mineral-soil wetlands of the Northeast and upper Midwest. They are often associated with lakes and ponds, but are also found along streams, where the water level does not fluctuate greatly. The size of occurrences ranges from small pockets to extensive acreages. The emergent wetlands often have a patchwork of shrub and graminoid dominance; typical species include *Alnus incana*, *Spiraea alba*, *Myrica gale, Calamagrostis canadensis*, tall *Carex* spp., and *Juncus effusus*. Trees are generally absent and, if present, are scattered. Submergent wetlands include a variety of macrophytes, often with a border of non-persistent emergent vegetation dominated by *Pontederia cordata*. The submergent vegetation zones may be severely impacted by non-native invasive aquatics including *Myriophyllum spicatum* and others.

DISTRIBUTION

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Range: New England and northern New York west across the upper Great Lakes to Minnesota, and adjacent Canada, southward to Pennsylvania and Ohio; mostly north of the glacial boundary.
Ecological Divisions: 201, 202
TNC Ecoregions: 47:C, 48:C, 49:C, 59:C, 61:C, 63:C, 64:C
Subnations/Nations: CT:c, IL:?, IN:?, MA:c, ME:c, MI:c, MN:c, NB:, NH:c, NY:c, OH:?, ON:, PA:c, QC:, VT:c, WI:c

CONCEPT

Associations:
Acer rubrum / Carex stricta - Onoclea sensibilis Woodland (G3G5, Red Maple - Tussock Sedge Wooded Marsh, CEGL006119)
Alnus incana - Cornus sericea / Clematis virginiana Shrubland (G4G5, Alluvial Alder Thicket, CEGL006062)
Alnus incana Swamp Shrubland (G5?, Speckled Alder Swamp, CEGL002381)
Alnus serrulata Eastern Shrubland (G4G5, Smooth Alder Swamp, CEGL005082)
Calamagrostis canadensis - Phalaris arundinacea Herbaceous Vegetation (G4G5, Bluejoint Wet Meadow, CEGL005174)
Calamagrostis canadensis - Scirpus spp. - Dulichium arundinaceum Herbaceous Vegetation (G?, Seasonally Flooded Mixed Graminoid Meadow, CEGL006519)
Carex lacustris Herbaceous Vegetation (G4G5, Lake Sedge Wet Meadow, CEGL002256)
Carex rostrata - Carex lacustris - (Carex vesicaria) Herbaceous Vegetation (G4G5, Northern Sedge Wet Meadow, CEGL002257)
Carex stricta - Carex spp. Herbaceous Vegetation (G4?, Tussock Sedge Wet Meadow, CEGL002258)
Carex stricta - Carex vesicaria Seasonally Flooded Herbaceous Vegetation (G?, Eastern Tussock Sedge Meadow, CEGL006412)
Cephalanthus occidentalis / Carex spp. Northern Shrubland (G4, Northern Buttonbush Swamp, CEGL002190)
Elodea canadensis - Potamogeton spp. Eastern Herbaceous Vegetation [Placeholder] (G?, CEGL006431)
Equisetum fluviatile - (Eleocharis palustris) Herbaceous Vegetation (G4, Water Horsetail - Spikerush Marsh, CEGL005258)
Juncus balticus - Carex stricta - Lythrum alatum var. alatum Herbaceous Vegetation (G2Q, Shenandoah Herbaceous Seep, CEGL006170)
Juncus effusus Seasonally Flooded Herbaceous Vegetation (G5, Rush Marsh, CEGL004112)
Juncus militaris Herbaceous Vegetation (G?, CEGL006345)
Myrica gale - Spiraea alba - Chamaedaphne calyculata Shrubland (G?, Sweetgale Mixed Shrub Fen, CEGL006512)
Nuphar lutea ssp. advena - Nymphaea odorata Herbaceous Vegetation (G4G5, Water-lily Aquatic Wetland, CEGL002386)
Nymphaea odorata - Nuphar lutea (ssp. pumila, ssp. variegata) Herbaceous Vegetation (G5, Northern Water-lily Aquatic Wetland, CEGL002562)
Nymphaea tetragona - Nuphar lutea (ssp. pumila, ssp. variegata) Herbaceous Vegetation (G4G5, Boreal Water-lily Aquatic Wetland, CEGL002563)
Phalaris arundinacea Eastern Herbaceous Vegetation (GW, Reed Canary Grass Eastern Marsh, CEGL006044)

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Phragmites australis Eastern North America Temperate Semi-natural Herbaceous Vegetation (GW, Eastern Reed Marsh, CEGL004141)
Pontederia cordata - Peltandra virginica Semipermanently Flooded Herbaceous Vegetation [Placeholder] (G?, Pickerelweed Marsh, CEGL004291)
Potamogeton spp. - Ceratophyllum spp. Midwest Herbaceous Vegetation (G5, Midwest Pondweed Submerged Aquatic Wetland, CEGL002282)
Schoenoplectus (tabernaemontani, acutus) Eastern Herbaceous Vegetation (G?, Bulrush Deepwater Marsh, CEGL006275)
Schoenoplectus acutus - (Schoenoplectus fluviatilis) Freshwater Herbaceous Vegetation (G4G5, Freshwater Bulrush Marsh, CEGL002225)
Schoenoplectus fluviatilis - Schoenoplectus spp. Herbaceous Vegetation (G3G4, River Bulrush Marsh, CEGL002221)
Schoenoplectus tabernaemontani - Typha spp. - (Sparganium spp., Juncus spp.) Herbaceous Vegetation (G4G5, Bulrush - Cattail - Burreed Shallow Marsh, CEGL002026)
Scirpus cyperinus Seasonally Flooded Herbaceous Vegetation (G?, CEGL006349)
Typha (angustifolia, latifolia) - (Schoenoplectus spp.) Eastern Herbaceous Vegetation (G5, Eastern Cattail Marsh, CEGL006153)
Typha latifolia Southern Herbaceous Vegetation (G5, Southern Cattail Marsh, CEGL004150)
Typha spp. - Schoenoplectus acutus - Mixed Herbs Midwest Herbaceous Vegetation (G4?, Midwest Mixed Emergent Deep Marsh, CEGL002229)
Typha spp. Midwest Herbaceous Vegetation (G5, Midwest Cattail Deep Marsh, CEGL002233)
Vallisneria americana - Potamogeton perfoliatus Herbaceous Vegetation (G5, Open Water Marsh with Mixed Submergents/Emergents, CEGL006196)
Zizania (aquatica, palustris) Herbaceous Vegetation (G3G4, Wild Rice Marsh, CEGL002382)

SOURCES

References: Comer and Albert 1997
Last updated: 09 Jan 2003 **Stakeholders:** ECS, MCS
Concept Author: S.C. Gawler, D. Faber-Langendoen **LeadResp:** ECS

CES201.048 North Atlantic Rocky Intertidal

Division 201, Herbaceous Wetland

Spatial Scale & Pattern: Linear
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Wetland
Diagnostic Classifiers: Moss/Lichen (Nonvascular), Tidal flat, Lichen, Alga, Saltwater (Polyhaline), <24-hour hydroperiod
Non-Diagnostic Classifiers: Lowland [Lowland], Nonvascular
Concept Summary: This system represents the intertidal zone with solid rock substrates that can experience extremes of exposure to winds, waves, currents, and ice-scour. This encompasses both exposed and partially exposed habitats. Lichens (often *Xantharia* spp., *Verrucaria* spp., and *Vaucheria* spp.) and blue-green algae (*Caliathrix* spp.) are present in the supralittoral and high littoral, respectively. Barnacles, usually *Semibalanus balanoides,* are found in the mid-intertidal zone, usually in crevices that offer some protection from the extreme elements. Mussels are found in the lower intertidal, also appearing mostly in crevices. Diagnostic species include Irish moss (*Chandrus crispus*); rockweed (*Fucus vesiculosus, Fucus evanescens*, and *Fucus spiralis*; knotted wrack (*Ascophyllum nodosurn*); hollow stemmed kelp

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(*Laminaria* spp.); blue mussels (*Mytilus edulis*); common periwinkles (*Littorina littorea*); dogwhelks (*Nucella lapillus*); and springtails (*Anurida maritima*). In the low intertidal, small fronds of kelp may be present, but short, torn stipes are often all that remains. Rockweed and knotted wrack which are typically found in less exposed rocky habitats are small, restricted to crevices, or missing. Tidepools are frequently found in these habitats and are inhabited by both intertidal and subtidal species. Tidepools are nurseries for lumpfish, sea snails, and pollock. Many other fish have also been identified in tidepools. Many species of birds are found on these habitats. Purple Sandpipers are found in the winter in these habitats. Ruddy Turnstone and Sanderlings are the main species in spring and fall migrations. Other shorebirds that also use rocky shores include Black-bellied Plovers and Pectoral Sandpipers.

DISTRIBUTION

Ecological Divisions: 103, 201, 202?
TNC Ecoregions: 63:C
Subnations/Nations: LB:, MA:, ME:, NB:, NH:, NS:

CONCEPT

SOURCES

References: Brown 1993
Last updated: 18 Apr 2003 **Stakeholders:** ECS
Concept Author: S. Gawler, P. Comer **LeadResp:** ECS

CES201.587 Laurentian-Acadian Floodplain Forest

Division 201, Mixed Upland and Wetland

Spatial Scale & Pattern: Large Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland, Wetland
Diagnostic Classifiers: Forest and Woodland (Treed), Shrubland (Shrub-dominated), Woody-Herbaceous, Herbaceous, Flood Scouring, Riverine / Alluvial, Short (<5 yrs) Flooding Interval [Short interval, Spring Flooding]
Non-Diagnostic Classifiers: Lowland, Toeslope/Valley Bottom, Glaciated, Eutrophic Soil, Mesotrophic Soil, Circumneutral Soil, Acidic Soil, Deep Soil, Mineral: W/ A-Horizon >10 cm, Silt Soil Texture, Udic, Unconsolidated, Very Short Disturbance Interval, Broad-Leaved Deciduous Tree, Broad-Leaved Shrub, Graminoid, Moderate (100-500 yrs) Persistence, Mesotrophic Water
Concept Summary: This system encompasses north-temperate floodplains in the northeastern and north-central U.S. and adjacent Canada at the northern end of the range of silver maple. They occur along medium to large rivers where topography and process have resulted in the development of a complex of upland and wetland temperate alluvial vegetation on generally flat topography. This complex includes floodplain forests, with *Acer saccharinum* characteristic, as well as herbaceous sloughs and shrub wetlands. Most areas are underwater each spring; microtopography determines how long the various habitats are inundated. Associated trees include *Acer rubrum* and *Carpinus caroliniana*, the latter frequent but never abundant. On terraces or in more calcareous areas, *Acer saccharum* or *Quercus rubra* may be locally prominent, with *Betula alleghaniensis* and *Fraxinus* spp. *Salix nigra* is characteristic of the levees adjacent to the channel. Common shrubs include *Cornus amomum* and *Viburnum* spp. The herb layer in the forested portions often features abundant spring ephemerals, giving way to

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a fern-dominated understory in many areas by mid-summer. Non-forested wetlands associated with these systems include shrub-dominated and graminoid-herbaceous vegetation.
Comments: These floodplains are similar to those to the south in the Central Interior, North-Central Interior Floodplain (CES202.694) and Appalachian Division, Central Appalachian Floodplain (CES202.608) in having *Acer saccharinum* as a characteristic species; however, they are generally more depauperate and lack certain tree species that characterize central Appalachian floodplains such as *Platanus occidentalis, Betula nigra*, and *Quercus palustris*.

DISTRIBUTION

Range: Central and northern New England and adjacent Canada west to the Great Lakes.
Ecological Divisions: 103, 201
TNC Ecoregions: 47:C, 48:C, 61:?, 63:C, 64:C
Subnations/Nations: ME:c, MI:c, MN:c, NB:c, NH:c, NY:c, VT:c, WI:c

CONCEPT

Associations:
Acer saccharinum - (Populus deltoides) / Matteuccia struthiopteris Forest (G?, Silver Maple Floodplain Levee Forest (Ostrich Fern Type), CEGL006147)
Acer saccharinum - Ulmus americana - (Populus deltoides) Forest (G4?, Silver Maple - Elm - (Cottonwood) Forest, CEGL002586)
Acer saccharinum / Onoclea sensibilis - Boehmeria cylindrica Forest (G?, Silver Maple Floodplain Bottom Forest (Sensitive Fern Type), CEGL006176)
Acer saccharum - Fraxinus spp. - Tilia americana / Matteuccia struthiopteris - Ageratina altissima Forest (G?, Terrace Hardwood Floodplain Forest, CEGL006114)
Alnus incana Swamp Shrubland (G5?, Speckled Alder Swamp, CEGL002381)
Calamagrostis canadensis - Phalaris arundinacea Herbaceous Vegetation (G4G5, Bluejoint Wet Meadow, CEGL005174)
Calamagrostis canadensis - Scirpus spp. - Dulichium arundinaceum Herbaceous Vegetation (G?, Seasonally Flooded Mixed Graminoid Meadow, CEGL006519)
Cephalanthus occidentalis / Glyceria canadensis Shrubland (G?, Buttonbush Shrub Swamp, CEGL006069)
Fraxinus pennsylvanica - Ulmus americana - (Acer negundo, Tilia americana) Northern Forest (G3G4, Northern Ash - Elm Floodplain Forest, CEGL002089)
River Mud Flats Sparse Vegetation (G?, River Mud Flats, CEGL002314)
Riverine Sand Flats - Bars Sparse Vegetation (G4G5, Riverine Sand Flats, CEGL002049)

SOURCES

Last updated: 09 Jan 2003
Concept Author: S.C. Gawler
Stakeholders: ECS, SCS, MCS
LeadResp: ECS

CES201.570 Laurentian-Acadian Calcareous Cliff and Talus

Division 201, Barren

Spatial Scale & Pattern: Small Patch
Required Classifiers: Natural/Semi-natural, Non-vegetated (<10% vasc.), Upland
Diagnostic Classifiers: Ridge/Summit/Upper Slope, Cliff (Substrate), Talus (Substrate), Alkaline Soil, Circumneutral Soil

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Non-Diagnostic Classifiers: Montane, Lowland, Glaciated, Very Shallow Soil, Intermediate Disturbance Interval, Landslide, Moderate (100-500 yrs) Persistence
Concept Summary: This cliff system occurs at low to mid elevations, well below treeline, from New England west to the Great Lakes. It consists of vertical or near-vertical cliffs and the talus slopes below, where weathering and/or bedrock chemistry produce circumneutral to calcareous pH and enriched nutrient availability. The vegetation is often sparse, but may include patches of small trees. *Thuja occidentalis* may dominate on some cliffs (and reach very old ages, upwards of 1000 years). *Fraxinus* spp. and *Tilia americana* are woody indicators of the enriched setting.

DISTRIBUTION

Range: Scattered locations from New England and adjacent Canada west to the Great Lakes and possibly northern Minnesota
Ecological Divisions: 201
TNC Ecoregions: 47:?, 48:C, 63:C
Subnations/Nations: ME:c, MI:c, MN:p, NH:c, NY:c, VT:c, WI:c

CONCEPT

Associations:
Acer saccharum - Tilia americana - Fraxinus americana / Ostrya virginiana / Geranium robertianum Woodland (G3G5, Rich Northern Hardwood Woodland, CEGL005058)--(peripheral)
Carex scirpoidea Alkaline Cliff Sparse Vegetation (G?, Near-Boreal Alkaline Cliff, CEGL006526)
Limestone - Dolostone Midwest Dry Cliff Sparse Vegetation (G4G5, Midwest Dry Limestone - Dolostone Cliff, CEGL002291)
Limestone - Dolostone Midwest Moist Cliff Sparse Vegetation (G4G5, Midwest Moist Limestone - Dolostone Cliff, CEGL002292)
Limestone - Dolostone Talus Sparse Vegetation (G4G5, Midwest Limestone - Dolostone Talus, CEGL002308)
Thuja occidentalis Carbonate Talus Woodland (G3G4, White-cedar Limestone Talus Woodland, CEGL005172)
Thuja occidentalis Cliff Woodland (G3, White-cedar Cliff Woodland, CEGL002451)
Vegetation: *Thuja occidentalis* may dominate on some cliffs (and reach very old ages, upwards of 1000 years). *Fraxinus* spp. and *Tilia americana* are woody indicators of the enriched setting (Kelly and Larson 1997).

SOURCES

References: Kelly and Larson 1997
Last updated: 09 Jan 2003 **Stakeholders:** ECS, MCS
Concept Author: S.C. Gawler **LeadResp:** ECS

CES201.586 Laurentian-Acadian Rocky Lakeshore

Division 201, Barren

Spatial Scale & Pattern: Small Patch
Required Classifiers: Natural/Semi-natural, Non-vegetated (<10% vasc.), Upland, Wetland
Diagnostic Classifiers: Flood Scouring, Broad-Leaved Shrub, Dwarf-Shrub, Graminoid, Depressional, Short (<5 yrs) Flooding Interval [Short interval, Irregular Flooding]

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Non-Diagnostic Classifiers: Lowland, Glaciated, Mesotrophic Soil, Oligotrophic Soil, Mineral: W/ A-Horizon <10 cm, Sand Soil Texture, Very Short Disturbance Interval
Concept Summary: This system encompasses primarily upland vegetation along lakeshores or rivershores in the glaciated Northeast and upper Midwest (not including the Great Lakes). Some areas may be briefly inundated during high water periods. The substrate is sandy to gravelly, sometimes consolidated rock; there may be muddy patches. Ice-scour is not a major influence although it may be locally important. These shores may be narrow zones of shrubs and/or sparse vegetation on rocks or sandy beaches.
Comments: Very little data on these. May not be defensible as a separate system, keep in for now as a placeholder. If it is combined with the surrounding uplands, the associations tagged to this system may become orphans.

DISTRIBUTION

Range: Northern New England and northern New York west across the upper Great Lakes to northern Minnesota, and adjacent Canada; occasional southwards.
Ecological Divisions: 201
TNC Ecoregions: 47:C, 48:C, 63:C, 64:C
Subnations/Nations: ME:p, MI:c, MN:c, NH:p, NY:c, VT:c, WI:p

CONCEPT

Associations:
Eroding Clay Bank Sparse Vegetation (G?, Eroding Clay Bank, CEGL002584)
Igneous - Metamorphic Cobble - Gravel Inland Lake Shore Sparse Vegetation (G4G5, Inland Lake Igneous - Metamorphic Cobble - Gravel Shore, CEGL002303)
Igneous - Metamorphic Cobble - Gravel River Shore Sparse Vegetation (G4G5, Riverine Igneous - Metamorphic Cobble - Gravel Shore, CEGL002304)
Inland Freshwater Strand Beach Sparse Vegetation (G4G5, Inland Freshwater Strand Beach, CEGL002310)
Lake Mud Flats Sparse Vegetation (G?, Lake Mud Flats, CEGL002313)
Sandstone Bedrock River Shore Sparse Vegetation (G?, River Ledge Sandstone Pavement, CEGL002302)
Spartina pectinata - Muhlenbergia richardsonis - Sporobolus heterolepis - Oligoneuron album - Euthamia graminifolia Sparse Vegetation (G1, River Ledge Limestone Pavement, CEGL005233)
Spartina pectinata North Atlantic Coast Herbaceous Vegetation (G?, CEGL006095)

SOURCES

Last updated: 09 Jan 2003
Concept Author: S.C. Gawler
Stakeholders: ECS, MCS
LeadResp: ECS

CES201.051 North Atlantic Cobble Shore

Division 201, Barren

Spatial Scale & Pattern: Linear
Required Classifiers: Natural/Semi-natural, Non-vegetated (<10% vasc.), Upland, Wetland
Non-Diagnostic Classifiers: Lowland [Lowland], Beach (Landform), Boreal [Boreal Hyperoceanic], Salt Spray, <24-hour hydroperiod
Concept Summary: This system encompasses areas of varying exposure that include boulder, cobble, and gravel shores, often adjacent to bedrock shoreline and rocky intertidal areas. Cobble

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shores may have >75% cobble bottom. Some occurrences are mixed sand and gravel beaches, others have different combinations of particle sizes. These areas have sufficient exposure to winnow out the fine sand-, silt- and clay-sized particles without removing the larger grain sizes. The bottom is usually comprised of cobble and gravel, although shell hash may also be present in various amounts. These areas have low diversity, probably due to insufficient nutrition for and high disturbance of infauna. Diagnostic species include species colonizing from nearby rocky areas if present, e.g., Irish moss (*Chandrus crispus*), rockweed (*Fucus vesiculosus*), knotted wrack (*Ascophyllum nodosum*), coralline algae (*Corallina officinalis*), and kelp (*Laminaria* spp.). Fauna is composed of the following: segmented worms (*Enchytraeus* spp.), collembola (mostly *Anurida maritima*), blue mussels (*Mytilus* spp.), periwinkles (*Littorina littorea, Littorina obtusata, Littorina saxatilis*), limpets (*Tectura testudinalis*), and barnacles (*Semibalanus balanoides*), among others.

DISTRIBUTION

Ecological Divisions: 103, 201, 202
TNC Ecoregions: 63:C
Subnations/Nations: LB:, MA:, ME:, NB:, NH:, NS:, QC:

CONCEPT

SOURCES

References: Brown 1993
Last updated: 18 Apr 2003 **Stakeholders:** ECS
Concept Author: S. Gawler, P. Comer **LeadResp:** ECS

CES201.050 North Atlantic Intertidal Mudflat

Division 201, Barren

Spatial Scale & Pattern: Linear
Required Classifiers: Natural/Semi-natural, Non-vegetated (<10% vasc.), Wetland
Non-Diagnostic Classifiers: Lowland [Lowland], Herbaceous, <24-hour hydroperiod
Concept Summary: Mudflats are usually located in quiet pockets of bays and protected by headlands. Sand-sized particles are mixed with sift and clay. In the summer, *Enteromorpha intestinalis* can cover these mudflats. Other characteristic species include *Enteromorpha prolifera, Rhizoclonium riparium, Ruppia maritima,* and *Zostera marina*.
Comments: For classification of these types in Maine (Brown 1993), it has been suggested that northeastern mudflats (east of the Penobscot River) contain somewhat different assemblages of organisms than do southwestern mudflats (west of the Penobscot River). Some factor (perhaps temperature) will be necessary to separate these communities. However, they were left combined until more information is available to make better distinctions.

DISTRIBUTION

Ecological Divisions: 103, 201, 202?
TNC Ecoregions: 63:C
Subnations/Nations: LB:, MA:, ME:, NB:, NH:, NS:, QC:?

CONCEPT

Associations:

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Zostera marina Herbaceous Vegetation (G?, Eel-grass Meadow, CEGL004336)

SOURCES

References: Brown 1993
Last updated: 18 Apr 2003 **Stakeholders:** ECS
Concept Author: S. Gawler, P. Comer **LeadResp:** ECS

CES201.049 North Atlantic Tidal Sand Flat

Division 201, Barren

Spatial Scale & Pattern: Large Patch
Required Classifiers: Natural/Semi-natural, Non-vegetated (<10% vasc.), Wetland
Diagnostic Classifiers: Boreal [Boreal Hyperoceanic], Unconsolidated, Alga
Non-Diagnostic Classifiers: Lowland [Lowland]
Concept Summary: This system of seagrass beds occurs primarily in the embayed regions of Maine north into Canada. The series of barriers provides area for colonization of hydromorphic herbaceous vegetation in protected sounds and lagoons which are subject to wind tides only. Local habitats range from small guts, shallow tributary creeks, and large marsh pools along freshwater and oligohaline sections of tidal rivers to shallow estuarine bays, tidal creeks, and salt marsh pools. These species are largely replaced by *Zostera marina*. The diversity in these sheltered habitats is higher than that of exposed and partially exposed sandy beaches.

DISTRIBUTION

Ecological Divisions: 103, 201, 202
TNC Ecoregions: 63:
Subnations/Nations: LB:, MA:, ME:, NB:, NH:, NI:, NS:, QC:

CONCEPT

Associations:
Zostera marina Herbaceous Vegetation (G?, Eel-grass Meadow, CEGL004336)

SOURCES

References: Brown 1993
Last updated: 18 Apr 2003 **Stakeholders:** ECS
Concept Author: S. Gawler, P. Comer **LeadResp:** ECS

CES202.593 Appalachian Hemlock-Hardwood Forest

Division 202, Forest and Woodland

Spatial Scale & Pattern: Matrix
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Mesotrophic Soil, Needle-Leaved Tree, Broad-Leaved Deciduous Tree, Pinus spp. - Tsuga canadensis
Non-Diagnostic Classifiers: Lowland, Forest and Woodland (Treed), Sideslope, Toeslope/Valley Bottom, Temperate, Acidic Soil, Shallow Soil, Deep Soil, Mineral: W/ A-Horizon >10 cm, Ustic, Long Disturbance Interval, Moderate (100-500 yrs) Persistence
Concept Summary: This forested system of the northeastern U.S. ranges from central New England west to Lake Erie and south to Virginia. It is one of the matrix forest types in the

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northern part of the Central Interior and Appalachian Division, in which *Tsuga canadensis* (or in some cases *Pinus strobus*) is mixed with northern hardwoods such as *Acer saccharum* and *Fagus grandifolia*, as well as with *Quercus* spp. (most commonly *Quercus rubra*), *Liriodendron tulipifera, Prunus serotina*, and *Betula lenta* (or other *Betula* spp.).
Comments: Northward this system is replaced by Laurentian-Acadian Pine-Hemlock-Hardwood Forest (CES201.563), but the limits of both are not yet clear in western New York (Allegheny Plateau) and central New England.

DISTRIBUTION

Range: Central New England south to West Virginia and Virginia.
Ecological Divisions: 202
TNC Ecoregions: 49:P, 50:?, 51:C, 52:P, 59:C, 60:P, 61:C
Subnations/Nations: CT:, GA:c, MA:, MD:, NC:c, NH:, NJ:, NY:c, OH:?, PA:c, SC:c, TN:c, VA:c, VT:, WV:c

CONCEPT

Associations:
Acer rubrum - Nyssa sylvatica - Betula alleghaniensis / Sphagnum spp. Forest (G?, Red Maple - Black Gum Basin Swamp, CEGL006014)
Acer rubrum - Nyssa sylvatica High Allegheny Plateau, Central Appalachian Forest (G?, Central Appalachian Forested Acid Seep, CEGL006132)
Acer saccharum - Betula alleghaniensis - Prunus serotina Forest (G4, Central Appalachian Northern Hardwood Forest, CEGL006045)
Acer saccharum - Pinus strobus / Acer pensylvanicum Forest (G?, Northern Hardwood - White Pine Forest, CEGL005005)
Acer saccharum - Quercus rubra / Hepatica nobilis var. obtusa Forest (G?, CEGL006046)
Betula alleghaniensis - (Tsuga canadensis) / Rhododendron maximum / Leucothoe fontanesiana Forest (G3G4Q, Blue Ridge Hemlock - Northern Hardwood Forest, CEGL007861)
Betula lenta / Ilex montana / Lycopodium annotinum Forest (GM, Central Appalachian Northern Hardwood Forest (Sweet Birch / Clubmoss Type), CEGL008503)
Betula papyrifera / Acer saccharum - Mixed Hardwoods Forest (G4?, Paper Birch / Sugar Maple - Mixed Hardwoods Forest, CEGL002464)
Chrysosplenium americanum Herbaceous Vegetation (G3G5, Golden-saxifrage Seep, CEGL006193)
Deschampsia caespitosa - Symplocarpus foetidus Herbaceous Vegetation (G1, Inland Acidic Seep Community, CEGL006101)
Liriodendron tulipifera - Betula lenta - Tsuga canadensis / Rhododendron maximum Forest (G5, Southern Appalachian Acid Cove Forest (Typic Type), CEGL007543)
Picea rubens - Betula alleghaniensis - Prunus serotina Forest (G?, CEGL006029)
Pinus strobus - Tsuga canadensis / Acer pensylvanicum / Polystichum acrostichoides Forest (G4?, Central Appalachian White Pine - Eastern Hemlock Forest, CEGL006019)
Pinus strobus - Tsuga canadensis / Rhododendron maximum - (Leucothoe fontanesiana) Forest (G4, Southern Appalachian Eastern Hemlock Forest (White Pine Type), CEGL007102)
Pinus strobus - Tsuga canadensis Lower New England / Northern Piedmont Forest (G5, White Pine - Hemlock Dry-Mesic Coniferous Forest, CEGL006328)
Pinus strobus Successional Forest (GD, Eastern White Pine Successional Forest, CEGL007944)

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Quercus bicolor / Vaccinium corymbosum / Carex stipata Forest (G?, Perched Swamp White Oak Swamp, CEGL006241)
Quercus rubra - Acer saccharum - Fagus grandifolia / Viburnum acerifolium Forest (G?, Red Oak - Northern Hardwood Forest, CEGL006173)
Quercus rubra - Acer saccharum - Liriodendron tulipifera Forest (G?, High Allegheny Rich Red Oak - Sugar Maple Forest, CEGL006125)
Rhododendron maximum Upland Shrubland (G3?Q, Montane Rhododendron Thicket, CEGL003819)
Thuja occidentalis - Pinus strobus - Tsuga canadensis / Carex eburnea Forest (G1G2, Southern Appalachian Northern White-cedar Slope Forest, CEGL008426)
Tsuga canadensis - (Betula alleghaniensis, Quercus rubra) / Ilex montana / Rhododendron catawbiense Forest (G1?, Eastern Hemlock / Catawba Rhododendron Forest, CEGL008513)
Tsuga canadensis - (Fagus grandifolia, Tilia americana var. heterophylla) / Magnolia tripetala Forest (G4, Cumberland/Appalachian Hemlock - Hardwood Cove Forest, CEGL008407)
Tsuga canadensis - Betula alleghaniensis - Prunus serotina / Rhododendron maximum Forest (G?, Central Appalachian Hemlock - Northern Hardwood Forest, CEGL006206)
Tsuga canadensis - Betula alleghaniensis / Veratrum viride - Carex scabrata - Oclemena acuminata Forest (G2, High-Elevation Hemlock - Yellow Birch Seepage Swamp, CEGL008533)
Tsuga canadensis - Betula alleghaniensis Lower New England / Northern Piedmont Forest (G4?, Hemlock - Northern Hardwood Forest, CEGL006109)
Tsuga canadensis - Fagus grandifolia - Acer saccharum / (Hamamelis virginiana, Kalmia latifolia) Forest (G3?, East-central Hemlock Hardwood Forest, CEGL005043)
Tsuga canadensis - Fagus grandifolia Forest (G4G5, Hemlock - Beech Forest, CEGL006088)
Tsuga canadensis - Quercus prinus / Kalmia latifolia - Rhododendron (catawbiense, maximum) / Galax urceolata Forest (G4, Central Appalachian Acidic Cove Forest, CEGL008512)
Tsuga canadensis / Rhododendron maximum - (Clethra acuminata, Leucothoe fontanesiana) Forest (G3G4, Southern Appalachian Eastern Hemlock Forest (Typic Type), CEGL007136)
Tsuga caroliniana - (Tsuga canadensis) / Rhododendron maximum Forest (G1G2, Carolina Hemlock Forest (Mesic Type), CEGL007138)
Environment: This system occurs on protected low and mid slopes and valley bottoms. It often occurs between Southern and Central Appalachian Cove Forest (CES202.373) in the lowest areas and Southern and Central Appalachian Oak Forest (CES202.886) on the mid slopes. It is considered a system of intermediate moisture regime.
Vegetation: The canopy is usually dominated by *Tsuga canadensis* but may also contain large amounts of *Pinus strobus* and *Quercus* spp. throughout its range and *Fagus grandifolia* and *Acer saccharum* further north. The understory varies quite a bit, but tends to be dominated by evergreen shrubs and only occasionally by herbs.
Dynamics: This system is currently being devastated in large parts of its range by the hemlock wooly adelgid (*Adelges tsugae* Annand). This sucking insect is continuing to cause close to 100% mortality as it spreads from the north into the southern United States. The insect will most likely cause hemlock communities to more closely resemble Southern and Central Appalachian Oak Forest (CES202.886) as time passes and canopy hemlocks are replaced by other canopy trees.

Historically, this system was probably only subject to occasional fires. Fires that did occur may have been catastrophic and may have lead to even-aged stands of pine and hemlock.

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SPATIAL CHARACTERISTICS

Spatial Summary: Large patch
Size: Some examples may be more than 1000 acres, but most are probably less than 50 acres.
Heterogeneity: Within each occurrence, this system is fairly homogenous.
Adjacent Ecological Systems: Southern and Central Appalachian Cove Forest (CES202.373) occurs downslope from these forests in the coves and tend to be more mesic and more species-rich than the hemlock forests. Southern and Central Appalachian Oak Forest (CES202.886) occurs upslope from this system and tend to be drier and even less diverse than hemlock forests. Hemlock forests may grade into Southern Appalachian Low Mountain Pine Forest (CES202.332) in especially dry occurrences of this system.

SOURCES

Last updated: 09 Jan 2003 **Stakeholders:** SCS, MCS, ECS
Concept Author: S.C. Gawler, R. White, R. Evans, M. Pyne **LeadResp:** SCS

CES202.591 Central Appalachian Oak and Pine Forest

Division 202, Forest and Woodland

Spatial Scale & Pattern: Large Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Forest and Woodland (Treed), Ridge/Summit/Upper Slope, Acidic Soil, Pinus (strobus, rigida, echinata, virginiana) - Quercus prinus
Non-Diagnostic Classifiers: Lowland, Sideslope, Oligotrophic Soil, Mineral: W/ A-Horizon <10 cm, Sand Soil Texture, Loam Soil Texture, Ustic, F-Patch/Medium Intensity, W-Patch/Low Intensity, Needle-Leaved Tree, Broad-Leaved Tree
Concept Summary: These oak-pine forests cover large areas in the low- to mid-elevation central Appalachians and foothills. The topography and landscape position range from rolling hills to steep slopes, with occasional occurrences on more level ancient alluvial fans. The soils are coarse and infertile; they may be deep, on glacial deposits, or shallow, on rocky slopes of acidic rock (shale, sandstone, other acidic igneous or metamorphic rock). The well-drained soils and exposure create dry to dry-mesic conditions. The forest is mostly closed-canopy but can include more open woodlands. It is dominated by a variable mixture of dry-site oak and pine species, including *Quercus prinus*, *Pinus virginiana*, and *Pinus strobus*. The system may include areas of pine forest, and mixed oak-pine forest. Heath shrubs such as *Vaccinium pallidum, Gaylussacia baccata*, and *Kalmia latifolia* are common in the understory. Within these forests, hillslope pockets with impeded drainage may support small isolated wetlands with *Acer rubrum* and *Nyssa sylvatica* characteristic. Disturbance agents include fire, windthrow, and ice damage.
Comments: Need to clarify the conceptual boundaries between this and the matrix dry oak forest system of Division 202.

DISTRIBUTION

Range: Central New England through Pennsylvania, south to Virginia
Ecological Divisions: 202
TNC Ecoregions: 52:C, 59:C, 60:P, 61:C
Subnations/Nations: CT:, DE:?, MD:, ME:, NH:, NJ:, NY:, OH:?, PA:, RI:, VA:, VT:, WV:

CONCEPT

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Associations:
Acer rubrum - Nyssa sylvatica High Allegheny Plateau, Central Appalachian Forest (G?, Central Appalachian Forested Acid Seep, CEGL006132)
Castanea dentata - Quercus prinus Forest (GH, American Chestnut Forest (Subxeric Type), CEGL007196)
Pinus rigida - Quercus (velutina, coccinea, prinus) Forest (G?, CEGL006290)
Pinus strobus - Pinus resinosa - Pinus rigida Forest (G4G5, CEGL006259)
Pinus strobus - Quercus (rubra, velutina) - Fagus grandifolia Forest (G5, White Pine - Oak Forest, CEGL006293)
Pinus strobus - Quercus alba - Quercus coccinea / Vaccinium stamineum Forest (G4, Central Appalachian / Piedmont White Pine - Xeric Oak Forest, CEGL008539)
Pinus strobus - Quercus rubra - Liriodendron tulipifera Forest (G?, CEGL006304)
Pinus strobus / Vaccinium pallidum Forest (G?, White Pine - Blueberry Forest of Low-Elevation Slopes and Hills, CEGL007099)
Pinus strobus Successional Forest (GD, Eastern White Pine Successional Forest, CEGL007944)
Pinus virginiana - Pinus (rigida, echinata) - (Quercus prinus) / Vaccinium pallidum Forest (G4?, Appalachian Low-Elevation Mixed Pine / Hillside Blueberry Forest, CEGL007119)
Pinus virginiana - Quercus (coccinea, prinus) Forest (G?, Virginia Pine - Oak Forest, CEGL005040)
Pinus virginiana Successional Forest (GD, Virginia Pine Successional Forest, CEGL002591)
Quercus (prinus, coccinea) / Kalmia latifolia / (Galax urceolata, Gaultheria procumbens) Forest (G5, Chestnut Oak Forest (Xeric Ridge Type), CEGL006271)
Quercus prinus - Quercus (rubra, velutina) / Gaylussacia baccata Forest (G5, Northern Appalachian Dry Oak Forest, CEGL006282)
Quercus rubra - (Quercus prinus, Quercus velutina) / Rhododendron periclymenoides / Lysimachia quadrifolia - Hieracium paniculatum Forest (G2G3, Mixed Oak / Heath Forest (Northern Red Oak / Mixed Herbs Type), CEGL008523)

SPATIAL CHARACTERISTICS

Spatial Summary: Large- patch (at outer range) to matrix (in center of range) system that may cover extensive hillslopes and low ridges.

SOURCES

Last updated: 09 Jan 2003 **Stakeholders:** ECS, SCS
Concept Author: S.C. Gawler **LeadResp:** ECS

CES202.600 Central Appalachian Pine-Oak Rocky Woodland

Division 202, Forest and Woodland

Spatial Scale & Pattern: Large Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Forest and Woodland (Treed), Shrubland (Shrub-dominated), Woody-Herbaceous, Ridge/Summit/Upper Slope, Acidic Soil, Pinus (strobus, rigida, echinata, virginiana) - Quercus prinus
Non-Diagnostic Classifiers: Lowland, Temperate, Oligotrophic Soil, Shallow Soil, Ustic, Consolidated, F-Patch/Medium Intensity, Needle-Leaved Tree, Broad-Leaved Deciduous Tree, Moderate (100-500 yrs) Persistence

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Concept Summary: This system of the central Appalachians encompasses open or scantily wooded hilltops and outcrops, or rocky slopes, at lower elevations. The substrate rock is granitic or of other acidic lithology. The vegetation is patchy, with woodland as well as open portions. *Pinus* spp. are diagnostic, and often are mixed with xerophytic *Quercus* spp. Conditions are dry and nutrient-poor, and many if not most sites have a history of fire.
Comments: The northern extent of this system in central New England may overlap with Laurentian-Acadian Acidic Rocky Outcrop (CES201.571).

DISTRIBUTION

Range: Central New England south to Virginia.
Ecological Divisions: 202
TNC Ecoregions: 49:P, 52:?, 59:C, 61:C
Subnations/Nations: CT:, MA:, MD:?, ME:, NH:, NJ:, NY:, PA:, VA:, VT:, WV:

CONCEPT

Associations:
(Pinus strobus, Quercus rubra) / Danthonia spicata Acid Bedrock Wooded Herbaceous Vegetation (G3G4, White Pine - Red Oak Bedrock Glade, CEGL005101)
Juniperus virginiana - Fraxinus americana / Danthonia spicata - Poa compressa Woodland (G2G3, Traprock Ridge, CEGL006002)
Paulownia tomentosa Woodland (GW, Princess-tree Woodland, CEGL003687)
Photinia melanocarpa - Gaylussacia baccata / Carex pensylvanica Shrubland (G1?, High-Elevation Outcrop Barren (Black Chokeberry Igneous / Metamorphic Type), CEGL008508)
Picea rubens / Vaccinium angustifolium High Allegheny Plateau Woodland (G3G5, Central Appalachian Red Spruce Woodland, CEGL006254)
Pinus (pungens, rigida) / Quercus ilicifolia / Gaylussacia baccata Woodland (G4, Central Appalachian Table Mountain Pine - Pitch Pine - Heath Woodland, CEGL004996)
Pinus echinata - Quercus prinus - Quercus stellata / Vaccinium pallidum / Pityopsis graminifolia var. latifolia Woodland (G2?, Pine-Oak Virginia Shield Barrens, CEGL004445)
Pinus pungens - Pinus rigida - (Quercus prinus) / Kalmia latifolia - Vaccinium pallidum Woodland (G3, Blue Ridge Table Mountain Pine - Pitch Pine Woodland (Typic Type), CEGL007097)
Pinus rigida - Quercus (coccinea, velutina) / Schizachyrium scoparium Woodland (G3G5, CEGL006166)
Pinus rigida / Photinia melanocarpa / Deschampsia flexuosa - Schizachyrium scoparium Woodland (G?, Pitch Pine Rocky Summit, CEGL006116)
Pinus rigida / Quercus ilicifolia / Photinia melanocarpa Woodland (G4G5, High Allegheny Pine Barrens, CEGL006323)
Quercus ilicifolia - Prunus pumila Shrubland (G?, Ridgetop Scrub Oak Barrens, CEGL006121)
Quercus ilicifolia Shrubland [Placeholder] (G?, CEGL003883)
Quercus prinus - Pinus virginiana - Quercus (marilandica, stellata) / Dichanthelium depauperatum Woodland (G2?, Central Appalachian Xeric Sandstone Woodland, CEGL008540)
Quercus prinus / Quercus ilicifolia / Danthonia spicata - Solidago bicolor Woodland (G3?, Central Appalachian Xeric Shale Woodland (Rock Chestnut Oak / Mixed Herbs Type), CEGL008526)
Quercus rubra - Quercus prinus - Pinus strobus / Penstemon hirsutus Woodland (G3G5, CEGL006074)

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Saxifraga michauxii Herbaceous Vegetation (G3?, Low-Elevation Rocky Summit (Acidic Type), CEGL004524)
Vaccinium (angustifolium, myrtilloides, pallidum) High Allegheny Plateau / Central Appalachian Dwarf-shrubland (G?, Central Appalachian Blueberry Shrubland, CEGL003958)
Vaccinium angustifolium - Sorbus americana / Sibbaldiopsis tridentata Dwarf-shrubland (G?, Blueberry Granite Barrens, CEGL005094)

SOURCES

Last updated: 09 Jan 2003 **Stakeholders:** ECS, SCS
Concept Author: S.C. Gawler **LeadResp:** ECS

CES202.592 Northeastern Interior Dry Oak Forest

Division 202, Forest and Woodland

Spatial Scale & Pattern: Matrix
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Lowland, Forest and Woodland (Treed), Acidic Soil, Quercus - Carya
Non-Diagnostic Classifiers: Sideslope, Toeslope/Valley Bottom, Mineral: W/ A-Horizon >10 cm, Loam Soil Texture, Ustic, F-Patch/Medium Intensity, Broad-Leaved Deciduous Tree
Concept Summary: These oak-dominated forests are one of the matrix forest systems in the northeastern and north-central U.S. Occurring in dry to dry-mesic settings, they grade from closed-canopy forests to patchy-canopy woodlands. They cover large expanses at low to mid elevations, where the topography is flat to gently rolling, occasionally steep. Soils are acidic and relatively infertile, but not strongly xeric. Oak species characteristic of dry-mesic conditions (e.g., *Quercus rubra, Quercus alba, Quercus velutina*, and *Quercus coccinea*) and *Carya* spp. are dominant in mature stands. *Castanea dentata* was a prominent tree before chestnut blight eradicated it as a canopy constituent. *Acer rubrum, Betula lenta*, and *Betula alleghaniensis* may be common associates. Especially on the drier and more acidic sites, heaths, including *Kalmia latifolia, Gaylussacia baccata*, and *Vaccinium* spp., may be important shrubs or dwarf-shrubs. With a long history of human habitation, many of the forests are early- to mid-successional, where *Pinus strobus, Pinus virginiana*, or *Liriodendron tulipifera* may be dominant or codominant. Within these forests, hillslope pockets with impeded drainage may support small isolated wetlands, including non-forested seeps or forested wetlands with *Acer rubrum, Quercus bicolor*, or *Nyssa sylvatica* characteristic.

DISTRIBUTION

Range: Central New England west and south through Pennsylvania to North Carolina and Tennessee.
Ecological Divisions: 202
TNC Ecoregions: 49:C, 59:C, 60:C, 61:C, 64:P
Subnations/Nations: CT:, MA:, MD:, ME:, NC:, NH:, NJ:, NY:, OH:, PA:, RI:, TN:, VA:, VT:, WV:

CONCEPT

Associations:
Acer rubrum - Nyssa sylvatica - Betula alleghaniensis / Sphagnum spp. Forest (G?, Red Maple - Black Gum Basin Swamp, CEGL006014)

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Acer rubrum - Nyssa sylvatica High Allegheny Plateau, Central Appalachian Forest (G?, Central Appalachian Forested Acid Seep, CEGL006132)
Carya (glabra, ovata) - Fraxinus americana - Quercus spp. Forest (G?, CEGL006236)
Castanea dentata - Quercus rubra Forest (GH, American Chestnut Forest (Mesic Montane Type), CEGL007286)
Deschampsia caespitosa - Symplocarpus foetidus Herbaceous Vegetation (G1, Inland Acidic Seep Community, CEGL006101)
Kalmia latifolia / Schizachyrium scoparium / Cladonia spp. Shrub Herbaceous Vegetation (G1, Southern Appalachian High-Elevation Mafic Glade (Flatrock Type), CEGL004238)
Pinus strobus - Quercus (rubra, velutina) - Fagus grandifolia Forest (G5, White Pine - Oak Forest, CEGL006293)
Pinus strobus Successional Forest (GD, Eastern White Pine Successional Forest, CEGL007944)
Pinus virginiana Successional Forest (GD, Virginia Pine Successional Forest, CEGL002591)
Quercus (alba, rubra, velutina) / Cornus florida / Viburnum acerifolium Forest (G?, Dry Oak-Hickory Forest, CEGL006336)
Quercus (velutina, alba) / Vaccinium pallidum High Allegheny Plateau, Western Allegheny Plateau Forest (G?, CEGL006018)
Quercus alba - Quercus (rubra, coccinea) - Carya (alba, glabra) / Vaccinium pallidum Piedmont Dry-Mesic Forest (G5?, Piedmont Dry-Mesic Oak - Hickory Forest, CEGL008475)
Quercus alba - Quercus prinus - Carya glabra / Cornus florida / Vaccinium pallidum / Carex pensylvanica Forest (G4?, Central Appalachian Acidic Oak - Hickory Forest, CEGL008515)
Quercus alba - Quercus rubra - Carya (alba, ovata) / Cornus florida Acid Forest (L, G3, White Oak - Red Oak Dry-Mesic Acid Forest, CEGL002067)--may be too far west
Quercus alba - Quercus rubra - Carya ovata Glaciated Forest (L, G4?, Midwestern White Oak - Red Oak Forest, CEGL002068)--may be too far west
Quercus alba - Quercus rubra - Quercus prinus - Acer saccharum / Lindera benzoin Forest (L, G?, White Oak - Chestnut Oak - Maple Acid Forest, CEGL002059)--may be too far west
Quercus bicolor / Vaccinium corymbosum / Carex stipata Forest (G?, Perched Swamp White Oak Swamp, CEGL006241)
Quercus coccinea - Quercus velutina - Quercus alba / Amelanchier arborea / Gaylussacia baccata Forest (G3G4, Mixed Oak / Heath Forest (Low-Elevation White Oak - Scarlet Oak - Black Oak Type), CEGL008521)
Quercus prinus - Quercus (alba, coccinea, velutina) / Viburnum acerifolium - (Kalmia latifolia) Forest (G4?, Appalachian Oak - (Chestnut) Forest, CEGL005023)
Quercus prinus - Quercus rubra - Carya (glabra, alba) / Gaylussacia baccata Forest (G5, Central Appalachian Rocky Dry-Mesic Oak Forest, CEGL006057)
Quercus prinus - Quercus rubra - Carya ovalis / Solidago (ulmifolia, arguta) - Galium latifolium Forest (G3G4, Central Appalachian Basic Oak - Hickory Forest (Montane Type), CEGL008516)
Quercus prinus - Quercus velutina / Oxydendrum arboreum - Cornus florida Forest (G4?, Mixed Oak / Heath Forest (Rock Chestnut Oak - Black Oak Type), CEGL008522)
Quercus prinus / Rhododendron catawbiense - Kalmia latifolia Forest (G3?, Central Appalachian Rock Chestnut Oak / Catawba Rhododendron Forest, CEGL008524)
Quercus rubra - (Quercus prinus) / Vaccinium spp. / Deschampsia flexuosa Woodland (G3G5, Appalachian Red Oak Woodland (Northern Type), CEGL006134)

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Quercus rubra - Acer rubrum / Calycanthus floridus - Pyrularia pubera / Thelypteris noveboracensis Forest (G4?, Appalachian Montane Oak - Hickory Forest (Red Oak Type), CEGL006192)
Quercus rubra - Carya ovata / Dennstaedtia punctilobula - Eupatorium purpureum - (Stachys nuttallii) Forest (G2, Central Appalachian Montane Oak - Hickory Forest (High-Elevation Northern Red Oak - Shagbark Hickory Type), CEGL008520)
Quercus rubra - Quercus alba - Fraxinus americana - Carya (ovata, ovalis) / Actaea racemosa Forest (G3, Central Appalachian Montane Oak - Hickory Forest (Northern Red Oak - White Oak - White Ash Type), CEGL008518)
Quercus rubra - Quercus alba / Rhododendron prinophyllum - Ilex montana / Calamagrostis porteri Forest (G3?, Northern Red Oak Forest (Early Azalea / Porter Reedgrass Type), CEGL008506)
Quercus rubra - Quercus prinus / Deschampsia flexuosa - Danthonia compressa - Calamagrostis porteri Woodland (G?, Central Appalachian High-Elevation Red Oak Woodland (Southern Type), CEGL004714)
Quercus rubra / Ilex montana - Menziesia pilosa / Dennstaedtia punctilobula Forest (G3?, Northern Red Oak Forest (Minniebush / Hay-scented Fern Type), CEGL008505)

SPATIAL CHARACTERISTICS

Spatial Summary: These were historically among the most important matrix forests of the northeast. They cover extensive areas where conditions are not extreme. Upslope they may grade into xeric oak ridge systems or rocky oak - pine forests/woodlands. Mesic cove forest systems may be embedded within this matrix in protected draws. Small pocket wetlands, not discriminated as separate systems, may also occur within these forests.

SOURCES

Last updated: 09 Jan 2003
Concept Author: S.C. Gawler
Stakeholders: ECS, MCS, SCS
LeadResp: ECS

CES202.604 North-Central Appalachian Acidic Swamp

Division 202, Woody Wetland

Spatial Scale & Pattern: Large Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Wetland
Diagnostic Classifiers: Forest and Woodland (Treed), Needle-Leaved Tree, Extensive Wet Flat, 30-180-day hydroperiod
Non-Diagnostic Classifiers: Lowland, Temperate, Organic Peat (>40 cm), Mineral: W/ A-Horizon >10 cm, Broad-Leaved Deciduous Tree, Moderate (100-500 yrs) Persistence, Acidic Water, Shallow (<15 cm) Water
Concept Summary: These swamps are distributed through the Central Appalachians south to Virginia. They are found in basins, or on gently sloping seepage lowlands. The acidic substrate is mineral soil, often with a component of organic muck; if peat is present, it usually forms an organic epipedon over the mineral soil rather than a true peat substrate. *Tsuga canadensis* is usually present and may be dominant. It is often mixed with deciduous wetland trees such as *Acer rubrum* or *Nyssa sylvatica*. *Sphagnum* is an important component of the bryoid layer. Basin swamps tend to be more nutrient-poor and less species-rich than seepage swamps; in some

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settings, the two occur adjacent to each other with the basin swamp vegetation surrounded by seepage swamp vegetation on its upland periphery.
Comments: This system excludes swamps with *Chamaecyparis thyoides*, a tree more characteristic of the Coastal Plain, but which sometimes occurs inland. See Atlantic Coastal Plain Northern Basin Peat Swamp (CES203.522).

DISTRIBUTION

Range: Central New England south to West Virginia and Virginia.
Ecological Divisions: 202
TNC Ecoregions: 49:P, 52:?, 59:C, 60:P, 61:C
Subnations/Nations: CT:, MA:, MD:, NH:, NJ:, NY:, PA:, RI:, VA:, VT:, WV:

CONCEPT

Associations:
Acer rubrum - Fraxinus (pennsylvanica, americana) / Lindera benzoin / Symplocarpus foetidus Forest (G4G5, Southern New England Red Maple Seepage Swamp, CEGL006406)
Acer rubrum - Nyssa sylvatica - (Pinus rigida) / Ilex verticillata / Osmunda cinnamomea Forest (G3G4, CEGL007853)
Acer rubrum - Nyssa sylvatica - Betula alleghaniensis / Sphagnum spp. Forest (G?, Red Maple - Black Gum Basin Swamp, CEGL006014)
Acer rubrum - Nyssa sylvatica - Magnolia virginiana Forest (G3?, Southern Red Maple - Black Gum Swamp Forest, CEGL006238)
Acer rubrum - Nyssa sylvatica High Allegheny Plateau, Central Appalachian Forest (G?, Central Appalachian Forested Acid Seep, CEGL006132)
Acer rubrum / Rhododendron viscosum - Clethra alnifolia Forest (G?, Southern New England Red Maple - Swamp, CEGL006156)
Betula alleghaniensis - Acer rubrum - (Tsuga canadensis, Abies balsamea) / Osmunda cinnamomea Forest (G4?, Hardwood - Conifer Seepage Forest, CEGL006380)
Fraxinus nigra - Abies balsamea / Rhamnus alnifolia Forest (G1, Central Appalachian Circumneutral Seepage Swamp, CEGL006003)
Picea rubens - (Tsuga canadensis) / Rhododendron maximum Saturated Forest (G2?, Swamp Forest - Bog Complex (Spruce Type), CEGL006277)
Picea rubens - Abies balsamea / Sphagnum magellanicum Forest (G?, Lower New England Spruce - Fir Swamp, CEGL006311)
Quercus bicolor / Vaccinium corymbosum / Carex stipata Forest (G?, Perched Swamp White Oak Swamp, CEGL006241)
Tsuga canadensis - Betula alleghaniensis / Ilex verticillata / Sphagnum spp. Forest (G5, Hemlock - Hardwood Swamp, CEGL006226)
Tsuga canadensis / Rhododendron maximum / Sphagnum spp. Forest (G?, Eastern Hemlock - Great Laurel Swamp, CEGL006279)

SOURCES

Last updated: 23 Mar 2003
Concept Author: S.C. Gawler
Stakeholders: ECS, MCS
LeadResp: ECS

CES202.606 North-Central Interior and Appalachian Acid Peatland

Division 202, Woody Wetland

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Spatial Scale & Pattern: Small Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Wetland
Diagnostic Classifiers: Shrubland (Shrub-dominated), Organic Peat (>40 cm), Acidic Water, >180-day hydroperiod
Non-Diagnostic Classifiers: Lowland, Temperate, Unconsolidated, Long (>500 yrs) Persistence, Depressional, Oligotrophic Water
Concept Summary: These *Sphagnum* and shrub peatlands occur in basins south of the Laurentian-Acadian region down to near the glacial boundary in the northeastern and north-central U.S. They are found in colder regions of the division, mostly in areas where glacial stagnation left coarse deposits and glacial depressions (many are "kettleholes"). The basins are generally closed, i.e., without inlets or outlets of surface water. The nutrient-poor substrate and the reduced throughflow of water create oligotrophic conditions fostering the development of *Sphagnum* peat and the growth of peatland vegetation. In deeper basins, the vascular vegetation grows on a *Sphagnum* mat over water, with no mineral soil development. Ericaceous shrubs and dwarf-shrubs (e.g., *Chamaedaphne calyculata*) dominate, with patches of graminoid dominance. Some peatlands may have a sparse tree layer. Although these are often called bogs, in most cases they are technically fens (albeit nutrient-poor ones), as the vegetation remains in contact with the groundwater.
Comments: This system occurs south of the Laurentian-Acadian region, and these acidic peatlands are distinctive and discrete elements of the landscape. They are related to Laurentian-Acadian Acidic Swamp (CES201.574). There are enough differences in landscape setting and more temperate floristic elements to distinguish them. They include treed, shrub, and graminoid associations. In the Midwest, it may be necessary to split off the shrub/graminoid acid peatland (poor fen) types.

DISTRIBUTION

Range: Central New England to the Great Lakes and south-central Minnesota southward, generally associated with the glacial terminus or stagnation zones.
Ecological Divisions: 202
TNC Ecoregions: 45:P, 46:P, 48:P, 49:P, 59:?, 60:P, 61:C, 62:C, 64:P
Subnations/Nations: CT:, IL:c, IN:c, MA:, ME:, MI:c, MN:c, NH:, NJ:, NY:, OH:c, ON:c, PA:, RI:, VT:, WI:c

CONCEPT

Associations:
Carex lasiocarpa - Carex oligosperma - (Lysimachia terrestris) / Sphagnum spp. / Spiraea tomentosa Herbaceous Vegetation (G3G4, Midwestern Graminoid Poor Fen, CEGL005279)
Carex oligosperma - Carex pauciflora - Eriophorum vaginatum / Sphagnum spp. Herbaceous Vegetation (G4G5, Open Graminoid / Sphagnum Bog, CEGL005256)
Chamaecyparis thyoides / Chamaedaphne calyculata Woodland (G3G4, CEGL006321)
Chamaedaphne calyculata - (Gaylussacia dumosa) - Decodon verticillatus / Woodwardia virginica Dwarf-shrubland (G5, Southern New England Bog, CEGL006008)
Chamaedaphne calyculata / Carex oligosperma - Eriophorum virginicum Dwarf-shrubland (G3G4, Leatherleaf Kettle Bog, CEGL005092)
Larix laricina / Photinia melanocarpa / Sphagnum spp. Forest (G4?, Central Tamarack Poor Swamp, CEGL002472)

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Myrica gale - Chamaedaphne calyculata / Carex (lasiocarpa, utriculata) - Utricularia spp. Shrub Herbaceous Vegetation (G4G5, Medium Fen, CEGL006302)
Myrica gale - Chamaedaphne calyculata / Carex exilis Shrub Herbaceous Vegetation (G?, Coastal Plain Poor Fen, CEGL006392)
Myrica gale - Dasiphora fruticosa ssp. floribunda / Carex lasiocarpa - Cladium mariscoides Shrub Herbaceous Vegetation (G2G3, CEGL006068)
Picea mariana / (Vaccinium corymbosum, Gaylussacia baccata) / Sphagnum sp. Woodland (G3G5, Black Spruce Woodland Bog, CEGL006098)
Pinus rigida / Chamaedaphne calyculata / Sphagnum spp. Woodland (G3G5, CEGL006194)
Sphagnum (rubellum, cuspidatum, torreyanum) - Vaccinium (oxycoccos, macrocarpon) Nonvascular Vegetation (G?, Peatland Moss Lawn, CEGL006394)
Vaccinium corymbosum - Gaylussacia baccata - Photinia melanocarpa / Calla palustris Shrubland (G2G3, Highbush Blueberry Poor Fen, CEGL005085)
Vaccinium corymbosum / Sphagnum spp. Shrubland (G3G5, Highbush Blueberry Bog Thicket, CEGL006190)

SOURCES

References: Damman and French 1987
Last updated: 23 Mar 2003 **Stakeholders:** ECS, MCS, SCS
Concept Author: S.C. Gawler **LeadResp:** ECS

CES202.605 North-Central Interior and Appalachian Rich Swamp

Division 202, Woody Wetland

Spatial Scale & Pattern: Small Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Wetland
Diagnostic Classifiers: Temperate, Broad-Leaved Deciduous Tree, Depressional, Mesotrophic Water, Saturated Soil
Non-Diagnostic Classifiers: Lowland, Forest and Woodland (Treed), Mineral: W/ A-Horizon >10 cm, Moderate (100-500 yrs) Persistence, Extensive Wet Flat, Intermittent Flooding
Concept Summary: These forested wetlands are scattered throughout the north-central Midwest (south of the Laurentian region) and the north-central Appalachians at low to mid elevations. They are found in basins where higher pH and/or nutrient levels are associated with a rich flora. Tree species include *Acer rubrum*, *Fraxinus nigra*, as well as calciphilic herbs. Conifers include *Larix laricina*, but typically not *Thuja occidentalis*, which is characteristic of more northern wetland systems. There may be shrubby or herbaceous openings within the primarily wooded cover. The substrate is primarily mineral soil, but there may be some peat development.
Comments: This system occurs south of the Laurentian-Acadian region, and these circumneutral or enriched swamps are often rather distinctive and discrete elements of the landscape. They are related to Laurentian-Acadian Alkaline Swamp (CES201.575) but have more temperate elements and generally lack *Thuja occidentalis*." More alkaline shrub/herb fens are treated as part of the North-Central Interior Shrub-Graminoid Alkaline Fen (CES202.702).

DISTRIBUTION

Range: Central New England to the southern Great Lakes and south-central Minnesota south to northern Illinois, Indiana, Ohio, Pennsylvania, and perhaps West Virginia and Virginia.

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Ecological Divisions: 202
TNC Ecoregions: 45:C, 46:C, 48:C, 49:P, 52:P, 59:C, 60:?, 61:C
Subnations/Nations: CT:, IL:c, IN:c, MA:, MI:c, MN:c, NJ:, NY:, OH:c, ON:c, PA:, RI:, VA:p, VT:, WI:c, WV:p

CONCEPT

Associations:
Acer (rubrum, saccharinum) - Fraxinus spp. - Ulmus americana Forest (L, G4?, Maple - Ash - Elm Swamp Forest, CEGL005038)
Acer rubrum - Larix laricina / Rhamnus alnifolia Woodland (G3G5, Red Maple - Larch Wooded Fen, CEGL006118)
Fraxinus nigra - Acer rubrum - (Larix laricina) / Rhamnus alnifolia Forest (G?, Rich Red Maple - Black Ash Swamp, CEGL006009)
Fraxinus nigra - Acer rubrum / Carex leptalea Saturated Forest (G?, Red Maple - Black Ash Swamp, CEGL007441)
Fraxinus nigra - Liriodendron tulipifera - Acer rubrum / Caltha palustris - Carex bromoides Forest (G3, Montane Black Ash Seepage Swamp, CEGL008416)
Larix laricina - Acer rubrum / (Rhamnus alnifolia, Vaccinium corymbosum) Forest (G2G3, Central Tamarack - Red Maple Rich Swamp, CEGL005232)

SOURCES

Last updated: 09 Jan 2003
Concept Author: S.C. Gawler
Stakeholders: ECS, MCS
LeadResp: ECS

CES202.608 Central Appalachian Floodplain

Division 202, Mixed Upland and Wetland

Spatial Scale & Pattern: Large Patch
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland, Wetland
Diagnostic Classifiers: Forest and Woodland (Treed), Toeslope/Valley Bottom, Broad-Leaved Deciduous Tree, Riverine / Alluvial, Intermittent Flooding, Short (<5 yrs) Flooding Interval
Non-Diagnostic Classifiers: Lowland, Temperate, Eutrophic Soil, Deep Soil, Mineral: W/ A-Horizon >10 cm, Silt Soil Texture, Udic, Ustic, Unconsolidated, Short Disturbance Interval, Flood Scouring, Moderate (100-500 yrs) Persistence, 1-29-day hydroperiod, 30-180-day hydroperiod
Concept Summary: This system encompasses floodplains from southern New England to Virginia. Mostly forested, these occur on floodplains of medium to large rivers where topography and process have resulted in the development of a relatively flat floodplain with a complex of upland and wetland temperate alluvial vegetation. This complex includes floodplain forests in which *Acer saccharinum, Populus deltoides*, and *Platanus occidentalis* are characteristic, as well as herbaceous sloughs and shrub wetlands. Most areas are underwater each spring; microtopography determines how long the various habitats are inundated. Depositional and erosional features may both be present depending on the particular floodplain, although there is a history of deposition in the floodplain formation.
Comments: This system is distinguished from floodplain systems northward (Laurentian-Acadian Floodplain Forest (CES201.587)) and westward (North-Central Interior Floodplain (CES202.694)).

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DISTRIBUTION

Range: Southern New England west to Lake Erie and south to Virginia. The James River in Virginia marks the southern extent of this system.
Ecological Divisions: 202
TNC Ecoregions: 49:C, 52:C, 59:C, 60:P, 61:C
Subnations/Nations: CT:c, MA:c, MD:c, NH:c, NJ:?, NY:c, OH:p, PA:c, VA:c, VT:c, WV:c

CONCEPT

Associations:
Acer negundo Forest (G4G5, Box-elder Floodplain Forest, CEGL005033)
Acer rubrum - Fraxinus pennsylvanica / Boehmeria cylindrica Forest [Provisional] (G?, Red Maple - Green Ash Forested Swamp, CEGL006548)
Acer saccharinum - (Populus deltoides) / Matteuccia struthiopteris Forest (G?, Silver Maple Floodplain Levee Forest (Ostrich Fern Type), CEGL006147)
Acer saccharinum - Ulmus americana - (Populus deltoides) Forest (G4?, Silver Maple - Elm - (Cottonwood) Forest, CEGL002586)
Acer saccharinum - Ulmus americana / Onoclea sensibilis Forest (G?, Silver Maple - Elm Floodplain Forest, CEGL006001)
Acer saccharinum - Ulmus americana / Physocarpus opulifolius Forest (G?, CEGL006042)
Acer saccharinum / Onoclea sensibilis - Boehmeria cylindrica Forest (G?, Silver Maple Floodplain Bottom Forest (Sensitive Fern Type), CEGL006176)
Acer saccharum - Fraxinus spp. - Tilia americana / Matteuccia struthiopteris - Ageratina altissima Forest (G?, Terrace Hardwood Floodplain Forest, CEGL006114)
Alnus serrulata - Physocarpus opulifolius Shrubland (G5, Allegheny Floodplain Alder Thicket, CEGL006251)
Alnus serrulata Eastern Shrubland (G4G5, Smooth Alder Swamp, CEGL005082)
Arundinaria gigantea ssp. gigantea Shrubland (G2?, Floodplain Canebrake, CEGL003836)
Betula nigra - Platanus occidentalis / Impatiens pallida Forest (G?, CEGL006184)
Betula nigra - Platanus occidentalis Forest (G5, River Birch - Sycamore Forest, CEGL002086)
Carex torta Herbaceous Vegetation (G3G4, Rocky Bar and Shore (Twisted Sedge Type), CEGL004103)
Cephalanthus occidentalis / Carex spp. - Lemna spp. Southern Shrubland (G4, Southern Buttonbush Pond, CEGL002191)
Fagus grandifolia - Quercus spp. - Acer rubrum - Juglans nigra Forest (G2G3, Beech - Mixed Hardwood Floodplain Forest, CEGL005014)
Fraxinus pennsylvanica - Ulmus spp. - Celtis occidentalis Forest (G3G5, Central Green Ash - Elm - Hackberry Forest, CEGL002014)
Justicia americana Herbaceous Vegetation (G4G5, Water-willow Rocky Bar and Shore, CEGL004286)
Liriodendron tulipifera - Pinus strobus - (Tsuga canadensis) / Carpinus caroliniana / Amphicarpaea bracteata Forest (G3, Central Appalachian Small-Stream Montane Floodplain Forest, CEGL008405)
Peltandra virginica - Saururus cernuus - Carex crinita / Climacium americanum Herbaceous Vegetation (G2?, Floodplain Pool, CEGL007696)
Platanus occidentalis - Acer saccharinum - Juglans nigra - Ulmus rubra Forest (G4, Sycamore - Silver Maple Calcareous Floodplain Forest, CEGL007334)

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Platanus occidentalis - Liquidambar styraciflua / Asimina triloba Forest (G5, Sycamore - Sweetgum Piedmont Swamp Forest, CEGL007340)
Quercus (palustris, phellos) - Acer rubrum / Cinna arundinacea Forest (G?, CEGL006605)
Quercus bicolor - Acer rubrum / Carpinus caroliniana Forest (G?, Swamp White Oak Floodplain Forest, CEGL006386)
Quercus palustris - Acer rubrum / Carex grayi - Geum canadense Forest (G?, CEGL006185)
Tilia americana - Acer saccharum - Acer nigrum / Laportea canadensis Forest (G?, Rich Floodplain Forest, CEGL006405)

SOURCES

Last updated: 09 Jan 2003
Concept Author: S.C. Gawler
Stakeholders: ECS, MCS, SCS
LeadResp: ECS

CES202.609 Central Appalachian Riparian

Division 202, Mixed Upland and Wetland

Spatial Scale & Pattern: Linear
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland, Wetland
Diagnostic Classifiers: Lowland, Very Short Disturbance Interval, Flood Scouring, Riverine / Alluvial, Intermittent Flooding
Non-Diagnostic Classifiers: Forest and Woodland (Treed), Sideslope, Toeslope/Valley Bottom, Temperate, Mesotrophic Soil, Udic, Ustic, Short (50-100 yrs) Persistence, Short (<5 yrs) Flooding Interval
Concept Summary: This riparian system ranges from southern New England to Virginia. It develops on floodplains and shores along river channels that lack a broad flat floodplain due to steeper sideslopes, higher gradient, or both. Flooding is the major process affecting the vegetation, but compared to flat floodplain areas, the substrate is more rapidly drained, and deposition is less important than erosion. The vegetation is a mosaic of forest, woodlands, shrublands, and herbaceous communities. Common trees include *Betula nigra, Platanus occidentalis*, and *Acer negundo*. *Panicum virgatum* and *Andropogon gerardii* are typical of open, flood-scoured rivershore prairies, and *Carex torta* is typical of wetter areas near the channel.
Comments: This is a high-gradient system, unlike the low-gradient system described in Central Appalachian Floodplain (CES202.608).

DISTRIBUTION

Range: Southern New England west to Lake Erie and south to Virginia. The James River in Virginia marks the southern extent of this system.
Ecological Divisions: 202
TNC Ecoregions: 49:C, 52:C, 59:C, 60:?, 61:C
Subnations/Nations: CT:c, MA:c, MD:c, NH:c, NJ:?, NY:c, OH:p, PA:c, VA:c, VT:c, WV:c

CONCEPT

Associations:
Alnus serrulata - Physocarpus opulifolius Shrubland (G5, Allegheny Floodplain Alder Thicket, CEGL006251)
Andropogon gerardii - Campanula rotundifolia - Solidago simplex Herbaceous Vegetation (G2, Northern Riverside Rock Outcrop, CEGL006284)

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Andropogon gerardii - Panicum virgatum - Baptisia australis Herbaceous Vegetation (G2G3, Fall-Line Riverwash Bedrock Prairie, CEGL006283)
Andropogon gerardii - Phlox subulata - Solidago simplex var. racemosa - Packera paupercula Herbaceous Vegetation (G2?, Potomac River Basalt Outcrop Scour Prairie, CEGL004284)
Betula nigra - Salix interior Shrubland (G4G5, Birch - Willow Riverbank Shrubland, CEGL003896)
Carex torta Herbaceous Vegetation (G3G4, Rocky Bar and Shore (Twisted Sedge Type), CEGL004103)
Hudsonia tomentosa - Paronychia argyrocoma Dwarf-shrubland (G1, Hudsonia Riverwash Barren, CEGL006232)
Justicia americana Herbaceous Vegetation (G4G5, Water-willow Rocky Bar and Shore, CEGL004286)
Panicum virgatum - Andropogon gerardii - Sorghastrum nutans Connecticut River High Terrace Herbaceous Vegetation (G1?, Connecticut River Floodplain Terrace Prairie, CEGL004623)
Pinus rigida - Hudsonia tomentosa - Pityopsis falcata Sparse Vegetation (G?, Inland Dune, CEGL006391)
Pinus strobus - Betula populifolia / Comptonia peregrina / Schizachyrium scoparium Woodland (G2, Dry River Bluff, CEGL006004)
Podostemum ceratophyllum Herbaceous Vegetation (G3G5, Rocky Bar and Shore (Riverweed Type), CEGL004331)
Quercus (palustris, phellos) - Acer rubrum / Cinna arundinacea Forest (G?, CEGL006605)
Salix nigra Temporarily Flooded Shrubland (G4?, Black Willow Riverbank Shrubland, CEGL003901)
Tsuga canadensis - (Pinus strobus) Temporarily Flooded Forest (G3, Montane Alluvial Forest (Small River Type), CEGL007143)

SOURCES

Last updated: 09 Jan 2003 **Stakeholders:** ECS, MCS, SCS
Concept Author: S.C. Gawler **LeadResp:** ECS, MCS

CES202.601 North-Central Appalachian Acidic Cliff and Talus

Division 202, Barren

Spatial Scale & Pattern: Small Patch
Required Classifiers: Natural/Semi-natural, Non-vegetated (<10% vasc.), Upland
Diagnostic Classifiers: Cliff (Substrate), Talus (Substrate), Temperate, Acidic Soil
Non-Diagnostic Classifiers: Lowland, Sideslope, Very Shallow Soil, Ustic, Landslide
Concept Summary: Sparsely vegetated to partially wooded cliffs and talus slopes in the Central Appalachians occurring on rocks of acidic lithology and lacking any indicators of enriched conditions. This cliff system occurs at low to mid elevations from central New England south to Tennessee. It consists of vertical or near-vertical cliffs and the talus slopes below, formed on hills of granitic, sandstone, or otherwise acidic bedrock. Most of the substrate is dry and exposed, but small (occasionally large) areas of seepage are often present. Vegetation in seepage areas tends to be more well-developed and floristically different from the surrounding dry cliffs. The vegetation is patchy and often sparse, punctuated with patches of small trees that may form woodlands in places. *Juniperus virginiana* is a characteristic tree species, *Toxicodendron radicans* a characteristic woody vine, and *Polypodium virginianum* a characteristic fern.

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DISTRIBUTION

Range: Central New England and New York south to Tennessee.
Ecological Divisions: 202
TNC Ecoregions: 49:?, 51:?, 52:?, 59:C, 60:?, 61:C
Subnations/Nations: CT:, MA:, MD:?, NY:, OH:, PA:, TN:, VA:, VT:, WV:

CONCEPT

Associations:
Asplenium montanum Central Appalachian Sandstone Sparse Vegetation (G?, Spleenwort Acidic Cliff, CEGL004391)
Betula alleghaniensis - Quercus rubra / Polypodium virginianum Woodland (G3G5, Northern Hardwood - Oak Talus Slope Woodland, CEGL006320)
Parthenocissus quinquefolia / Dicentra eximia Sparse Vegetation (G2G3Q, Appalachian Talus Slope, CEGL004454)
Quercus prinus - Betula lenta / Parthenocissus quinquefolia Talus Woodland (G?, Chestnut Oak - Black Birch - Virginia Creeper Wooded Talus Slopes, CEGL006565)
Sandstone Dry Cliff Sparse Vegetation (G4G5, Midwest Dry Sandstone Cliff, CEGL002045)
Sandstone Midwest Moist Cliff Sparse Vegetation (G4G5, Midwest Moist Sandstone Cliff, CEGL002287)
Umbilicaria mammulata Nonvascular Vegetation (G4?, Montane Cliff (Carolina Rocktripe Type), CEGL004387)
Umbilicaria muehlenbergii - Lasallia papulosa - (Melanelia stygia) Nonvascular Vegetation (G2?, Central Appalachian Talus Slope, CEGL004389)

SOURCES

Last updated: 09 Jan 2003
Concept Author: S.C. Gawler
Stakeholders: ECS, MCS, SCS
LeadResp: ECS

CES202.603 North-Central Appalachian Circumneutral Cliff and Talus

Division 202, Barren

Spatial Scale & Pattern: Small Patch
Required Classifiers: Natural/Semi-natural, Non-vegetated (<10% vasc.), Upland
Diagnostic Classifiers: Cliff (Substrate), Talus (Substrate), Temperate, Alkaline Soil
Non-Diagnostic Classifiers: Lowland, Sideslope, Circumneutral Soil, Very Shallow Soil, Ustic, Landslide, Moderate (100-500 yrs) Persistence
Concept Summary: This cliff system occurs at low to mid elevations from central New England south to Virginia. It consists of vertical or near-vertical cliffs and steep talus slopes, where weathering and/or bedrock lithology produce circumneutral to calcareous pH and enriched nutrient availability. Substrates include limestone, dolomite, and other rocks. The vegetation varies from sparse, to patches of small trees, in places forming woodland or even forest vegetation. *Fraxinus* spp., *Tilia americana*, and *Staphylea trifolia* are woody indicators of the enriched setting. The herb layer includes at least some species that are indicators of enriched conditions, e.g., *Impatiens pallida, Pellaea atropurpurea, Asplenium platyneuron*, or *Woodsia obtusa*.

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DISTRIBUTION

Range: Central New England and New York south to Virginia.
Ecological Divisions: 202
TNC Ecoregions: 52:?, 59:P, 60:?, 61:C
Subnations/Nations: MA:, MD:, ME:, NC:?, NH:, NJ:, NY:, OH:, PA:, TN:?, VA:, VT:, WV:

CONCEPT

Associations:
Acer saccharum - Fraxinus americana - Juglans cinerea / Staphylea trifolia Forest (G4?, CEGL006020)
Acer saccharum - Quercus muehlenbergii Forest (G?, Sugar Maple - Chinquapin Oak Forest, CEGL005010)
Acer saccharum - Tilia americana - Fraxinus americana / Ostrya virginiana / Geranium robertianum Woodland (G3G5, Rich Northern Hardwood Woodland, CEGL005058)
Asplenium ruta-muraria - Pellaea atropurpurea Sparse Vegetation (G3G4, Montane Cliff (Calcareous Type), CEGL004476)
Thuja occidentalis / Carex eburnea - Pellaea atropurpurea Woodland (G2G3, Appalachian Cliff White-cedar Woodland, CEGL002596)
Tilia americana - Fraxinus americana / Acer pensylvanicum - Ostrya virginiana / Parthenocissus quinquefolia - Impatiens pallida Woodland (G3, Central Appalachian Basic Boulderfield Forest (Montane Basswood - White Ash Type), CEGL008528)
Tilia americana - Fraxinus americana / Cornus florida Woodland (G3G5, CEGL006054)
Toxicodendron radicans / Heuchera americana - (Dichanthelium depauperatum, Woodsia obtusa) Herbaceous Vegetation (G?, Appalachian Mafic Cliff (Low-Elevation Type), CEGL004395)

SOURCES

Last updated: 09 Jan 2003
Concept Author: S.C. Gawler
Stakeholders: ECS, MCS, SCS
LeadResp: ECS

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APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

ACADIA				EORANK							
COMMON NAME	GLOBAL NAME	SRANK	GRANK	A	B	C	D	E	X	(blank)	Grand Total
Communities											
Black Spruce Woodland	Black spruce rocky woodland	S3	G4?			1					1
Jack Pine Woodland	Jack pine woodland	S3	G3G5		1						1
Low-elevation Bald	Three-toothed cinquefoil - blueberry low summit bald	S3	GNR		1						1
Lower-elevation Spruce - Fir Forest	Spruce - fir - broom-moss forest	S4	GNR		1						1
Maritime Spruce - Fir Forest	Maritime spruce - fir forest	S4	G4G5		1			1			2
Open Headland	Seaside goldenrod - goosetongue open headland	S4	GNR		1						1
Pitch Pine Woodland	Pitch pine rocky woodland	S3	G2		2						2
Raised Level Bog Ecosystem	Raised level bog ecosystem	S4	GNR		1						1
Red Pine Woodland	Red pine woodland	S3	G3G5					1			1
Sedge - Heath Fen	Sedge - leatherleaf fen lawn	S4	G4G5		1						1
Spruce - Northern Hardwoods Forest	Spruce - northern hardwoods forest	S4	GNR		1						1
Spruce - Pine Woodland	Red spruce - mixed conifer woodland	S4	G3G5		1						1
Streamshore Ecosystem	Streamshore ecosystem	S4	GNR					1			1
Total				0	11	1	0	3	0	0	15
Species											
Alpine Blueberry	Vaccinium boreale	S2	G4	1	1			1			3
Blinks	Montia fontana	S2	G5	1	1			2			4
Comb-leaved Mermaid-weed	Proserpinaca pectinata	S1	G5	1							1
Mountain Sandwort	Minuartia groenlandica	S3	G5	1	2						3
Mountain-laurel	Kalmia latifolia	S2	G5				1				1
New England Northern Reed Grass	Calamagrostis stricta ssp. inexpansa	S1	G5T5					1	1		2
Prototype Quillwort	Isoetes prototypus	S1	G1?					1			1
Salt-marsh Sedge	Carex recta	S1	G4					1			1
Screwstem	Bartonia paniculata	S1	G5	2				4			6
Sea-beach Sedge	Carex silicea	S3	G5			1		1			2

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

Smooth Sandwort	Minuartia glabra	S2	G4	1							1
Tarn	Tarn	S2	GNR					1			1
Water Awlwort	Subularia aquatica	S2	G5	1							1
White Cedar Woodland	White cedar rocky woodland	S2	GNR		2						2
Wiegand Sedge	Carex wiegandii	S3	G3	1	1			2			4
Total				9	5	1	1	14	1	0	33
Grand Total				9	16	2	1	17	1		48

BOSTON HARBOR				EORANK					
COMMON NAME	GNAME	RANK	GRANK	A	B	C	D	BLANK	Total
DEEP EMERGENT MARSH		?	?					1	1
ESTUARINE INTERTIDAL: BRACKISH TIDAL MARSH		?	?				1		1
ESTUARINE INTERTIDAL: SALT MARSH		?	?			1	2		3
MARITIME JUNIPER WOODLAND / SHRUBLAND		?	?					3	3
MARITIME ROCK CLIFF COMMUNITY		?	?					1	1
OAK - HICKORY FOREST		?	?			1			1
Grand Total						2	3	5	10

Species data to be compiled.

MARSH-BILLINGS				EORANK				
COMMON NAME	SCIENTIFIC NAME	SRANK	GRANK	A	B	C	D	Total
A grape fern	Botrychium sp							
Jefferson's salamander	Ambystoma jeffersonianum							

Data to be compiled

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

MINUTE MAN				EORANK				
COMMON NAME	GNAME	SRANK	GRANK	A	B	C	D	Total
BLACK GUM SWAMP		S2	?		1			1
KETTLEHOLE WET MEADOW		S3	?			2		2
Grand Total					1	2		3

Species data to be compiled.

MORRISTOWN				EORANK				
COMMON NAME	SCIENTIFIC NAME	SRANK	GRANK	A	B	C	D	Total

Datat to be compiled

ROOSEVELT-VANDERBILT				EORANK	
COMMON NAME	SCIENTIFIC NAME	SRANK	GRANK	blank	Total
Blanding's Turtle	Emydoidea blandingii	S2S3	G4		2
Shining Bedstraw	Galium concinnum	S1	G5		1
Shortnose Sturgeon	Acipenser brevirostrum	S1	G3		1
Woodland Agrimony	Agrimonia rostellata	S2	G5		1
Tidal River	Tidal river	S3	G4		1
Freshwater Tidal Marsh	Freshwater tidal marsh	S2	G3G4		1
Grand Total					7

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

SAINT-GAUDENS				EORANK				
COMNAME	SCIENTIFIC NAME	SRANK	GRANK	A	B	C	Blank	Total
A sedge	Carex bebbii	S2S3	G5				1	1
A horsetail	Equisetum variegatum	S2	G5			1		1
A turtle	Glyptemys insculpta	S3	G4				1	1
A minnow	Phoxinus eos	S3	G5				1	1
A pondweed	Potamogeton pectinatus	S2	G5				1	1
A pondweed	Potamogeton vaseyi	S2	G4				1	1
A forest type	SNE rich mesic forest	S1	GNR		1			1
	TOTAL				1	1	5	7

SARATOGA				EORANK	
COMMON NAME	SCIENTIFIC NAME	SRANK	GRANK	blank	Total
Circus cyaneus	Northern Harrier	S3B,S3N	G5		1
Platanthera hookeri	Hooker's Orchid	S1	G4		1
Grand Total					2

SAUGUS IRON WORKS				EORANK				
COMMON NAME	SCIENTIFIC NAME	SRANK	GRANK	A	B	C	D	Total
No elements reported								

WIER FARM				EORANK				
COMMON NAME	SCIENTIFIC NAME	SRANK	GRANK	A	B	C	D	Total

Data to be compiled

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
221	CT	Canada anemone	Anemone canadensis	SU	G5			2								2
		common raven	Corvus corax	S2B	G5				1							1
		Eastern woodrat	Neotoma floridana magister	SH	G5							1				1
		hemlock parsley	Conioselinum chinense	S3S4	G5				1							1
		Jefferson's Salamander	Ambystoma jeffersonianum	S3	G5					1						1
		Ostrich Fern borer	Paipapema species #2	S1S3	GU					1						1
		Roundleaf shadbush	Amelanchier sanguinea	S1	G5			1								1
		Slender cliffbrake	Cryptogramma stellari	S1	G5							1				1
		Small whorled pogonia	Isotria medeoloides	S1	G2				1							1
		Timber rattlesnake	Crotalus horridus	S1	G5					1				1		2
		Variegated Horsetail	Equisetum variegatum	S3	G5			1		1						2
		Whitlow-Grass	Draba reptans	S2	G5			1								1
	NJ	Adder's-tongue fern	Ophioglossum vulgatum	S3	G5									1		1
		Allegheny-vine	Adlumia fungosa	S2	G4	2			1							3
		American ginseng	Panax quinquefolius	S2	G4				1							1
		Brownish sedge	Carex brunnescens	S1	G5							1				1
		Dewey's sedge	Carex deweyana	S1	G5		1									1
		Floating heart	Nymphoides cordata	S3	G5		1									1
		Fly honeysuckle	Lonicera canadensis	S1	G5	1	1									2
		Fringed bottle-gentian	Gentiana andrewsii	S2	G4		1									1
		Hitchcock's sedge	Carex hitchcockiana	S2	G5	2			1							3
		Little grape fern	Botrychium simplex var. simplex	S1	G5TU									1		1
		Long beech fern	Thelypteris phegopteris	S2	G5				1							1
		marsh muhly	Muhlenbergia glomerata	S2	G5				1							1
		Mountain azalea	Rhododendron prinophyllum	S3	G5		1	1								2

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		Oak fern	Gymnocarpium dryopteris	S2	G5	1										1
		Painted trillium	Trillium undulatum	S3	G5				1							1
		paper birch	Betula papyrifera	S2	G5	2		1	1							4
		Pellitory	Parietraria pensylvanica	S3	G5				1							1
		Purple clematis	Clematis occidentalis	S2	G5			1								1
		Red pine	Pinus resinosa	S1	G5		1									1
		Red Spruce	Picea rubens	S1	G5				1							1
		River anemone	Anemone virginiana var. riparia	S2	G5T4T5		1									1
		Rosy twisted-stalk	Streptopus roseus	S1	G5		1									1
		Round-leaved serviceberry	Amelanchier sanguinea	S1	G5			1								1
		Soft-leaved sedge	Carex disperma	S2	G5							1				1
		Spring water starwort	Callitriche verna	S2	G5									1		1
		Stiff gentian	Gentianella quinquefolia	S2	G5										1	1
		Swamp lousewort	Pedicularis lanceolata	S3	G5	1	1									2
		Virginia snakeroot	Aristolochia serpentaria	S3	G5	1			2							3
		Wall-rue spleenwort	Asplenium ruta-muraria	S3	G5				1							1
		Water lobelia	Lobelia dortmanna	SH	G4							4				4
		Whorled milkweed	Asclepias verticillata	S2	G5							2				2
		Wild comfrey	Cynoglossum virginianum var. virginianum	S2	G5T5			1								1
		Yellow giant hyssop	Agastasche nepetoides	S2	G5				1							1
		Yellow oak	Quercus muehlenbergii	S3	G5	3										3
	NY	Atlantic white cedar	Chamaecyparis thyoides	S3	G4	1										1
		Bald eagle	Haliaeetus leucocephalus	S2S3	G4			1								1
		Blazing star	Chamaelirium luteum	S2	G5	1		1								2
		Dittany	Cunila origanoides	S3	G5		1	1								2
		Fence lizard	Sceloporus undulatus	S1	G5					1						1

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		Heath aster	Aster pilosus var. pringlei	S2S3	G4G5	1										1
		Illinois pinweed	Lechea racemulosa	S3	G5		3	1								4
		New England bluet	Enallagma lataerale	S2	G3	1										1
		Northern cricket frog	Acris crepitans	S1?	G5	1										1
		peregrine falcon	Falco peregrinus	S3	G4					1						1
		Prickly hornwort	Ceratophyllum echinatum	S2S3	G4?									1		1
		River birch	Betula nigra	S3	G5		1									1
		Scarlet Indian-paintbrush	Castilleja coccinea	S1	G5						1					1
		Shortnose sturgeon	Accipenser brevirostrum	S1	G3					1						1
		Spotted pondweed	Potamogeton pulcher	S2	G5		1									1
		Timber rattlesnake	Crotalus horridus	S3	G4			2		2			1	1		6
		Violet bush clover	Lespedeza violacea	S3	G5	1										1
		Water marigold	Megalodonta beckii var. beckii	S2S3	G4G5T4		1									1
		Water-thread pondweed	Potamogeton diversifolius	S1	G5		1									1
		Yellow harlequin	Corydalis flavula	S3	G5				1							1
	PA	Fetterbush	Leucothoe racemosa	S3	G5			1								1
		Sand cherry	Prunus pumila	S3	G5				3							3
		Variable sedge	Carex polymorpha	S1	G2		1									1
221 Total						19	18	17	20	9	1	10	6	1	1	102
M212	CT	Black Spruce	Picea mariana	S4	G5							1				1
		Bog sedge	Carex limosa	S1	G5							1				1
		common raven	Corvus corax	S2B	G5				1							1
		Creeping Snowberry	Gaultheria hispidula	S1	G5			1								1
		Dwarf mistletoe	Arceuthobium pusillum	S1	G5							1				1
		Dwarf Scouring Rush	Equisetum scirpoides	S1	G5					1		1				2
		False melic grass	Schizachne purpurescens	S1	G5		1									1

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		golden-crowned kinglet	Regulus satrapa	S2B	G5							1				1
		Hooded Merganser	Lophodytes cucullatus	S3B	G5				1							1
		magnolia warbler	Dendroica magnolia	S4B	G5					1						1
		N. Spring Salamander	Gyrinophilus porphyriticus	S2	G5									1		1
		Northern Yellow-eyed Grass	Xyris montana	S1	G4							1				1
		Pod grass	Scheuchzeria palustris	S1	G5							1				1
		Red pine	Pinus resinosa	S1	G5							1				1
		Red Spruce	Picea rubens	S2	G5			1		1						2
		Sedge	Carex crawei	S1S2	G3G5			1								1
		Sharp-lobed Hepatica	Hepatica nobilis var. acuta	S1	G5T5			1								1
		Sweet Coltsfoot	Petasites frigidus var. palmatus	S1	G5T5					1						1
		Three-leaved Solomon's Seal	Smilacina trifolia	S1	G5			1								1
		Three-toothed cinquefoil	Potentilla tridentata	S1	G5		2			1						3
		velvetleaf blueberry	Vaccinium myrtilloides	SH	G5							1				1
		white mandarin	Streptopus amplexifolius	S1	G5T5									1		1
		White Woodsorrel	Oxalis montana	S3	G5					1				1		2
		Wild Currant	Ribes rotundifolium	S1	G5							1				1
		Yellow-rumped Warbler	Dendroica coronata	S4B	G5					2						2
	MA	American ginseng	Panax quinquefolius	S3	G4									4		4
		Andrews' bottle gentian	Gentiana andrewsii	S2	G4									2		2
		Appalachian brook crayfish	Cambarus bartonii	NO DATA	NO DATA									2		2
		Balsam poplar	Populus balsamifera	S2S3	G5									1		1
		Bartram's shadbush	Amelanchier bartramiana	S2	G5									5		5
		Black maple	Acer nigrum	S3	G5Q									1		1
		Black-fruited woodrush	Luzula parviflora v.	S1	G5T5									1		1

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
			melanocarpa													
		Blackpoll warbler	Dendroica striata	S1	G5									1		1
		Broad waterleaf	Hydrophyllum canadense	S1	G5									1		1
		Brook lobelia	Lobelia kalmii	S2	G5									1		1
		Canadian sanicle	Sanicula canadensis	S2	G5									1		1
		Clustered snakeroot	Sanicula odorata	S2	G5									1		1
		Common moorhen	Gallinula chloropus	S1	G5									1		1
		Cooper's hawk	Accipiter cooperi	S3	G5									2		2
		Crooked-stem aster	Aster prenanthoides	S2	G4G5									1		1
		Eastern elderberry longhorn beetle	Desmocerus palliatus	S2S3	G?									1		1
		Fringed gentian	Gentianopsis crinita	S4	G5									6		6
		Gattinger's panic-grass	Panicum gattingeri	S3	G4									1		1
		glade fern	Diplazium pycnocarpon	S4	G5									3		3
		Goldie's Fern	Dryopteris goldiana	S4	G4									4		4
		Hairy wild lettuce	Lactuca hirsuta	SU	G4									1		1
		Hairy wood mint	Blephilia hirsuta	S1	G5									1		1
		Hairy-fruited sedge	Carex trichocarpa	S2	G4									1		1
		Heart-leaf paper birch	Betula cordifolia	SU	G5T5									1		1
		hemlock parsley	Conioselinum chinense	S3	G5									1		1
		Hoary willow	Salix candida	S3S4	G5									1		1
		Hooked sedge	Carex retrorsa	S2S3	G5									4		4
		Imperial moth	Eacles imperialis	S1	G5									1		1
		Intermediate spike-sedge	Eleocharis intermedia	S2	G5									2		2
		Lance-leaf grape fern	Botrychium lanceolatum v. angustisegmentum	S2S3	G5T4									1		1
		large round-leaf orchid	Platanthera orbiculata	S2S3	G5									1		1
		Large toothwort	Dentaria maxima	S3	G5Q									1		1

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		Large whorled pogonia	Isotria verticillata	S3S4	G5		2							2		4
		Large-bracted tick-trefoil	Desmodium cuspidatum	SU	G5									1		1
		Large-flowered bellwort	Uvularia grandiflora	S4	G5			1						4		5
		Large-leaved goldenrod	Solidago macrophylla	S2	G5									5		5
		Long-spurred violet	Viola rostrata	S2S3	G5		1							4		5
		Moonseed	Menispermum canadense	S3	G5									2		2
		Mountain cranberry	Vaccinium vitis-idaea	S1	G5T5									1		1
		Mountain winterberry	Ilex montana	S2	G5									3		3
		Mountain wood fern	Dryopteris campyloptera	S3	G5									2		2
		Mountain wood-fern	Dryopteris campyloptera	S3	G5									2		2
		Mourning warbler	Oporonis philadelphia	S1	G5									1		1
		Mustard white butterfly	Pieris napi oleraceae	S2	G5T4									1		1
		Northern mountain ash	Sorbus decora	S1	G4G5									2		2
		Northern white cedar	Thuja occidentalis	S1	G5									1		1
		Pendulous bulrush	Scirpus pendulus	S3	G5									7		7
		Prairie sedge	Carex prairea	S2S3	G5?									5		5
		Purple-stemmed cliffbrake	Pellaea atropurpurea	S3S4	G5									1		1
		Rand's goldenrod	Solidago simplex ssp. randii	S1	G5T4									2		2
		Round-leaved shadbush	Amelanchier sanguinea	S3	G5									3		3
		Sharp-shinned hawk	Accipiter striatus	S3	G5									3		3
		Small flowered agrimony	Agrimonia parviflora	S1	G5									2		2
		Smooth rock-cress	Arabis laevigata	S2	G5									3		3
		Spring cress	Cardamine bulbosa	S2S3	G5									1		1
		Stiff gentian	Gentianella quinquefolia	S2	G5									1		1
		Swamp red currant	Ribes triste	S3	G5									3		3
		Three-leaved snakeroot	Sanicula trifoliata	S2S3	G4									3		3
		Timber rattlesnake	Crotalus horridus	S1	G5									1		1

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		Tuckerman's sedge	Carex tuckermanii	S1	G4									1		1
		white mandarin	Streptopus amplexifolius	S3S4	G5T5									2		2
		Wild black currant	Ribes americanum	S4	G5									3		3
		Wild millet	Milium effusum	S2	G5									1		1
		Wood turtle	Clemmys insculpta	S3	G4									2		2
		Yellow oak	Quercus muhlenbergii	S3	G5									1		1
	ME	Alga-like Pondweed	Potamogeton confervoides	S1	G3G4					1						1
		Alpine Sweetgrass	Hierochloe alpina	S1	G5					2						2
		American Pipit	Anthus rubenscens	S1	G5					1						1
		Arctic charr	Salvelinus alpinus oquassa	S2	G5T2Q	1				1						2
		Bicknell's Thrush	Catharus bicknelli	S?	G3G4					1						1
		Bigelow's Sedge	Carex bigelowii	S2	G5					2		2				4
		Boreal Bentgrass	Agrostis mertensii	S2	G5										1	1
		Dwarf Rattlesnake Root	Prenanthes nana	S1	G5							1				1
		Fragrant Cliff Wood-Fern	Dryopteris fragrans	S3	G5							2				2
		Golden Eagle	Aquila chrysaetos	S1	G5									1		1
		Lapland diapensia	Diapensia lapponica	S2	G5					3						3
		Merlin	Falco columbarius	S2	G5					1						1
		Mountain Sandwort	Minuartia groenlandica	S3	G5					7		1				8
		Northern Comandra	Geocaulon lividum	S2	G5					7						7
		peregrine falcon	Falco peregrinus	S1	G4					1						1
		Rock vole	Microtus chrotorrhinus	S3	G4									1		1
		Silverling	Paronychia argyrocoma	S1S2	G4			1								1
		Smooth Sandwort	Minuartia glabra	S1S2	G4					1						1
		Squashberry	Viburnum edule	S2	G5					2		2				4
		Squawfoot mussel	Strophitus undulatus	S?	G5					1						1
		Vasey Rush	Juncus vaseyi	S1	G3G5					1						1

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Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		White pine	Pinus strobus (old-growth)	S5	G5					1						1
		Alpine Goldenrod	Solidago multiradiata	S1S2	G4										1	1
	NH	Alpine Azalea	Loiseleura procumbens	S3	G5		4	2						5		11
		Alpine Bearberry	Arctostaphylos alpina	S1	G5			1						2		3
		Alpine Bitter-cress	Cardamine bellidifolia	S1	G5									3		3
		Alpine Blueberry	Vaccinium boreale	S3	G3			4						5		9
		Alpine Brook Saxifrage	Saxifraga rivularis	S1	G5?			1						1		2
		Alpine Marsh Violet	Viola palustris	S2	G5				1					1		2
		Alpine Meadow Grass	Poa pratensis ssp. alpigena	S2	G?									3		3
		Alpine Speedwell	Veronica wormskjodii	S1	G4G5									1		1
		Alpine Sweetgrass	Hierochloe alpina	S2	G5			3						2		5
		Alpine Timothy	Phleum alpinum	S3	G5									1		1
		Alpine Willow-Herb	Epilobium alpinum	SU	G?Q									1		1
		Arnica	Arnica lanceolata	S1	G2G4									1		1
		Bearberry Willow	Salix uva-ursi	S3	G5	1	2	1	1					4		9
		Bigelow's Sedge	Carex bigelowii	S3	G5	5	1	4						3		13
		Bilberry	Vaccinium uliginosum var. albimontana	S3	G5T?	7	6	7	1					5		26
		Black Crowberry	Empetrum nigrum	S3	G5	1	6	10						7		24
		Black Sedge	Carex atratiformis	S1	G5									2		2
		Black-backed arctic woodpecker	Picoides arcticus	S3	G5									1		1
		Blue-joint reedgrass	Calamagrostis canadensis var. robusta	S3	G5T?	1	1							4		6
		Boott's Rattlesnake-Root	Prenanthes bootii	S1	G2	1	1	1						2		5
		Boreal Bentgrass	Agrostis borealis	S3	G?	1	3	1						5		10
		Broad-leaved Twayblade	Listera convallarioides	S2	G5									1		1
		Cloudberry	Rubus chamaemorus	S2	G5	2	3	1						1		7

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Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		Creeping Juniper	Juniperus horizontalis	S1	G5		1									1
		Cutler's Goldenrod	Solidago cutleri	S3	G5T4		1		1					4		6
		Dwarf Birch	Betula minor	S1S2	G4G5	3	4	1						5		13
		Dwarf Willow	Salix herbacea	S2	G5			1						2		3
		Ebony sedge	Carex eburnea	S1	G5				2							2
		Goldie's Fern	Dryopteris goldiana	S2	G4		1									1
		Heart-Leaved Twayblade	Listera cordata	S2	G5		2							1		3
		Hornemann Willow-Herb	Epilobium hornemanni	S2	G5									2		2
		Jack Pine	Pinus banksiana	S2	G5									1		1
		John's cabbage	Hydrophyllum virginianum	S2	G5		1									1
		Lapland diapensia	Diapensia lapponica	S3	G5	5	1	3						4		13
		Lapland Rosebay	Rhododendron lapponicum	S3	G5			3						3		6
		Lens Sedge	Carex lenticularis var. albimontana	S1	G5?T?									1		1
		Long-Bracted Orchid	Coeloglossum viride	NO DATA	NO DATA			1								1
		Moss Bell-Heather	Cassiope hypnoides	S2	G5		1	1	1					3		6
		Mountain Avens	Geum peckii	S2	G2	2	5	3						7		17
		Mountain Hairgrass	Deschampsia atropurpurea	S2	G5									7		7
		Mountain Sandwort	Minuartia groenlandica	S2	G4G5Q	4	1	4						5		14
		Mountain Sorrel	Oxyria digyna	S1	G3G5									2		2
		Mountain-heath	Phyllodoce caerulea	S2	G5	1	1	1	1					4		8
		Neglected Redd Bent-grass	Calamagrostis stricta var. robusta	SU	G?									1		1
		Northern Comandra	Geocaulon lividum	S2	G4			1						2		3
		Northern Goshawk	Accipiter gentilis	S4	G4									1		1
		Oakes' Eyebright	Euphrasia oaksii	S1	G4									2		2
		Pale Painted-Cup	Castilleja septentrionalis	S1	G5		1		1					1		3

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		peregrine falcon	Falco peregrinus	S1	G3	1										1
		Pickering's Reed Bent-grass	Calamagrostis pickeringii	S3	G3									4		4
		Proliferous Fescue	Festuca rubra var. prolifera	S1	G5T4									1		1
		Purple Crowberry	Empetrum atropurpureum	S2	G5		5	3	1					2		11
		Pursh's Goldenrod	Solidago purshii	S1	G5		1									1
		Robbins' Cinquefoil	Potentilla robbinsiana	S1	G1	1		1								2
		Rock Goldenrod	Solidago calcicola	S3	G4									1		1
		Rock vole	Microtus chrotorrhinus	S4	G5									1		1
		Scirpus-like Sedge	Carex scirpoidea	S1	G5	1								2		3
		Silver Willow	Salix argyrocarpa	S1	G4									1		1
		Silverling	Paronychia argyrocoma var. albimontana	S3	G4T2Q			1						1		2
		Small Birch	Betula minor	S2	G4G5		2	2	2					4		10
		Smooth Woodsia	Woodsia glabella	S1	G5				1							1
		Snowy Aster	Aster ptarmicoides	S1	G5	1										1
		Spiked Woodrush	Luzula spicata	S3	G3G5	2								5		7
		Spruce Grouse	Dendragapus canadensis	S3	G5									6		6
		Squirrel-corn	Dicentra canadensis	S2	G5	2	1									3
		Tea-Leaved Willow	Salix planifolia	S2	G5?		2							1		3
		Viviparous Knotweed	Polygonum viviparum	S2	G5									1		1
		Wavy Bluegrass	Poa fernaldiana	S3	G3G5									1		1
		Yellow Rattle	Rhinanthus crista-galli	S3	G?									1		1
	VT	American ginseng	Panax quinquefolius	S3	G4			2								2
		American shore-grass	Littorella americana	S2	G5					2						2
		Bay-breasted warbler	Dendroica castanea	S2	G5					1						1
		Goldie's Fern	Dryopteris goldiana	S3	G4			2								2
		Gray-cheeked thrush	Catharus minimus	SNA	G5		1	2		1						4

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Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		Large-leaved avens	Geum macrophyllum	S3	G5					1						1
		Long sedge	Carex folliculata	S3	G4G5			1		1						2
		Michaux's sedge	Carex michauxiana	S2	G5					1						1
		Northern mountain-ash	Sorbus decora	S2	G5					1						1
		Rusty blackbird	Euphagus carolinus	S3	G5			4								4
		Small-flowered rush	Luzula parviflora	S1	G4G5	1		1								2
		Squashberry	Viburnum edule	S1	G5							1				1
		Sticky tofieldia	Tofieldia glutinosa	S1	G5		1									1
		Summer sedge	Carex aestivalis	S1	G4			1								1
		Tuckerman's pondweed	Potamogeton confervoides	S1S2	G5					1						1
		Water sedge	Carex aquatilis	S2	G5		1	1								2
		Wild millet	Milium effusum	S3	G5	1				1						2
M212 Total						45	67	83	15	51		19	288		2	570
M221	GA	A Liverwort	Frullania cf.appalachiana	S1	G1?									1		1
		a moss	Herpetineuron toccoae	S1?	G4G5									1		1
			Hypnum cupressiforme var. filiforme	S1	G3									1		1
			Plagiothecium denticulatum	S3?	G5									1		1
		American Chestnut	Castanea dentata (fruiting individual)**	S3	G4									1		1
		American ginseng	Panax quinquefolius	S3	G4									5		5
		Appalachian sedge	Carex appalachica	S1?	G4									2		2
		Bearberry	Vaccinium erythrocarpum	S1	G5									3		3
		Blue Ridge Bittercress	Cardamine flagellifera	S3	G3									7		7
		Blue Ridge mountain mint	Pycnanthemum montanum	S3	G3G5									19		19
		Blue Ridge St. John's-wort	Hypericum buckleii	S1	G3									1		1
		Broad waterleaf	Hydrophyllum canadense	S3	G5									2		2
		broadleaf coreopsis	Coreopsis latifolia	S1	G3									1		1

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Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		Bush Honeysuckle	Diervilla sessilifolia	S3?	G4?									2		2
		Columbo	Frasera carolinensis	S3	G5									1		1
		common raven	Corvus corax	SU	G5									4		4
		Dutchman's Pipe	Aristolochia macrophylla	S3	G5									2		2
		False dandelion	Krigia montana	S3	G3									7		7
		Fort Mountain sedge	Carex amplisquama	S3	G3									3		3
		glade fern	Diplazium pycnocarpon	S3	G5									2		2
		Gooseberry	Ribes cynosbati	S3	G5									2		2
		Hairgrass	Deschampsia flexuosa	S3?	G5									5		5
		Hairy blueberry	Vaccinium hirsutum	S2S3	G3									7		7
		Horse gentian	Triosteum aurantiacum	S1	G5									3		3
		Large Twayblade	Liparis liliifolia	S3	G5									2		2
		large yellow ladyslipper	Cypripedium calceolus v. pubescens	S3	G5									1		1
		Lily of the valley	Convallaria majuscula	S2S3	G4									4		4
		Limber Honeysuckle	Lonicera dioica	S1	G5									2		2
		Manhart's sedge	Carex manhartii	S2S3	G3									13		13
		Minnie Bush	Menziesia pilosa	S1	G4G5									1		1
		Mountain Ash	Sorbus americana	S1	G5									1		1
		Mountain Bugbane	Cimicifuga americana	S3?	G5									2		2
		Mountain catchfly	Silene ovata	S1	G2									2		2
		Mountain Maple	Acer spicatum**	S2	G5									3		3
		Naked-Fruited Rush	Juncus gymnocarpus	S2	G4									5		5
		Ninebark	Physocarpus opulifolius	S3	G5									1		1
		nodding pogonia	Triphora trianthophora	S3?	G4									1		1
		Northern Starflower	Trientalis borealis	S1	G5									1		1
		Oval ladies tresses	Spiranthes ovalis	S2S3	G5									2		2

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Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		Painted trillium	Trillium undulatum	S3	G5									1		1
		pink ladyslipper	Cypripedium acaule	S4	G5									11		11
		Purple monkshood	Aconitum uncinatum	S3S4	G4									5		5
		Rosy twisted-stalk	Streptopus roseus	S1	G5									2		2
		Ruth's Sedge	Carex ruthii	S2S3	G3									3		3
		Seepage salamander	Desmognathus aeneus	S3	G3G4									8		8
		Silky/Blue Ridge bindweed	Calystegia catesbiana ssp. sericata	S2S3	G3T2T3									11		11
		Silverling	Paronychia argyrocoma**	S1	G4									1		1
		Spotted mandarin	Prosartes (Disporum) maculatum	S3	G3G4									3		3
		Striped Maple	Acer pensylvanicum	S3S4	G5									5		5
		sweet white trillium	Trillium simile	S1S2	G3									4		4
		Three-toothed cinquefoil	Sibbaldiopsis tridentata	S1	G5									1		1
		Umbrella Leaf	Diphylleia cymosa	S3	G4									3		3
		White bear sedge	Carex albursina	S1	G5									1		1
		White lettuce	Prenanthes alba	SR	G5									1		1
		Wild Sarsaparilla	Aralia nudicaulis	S2?	G5									6		6
		Wood lettuce	Saxifraga micranthidifolia	S3S4	G5									1		1
		yellow ladyslipper	Cypripedium calceolus	S3	G5									4		4
	MD	Allegheny woodrat	Neotoma floridana	S1	G3G4				1							1
		Downy alumroot	Heuchera pubescens	S3	G4?									2		2
		Ellisia	Ellisia nyctelea	S3	G5									1		1
		Halberd-leaved rose-mallow	Hibiscus laevis	S3	G3G5		4									4
		Honeyvine	Cynanchum laeve	S3	G5		1									1
		Lobed spleenwort	Asplenium pinnatifidum	S1	G4				1					2		3
		nodding trillium	Trillium cernuum	S3	G5		4									4
		Pale green orchid	Platanthera flava	S1	G4				1							1

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Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		Rustling wild petunia	Ruellia strepens	S1	G4G5			1								1
		Rustling wild-petunia	Ruellia strepens	S1	G4G5			2								2
		Scarlet ammannia	Ammannia coccinea	SU	G5			1								1
		Slender day flower	Commelina erecta var. angustifolia	S3	G5									1		1
		Snowy campion	Silene nivea	S1	G3G4				1							1
		Spring avens	Geum vernum	S3	G5									1		1
		Spring forget-me-not	Myosotis verna	S3	G5									1		1
		Starflower false Solomon's seal	Maianthemum stellatum	S1	G5			5								5
		Steele's meadow rue	Thalictrum steeleanum	S3?	G5									1		1
		Yellow passion flower	Passiflora lutea	S3	G5		2	2								4
	NC	a foliose lichen	Xanthoparmelia monticola	S2?	G2									1		1
		a ground beetle	Arianops coweeti	S?	G?									1		1
			Pterostichus blanchardi	S?	G?									1		1
			Pterostichus hypogea	S?	G?									2		2
			Trachus luculentus luculentus	S2?	G2T2?									3		3
		a land snail	Triodopsis tennesseenis	S1S2	G5									1		1
		A Liverwort	Cephaloziella obtusilobula	S1	G1									1		1
			Cephaloziella spinicaulis	S1	G?									1		1
			Drepanolejeunea appalachiana	S1	G2?									1		1
			Plagiochila sullivantii var. sullivantii	S2	G2T2									1		1
		Aaron's rod	Thermopsis villosa	S2?	G?									3		3
		alder flycatcher	Empidonax alnorum	S2BSZN	G5								1			1
		American bittersweet	Celastrus scandens	S2?	G5									1		1
		American ginseng	Panax quinquefolius	S4	G4								4	5		9

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		American speedwell	Veronica americana	S2tnS2	G5								2			2
		an aquatic lichen	Hydrothyra venosa	S2	G3									8		8
		Appalachian fir clubmoss	Huperzia appalachiana	S2tnS2	G3								2			2
		Appalachian gentian	Gentiana austromontana	S2?tS2	G3								1			1
		beargrass	Xerophyllum asphodeloides	S2tn23	G3								1			1
		bent avens	Geum geniculatum	S2tnS1	G2								4			4
		bigleaf waterleaf	Hydrophyllum macrophyllum	S1S2	G5									12		12
		bleeding heart	Dicentra eximia	S2	G4									2		2
		Blue Ridge Bittercress	Cardamine flagellifera	S3	G3									1		1
		Blue Ridge St. John's-wort	Hypericum buckleii	S3	G3									1		1
			Hypericum mitchellianum	S3	G3								3			3
		branching draba	Draba ramosissima	S2tnS1	G4								1			1
		broadleaf coreopsis	Coreopsis latifolia	S3	G3					1			1			2
		Canada leaf-cup	Polymnia canadensis	S2	G5									1		1
		Carey's saxifrage	Saxifraga careyana	S3tnS3	G3Q								1			1
		Carolina northern flying squirrel	Glaucomys sabrinus coloratus	S1tnS1	G5T1								1			1
		cerulean warbler	Dendroica cerulea	S3BS3N	G5									3		3
		chocolate lichen	Melanelia stygia	S1S2	G4G5									2		2
		common raven	Corvus corax	S3	G5								2	1		3
		Core's starwort	Stellaria corei	S3	G3									1		1
		creeping sunrose	Helianthemum propinquum	S1	G4									1		1
		Cumberland azalea	Rhododendron cumberlandense	S1	G2Q									2		2
		dwarf ginseng	Panax trifolius	S2	G5									1		1
		early hairstreak	Erora laeta	S2?	G4									1		1
		Fernald's haysedge	Carex aenea	S1	G5									2		2
		few-seeded sedge	Carex oligosperma	S1	G4									2		2

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		Fraser's loosestrife	Lysimachia fraseri	S1	G2									1		1
		Fraser's sedge	Cymophyllus fraserianus	S3tnS3	G4								2			2
		fringed black bindweed	Polygonum cilinode	S3	G5								3	1		4
		glade fern	Diplazium pycnocarpon	S2	G5									1		1
		glade spurge	Euphorbia purpurea	S1S2	G2									1		1
		golden tundra-moss	Rhytidium rugosum	S2	G5									2		2
		golden-crowned kinglet	Regulus satrapa	S3BS5N	G5									1		1
		Goldie's Fern	Dryopteris goldiana	S1S2	G4									2		2
		granite dome bluet	Houstonia longifolia var. glabra	S3	G5T3									3		3
		Gray's Lily	Lilium grayi	S3	G3								3			3
		green alder	Alnus viridis ssp. crispa	S1tnS1	G5T3T4								2			2
		green violet	Hybanthus concolor	S2S3	G5									1		1
		hermit thrush	Catharus guttatus	S1BS5N	G5									1		1
		Indian skipper	Hesperia sassacus	S1	G5									1		1
		lance-leaf moonwort	Botrychium lanceolatum v. angustisegmentum	S1	G5T3T4									1		1
		large purple-fringe orchis	Platanthera grandiflora	S2	G5									1		1
		large round-leaf orchid	Platanthera orbiculata	S3tS23	G5?								2			2
		magnolia warbler	Dendroica magnolia	S1BSZN	G5									1		1
		moss pink	Phlox subulata	S1	G5									1		1
		mountain bluet	Houstonia montana	S2	G2									1		1
		Mountain catchfly	Silene ovata	S2tnS1	G3								3			3
		mountain rattle-snake root	Prenanthes roanensis	S3	G3								10	5		15
		Mountain Sandwort	Minuartia groenlandica	S2tnS1	G5								2			2
		Naked-Fruited Rush	Juncus gymnocarpus	S3	G3									3		3
		narrowleaf/linear-leaved willowherb	Epilobium leptophyllum	S3tnS1	G5								1			1

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		necklace sedge	Carex projecta	S1	G5									1		1
		nodding mandarin	Disporum maculatum	S2	G3G4									10		10
		northern saw-whet owl	Aegolius acadius	S2BSZN	G5								1			1
		Pellitory	Parietraria pensylvanica	S2	G5									1		1
		peregrine falcon	Falco peregrinus	S1BS2N	G3								1			1
		pink ladyslipper	Cypripedium acaule	S5tnS4	G5								2			2
		piratebush	Buckleya distichophylla	S2tnS2	G2								24			24
		purple fringless orchid	Platanthera peramoena	S1	G5									1		1
		purpleleaf willowherb	Epilobium ciliatum	S2	G5								3			3
		Schweinitz's ragwort	Senecio schweinitzianus	S2	G5?								1	1		2
		Sharp-shinned hawk	Accipiter striatus	S2BS4N	G5									1		1
		short winged mold beetle	Arianops thornei	S?	G?									2		2
		Silky/Blue Ridge bindweed	Calystegia catesbiana ssp. seritaca	S2	G3T2T3									3		3
		silvery blue	Glaucopyche lygdamus	S1	G5									1		1
		southern nodding trillium	Trillium rugelii	S2?tS2	G3								3			3
		southern rock vole	Microtus chrotorrhinus carolinensis	S2	G5T3									1		1
		spreading avens	Geum radiatum	S1tnS1	G1								1			1
		streambank mock-orange	Philadelphus hirsutus	S1S2	G5									2		2
		swamp bluegrass	Poa palustrus	S1tnSH	G5								1			1
		sweet white trillium	Trillium simile	S1	G?									1		1
		Three-toothed cinquefoil	Sibbaldiopsis tridentata	S3tnS2	G5								1			1
		trailing wolfsbane	Aconitum reclinatum	S2	G3									1		1
		whiteleaf sunflower	Helianthus glaucophyllus	S3tnS1	G3								1			1
		white-leaved sunflower	Helianthus glaucophyllus	S3	G3									1		1
		wood lily	Lilium philadelphicum	S1tnS1	G5								1			1
		wretched sedge	Carex misera	S3	G3								3	1		4

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		yellow bellied sapsucker	Sphyrapicus varius	S2BS5N	G5									1		1
		yellow-bellied sapsucker	Sphyrapicus varius	S2BS5N	G5									5		5
		yellowwood	Cladrastis kentuckea	S3	G4									1		1
		zig-zag salamander	Plethodon dorsalis	S1	G5Q									1		1
	PA	Amianthium borer	Papaipema sp. 1	S2	G2		2									2
		Barrens xylotype	Xylotype capax	S2	G4					1						1
		Dwarf iris	Iris verna	S1	G5			1								1
		Eastern woodrat	Neotoma floridana magister	S3	G5T4		1									1
		Footpath sallow	Metaxaglaea semitaria	S3	G5					1						1
		glade spurge	Euphorbia purpurea	S1	G2		2									2
		Golden club	Orontium aquaticum	S2S3	G5				1							1
		Hartford fern	Lygodium palmatum	S2	G4				1							1
		Kidney-leaved twayblade	Listera smallii	S1	G4	1										1
		Limestone petunia	Ruellia strepens	S2	G4G5	1										1
		Naked-Fruited Rush	Juncus gymnocarpus	S1	G2G3		2									2
		Noctuid moth	Aphareta purpurea	S2	G4		1									1
			Aplectoides condita	S2	G4	1										1
			Platyperigia meralis	S3	G4		1									1
			Zale submediana	S2	G4		1									1
	TN	Allegheny woodrat	Neotoma magister	S3S4	G3G4									1		1
		American ginseng	Panax quinquefolius	S3	G4									10		10
		American wintergreen	Pyrola americana	S1	G5									3		3
		Appalachian gentian	Gentiana austromontana	S2S3	G3								3	10		13
		Appalachian sedge	Carex appalachica	S1	G4									6		6
		Appalachian woodsia	Woodsia appalachiana	S1S2	G5									1		1
		big-tooth aspen	Populus grandidentata	S2	G5									2		2
		Carey's saxifrage	Saxifraga careyana	S3	G3									3		3

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		Carolina hemlock	Cypripedium acaule	S2	G4									1		1
			Tsuga caroliniana	S2	G4									23		23
		chamomile grapefern	Botrychium matricariifolium	S1	G5									2		2
		common raven	Corvus corax	S2	G5									2		2
		cow parsnip	Heracleum lanatum	S1	G5									4		4
		crested shield-fern	Dryopteris cristata	S1	G5									2		2
		Fraser fir	Abies fraseri	S2	G2									3		3
		Fraser's sedge	Cymophyllus fraserianus	S3	G4									7		7
		golden seal	Hydrastis canadensis	S3	G4									3		3
		Hitchcock's sedge	Carex hitchcockiana	S1	G5									3		3
		John's cabbage	Hydrophyllum virginianum	S2	G5									8		8
		kidney-leaf twayblade	Listera smallii	S1S2	G4									6		6
		large cranberry	Vaccinium macrocarpon	S1	G4									2		2
		large purple-fringe orchis	Platanthera grandiflora	S1	G5									3		3
		large round-leaf orchid	Platanthera orbiculata	S2S3	G5?									8		8
		large yellow ladyslipper	Cypripedium calceolus v. pubescens	-	-									1		1
		long bracted green orchis	Coeloglossum viride v. virescens	S1	G5T5									1		1
		longleaf stitchwort	Stellaria longifolia	S1	G5									1		1
		mountain rattle-snake root	Prenanthes roanensis	S2	G3								1	3		4
		Naked-Fruited Rush	Juncus gymnocarpus	S2	G3									4		4
		narrow-leaved meadow-sweet	Spiraea alba	S1	G5									1		1
		northern beech fern	Thelypteris phegopteris	S1	G5									1		1
		pale corydalis	Corydalis sempervirens	S2	G4G5									4		4
		pale St. John's-wort	Hypericum ellipticum	S1	G5									2		2
		pink ladyslipper	Cypripedium acaule	S4	G5									40		40

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		piratebush	Buckleya distichophylla	S2	G2									1		1
		rattlesnake mannagrass	Glyceria canadensis	-	-											1
		rock skullcap	Scutellaria saxatilis	S1S2	G4?									6		6
		rough hawkweed	Hieracium scabrum	S2	G5									1		1
		round-leaf watercress	Cardamine rotundifolia	S2	G4									3		3
		small purple-fringed orchid	Platanthera psycodes	S2	G5									1		1
		small yellow ladyslipper	Cypripedium calceolus v. parviflorum	NO DATA	NO DATA									1		1
		trailing wolfsbane	Aconitum reclinatum	S2	G2									1		1
		vesper sparrow	Pooecetes gramineus	S2	G5									3		3
		white-leaved sunflower	Helianthus glaucophyllus	S1	G3									6		6
		yellow ladyslipper	Cypripedium calceolus	-	-									1		1
	VA	a cudweed	Gnaphalium uliginosum	S1	G5		1									1
		a hawthorne	Crataegus pruinosa	S1	G5		1									1
		a millipede	Semionellus placidus	S1	G3	1	1	1								3
		alder flycatcher	Empidonax alnorum	S2	G5					1						1
		alderleaf buckthorn	Rhamnus alnifolia	S1	G5			1								1
		amber-winged spreadwing	Lestes eurinus	S2	G4	1			1							2
		American purple vetch	Vicia americana	S1S2	G5		1									1
		Appalachian Bewick's wren	Thryomanes bewickii altus	S1	G5T?				1							1
		Appalachian fir clubmoss	Huperzia appalachiana	S2	G?	2	6	2								10
		balsam fir	Abies balsamea	S1	G5		2	1								3
		beaked dodder	Cuscuta rostrata	S2	G4	8	2	4								14
		blackburnian warbler	Dendroica fusca	S2	G5		1									1
		Blue Ridge Mountain amphipod	Stygobromus spinosus	S2	G2		2	2								4
		Blue Ridge St. John's-wort	Hypericum mitchellianum	S1S2	G3	5		12	1							18
		blueflag	Iris versicolor	S2	G5		6									6

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		bog bluegrass	Poa paludigena	S2	G3	1	4									5
		brown bog sedge	Carex buxbaumii	S2	G5		1									1
		bunchberry	Cornus canadensis	S1	G5			1								1
		canada burnet	Sanguisorba canadensis	S2	G5		4		1							5
		canada plum	Prunus nigra	S1	G4G5			1								1
		Canby's mountain-lover	Paxistima canbyi	S2	G2		1									1
		Carolina saxifrage	Saxifraga caroliniana	S2	G2		1									1
		common clammy-weed	Polanisia dodecandra	S1	G5Q	2										2
		common red raspberry	Rubus idaeus	S2	G5	6	1									7
		flexuose peatmoss	Sphagnum flexuosum	S1S2	G5Q					1						1
		Fraser fir	Abies fraseri	S1	G2	10										10
		freshwater cordgrass	Spartina pectinata	S2	G5			2								2
		fringed brome	Bromus ciliatus	S1	G5		1									1
		fringed scorpion weed	Phacelia fimbriata	S2	G2G3		2									2
		fringed scorpion-weed	Phacelia fimbriata	S2	G2G3	5	4									9
		glade spurge	Euphorbia purpurea	S2	G2	11	3	1								15
		golden-crowned kinglet	Regulus satrapa	S2	G5	10	6									16
		great indian-plantain	Cacalia muhlenbergii	S2	G3G4		4	4	1							9
		grey birch	Betula populifolia	S1	G5		1									1
		Hazel dodder	Cuscuta coryli	S2?	G5	2		2								4
		hemlock parsley	Conioselinum chinense	S1	G5			1								1
		Herb-Robert	Geranium robertianum	S1	G5		3									3
		hermit thrush	Catharus guttatus	S1	G5		16									16
		highland rush	Juncus trifidus	S1	G5	2										2
		inflated sedge	Carex vesicaria	S1S2	G5				1							1
		kankakee globe-mallow	Iliamna remota	S1	G1				1							1
		large purple-fringe orchis	Platanthera grandiflora	S1	G5		3	2								5

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		large-fruited sanicle	Sanicula trifoliata	S2	G4		13		2							15
		large-leaved phlox	Phlox amplifolia	S2	G3G5				1							1
		long-stalked holly	Ilex collina	S2	G3		1	2		1						4
		magnolia warbler	Dendroica magnolia	S2	G5	10	6									16
		marsh muhly	Muhlenbergia glomerata	S2	G4	4	3	1								8
		mountain bittercress	Cardamine clematitis	S2	G2		2	1	2							5
		mountain rattle-snake root	Prenanthes roanensis	S2	G3	6		13		5						24
		Mountain Sandwort	Minuartia groenlandica	S1	G5	1	1									2
		narrow false oats	Trisetum spicatum	S1	G5	1										1
		narrowleaf peatmoss	Sphagnum angustifolium	S1S2	G5					2						2
		narrowleaf/linear-leaved willowherb	Epilobium leptophyllum	S2S3	G5		2									2
		narrow-panicled rush	Juncus brevicaudatus	S2	G5		1									1
		nodding pogonia	Triphora trianthophora	S1	G4	3		1								4
		nodding trillium	Trillium cernuum	S2	G5	1	1	1								3
		nodding wild-rye	Elymus canadensis	S2?	G5				1							1
		northern bog clubmoss	Lycopodiella inundata	S1	G5				1							1
		pale sedge	Carex pallescens	S1	G5				1							1
		paper birch	Betula papyrifera	S2	G5		8	11								19
		Peaks of Otter salamander	Plethodon hubrichti	S2	G2	1										1
		peregrine falcon	Falco peregrinus	S1	G3					1						1
		piratebush	Buckleya distichophylla	S2	G2		1	2								3
		purple finch	Carpodacus purpureus	S1	G5					1						1
		pygmy salamander	Desmognathus wrighti	S2	G4		7	9								16
		Rand's goldenrod	Solidago simplex var. randii	S2S3	G5T3?	4	5	8								17
		red peatmoss	Sphagnum rubellum	S2	G5?					2						2
		red-breasted nuthatch	Sitta canadensis	S2	G5		6	4								10

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		roundleaf dogwood	Cornus rugosa	S1	G5		1	3								4
		sand grape	Vitis rupestris	S1	G3		5									5
		Shenandoah salamander	Plethodon shenandoah	S1	G1	4										4
		Sherando spinosoid groundwater amphipod	Stygobromus sp. nov.	S2	G2		2									2
		shovelnose salamander	Leurognathus marmoratus	S2?	G4		3									3
		silky dogwood	Cornus amomum ssp. obliqua	S2?	G5T?	2										2
		slender wheatgrass	Elymus trachycaulus ssp. trachycaulus	S2	G5T5			1								1
		slender wood reedgrass	Cinna latifolia	S2	G5	5	3	3	2							13
		soft fox sedge	Carex conjuncta	S2S3	G4G5		1									1
		speckled alder	Alnus incana ssp. rugosa	S2	G5T5	3	1	1	2							7
		spleckled alder	Alnus incana ssp. rugosa	S2	G5T5		1									1
		streambank mock-orange	Philadelphus hirsutus	S2	G5	2										2
		sword-leaved phlox	Phlox buckleyi	S2	G2G3			1								1
		tall cinquefoil	Potentilla arguta	S1	G5		1									1
		Three-toothed cinquefoil	Sibbaldiopsis tridentata	S2	G5	1	1	2								4
		Umbrella Leaf	Diphylleia cymosa	S2S3	G4	1	3	7	4	1						16
		VA northern flying squirrel	Glaucomys sabrinus fuscus	S1	G5T2	3			1							4
		Variable sedge	Carex polymorpha	S2	G2		1	1								2
		velvetleaf blueberry	Vaccinium myrtilloides	S1S2	G5		3									3
		Weller's salamander	Plethodon welleri	S2	G4		15									15
		western spotted coralroot	Corallorhiza maculata var. occidentalis	S1	G5T?		1									1
		white mandarin	Streptopus amplexifolius	S1	G5			2								2
		wild false-indigo	Baptisia australis	S2S3	G5	1		3								4
		Winged loosestrife	Lythrum alatum	S2	G5			1								1

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

Appalachian Trail (APPA)						EORANK										
ECOPROVINCE	STATE	COMMON_NAME	SCIENTIFIC NAME	STATE RANK	GLOBAL RANK	A	B	C	D	E	F	H	?	NO DATA	X	Grand Total
		winter wren	Troglodytes troglodytes	S2	G5	2	9	6		2						19
	WV	Arrow-arum	Peltandra virginica	S1	G5			1								1
		Broadhead skink	Eumeces laticeps	S2	G5		1									1
		Columbine duskywing	Erynnis lucilius	S1	G4									1		1
		Ellisia	Ellisia nyctelea	SU	G5									2		2
		hairy swamp loosestrife	Decodon verticillatus	S1	G5		4									4
		Halberd-leaved rose-mallow	Hibiscus laevis	S2	G3G5				9							9
		nodding trillium	Trillium cernuum	S1	G5		11									11
		rock skullcap	Scutellaria saxatilis	S1	G4		1									1
		Short's rockcress	Arabis shortii	S1S2	G5				1							1
		Snowy campion	Silene nivea	S1	G4			1								1
		Starflower false Solomon's seal	Maianthemum stellatum	S1	G5	8										8
		Three-flower melic grass	Melica nitens	S1	G5									2		2
		Timber rattlesnake	Crotalus horridus	S4	G5			20								20
		Tooth-cup	Ammannia coccinea	SU	G5			1								1
		Watermeal	Wolffia papulifera	S2	G5	1										1
		Winged loosestrife	Lythrum alatum	S1	G5									2		2
M221 Total						133	224	156	40	20			533	99		1206
Grand Total						197	309	256	75	80	1	29	827	100	3	1878

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

Appalachian Trail (APPA) COMMUNITIES (state)					EORANK					
ECOPROVINCE	STATE	STATE COMMUNITY_NAME	GLOBAL RANK	STATE RANK	A	B	C	D	E	Grand Total
221	NJ	Calcareous seepage swamp	G4?	S2S3		1				1
		Dry-mesic calcareous forest	G3G4?	S2?			1			1
		Floodplain forest	G4	S3?		1				1
		Mesic hemlock-hardwood forest	G4	S3S4	1	1				2
		Ridgetop pitch pine-scrub oak forest	G4	S1S2	1	1	1			3
		Talus slope community	G4?	S2S3	1	1				2
	NY	Floodplain forest	G3G4	S2S3				1		1
		Highbush blueberry bog thicket	G4	S3	1	1				2
		Inland Atlantic white cedar wetland swamp	G2G3	S1	1					1
		Oak-tuliptree forest	G4	S2S3	1	1	1			3
		Pitch pine-oak-heath rocky summit	G4	S3	1	1	1			3
		Rich sloping fen	G3	S1S2			1			1
		Rocky summit grassland	G3G4	S2S3		1				1
221 Total					7	9	5	1		22
M212	ME	Acidic Rocky Summit	No Data	S4					1	1
		Alpine Ridge	No Data	S2	1	1				2
		Alpine Ridge/Alpine tundra	No Data	S2		1				1
		Beaver Flowage	No Data	S5					1	1
		Beech-Birch-Maple Forest	No Data	S5		1				1
		Boreal Circumneutral Outcrop	No Data	S1					1	1
		Dimictic Oligotrophic Lake	No Data	SU					1	1
		Graminoid Swale	No Data	S4					1	1
		Hardwood Floodplain Forest	No Data	S3		1				1
		Hemlock Slope Forest	No Data	S4					1	1
		Krummholz	No Data	S3					1	1
		Midreach Stream	No Data	SU					1	1
		Mixed Hardwood-conifer Forest	No Data	S5	1					1

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

		Monomictic Mesotrophic Lake	No Data	SU					1	1
		Northern White Cedar Seepage Forest	No Data	S3					1	1
		Spruce Slope Forest	No Data	S4	1				1	2
		Spruce woodland	No Data	S3	1					1
		Spruce-fir Flats Forest	No Data	S5					1	1
		Streamshore Ecosystem	No Data	S4					1	1
		Subalpine Spruce-fir Forest	No Data	S3	1	1			1	3
		Tarn	No Data	S2	1				1	2
	NH	Acidic Level Fen	No Data	S3	1	1	1			3
		Acidic Rocky Summit/Rock Outcrop	No Data	S4	1					1
		Acidic Talus Slope Forest/Woodlands	No Data	No Data	1					1
		Alpine Community	No Data	S1	1	1	1			3
		Alpine/Subalpine Bog	No Data	S1	1	1	1	1		4
		Alpine/Subalpine Pond	No Data	S1S2	1		1			2
		Boreal Heathland	No Data	S1S2	1	1	1			3
		Calcareous cliff community	No Data	S1	1					1
		Calcareous rocky summit/rock outcrop community	No Data	S1		1				1
		Cold-Air Talus Forest/Woodland	No Data	No Data	1					1
		Dry transitional forest on acidic bedrock or till	No Data	S3		1				1
		High Elevation Spruce-Fir Forest	No Data	S3S4	2	1				3
		Mesic Hardwood Forest	No Data	S4	1	1				2
		Moist Subalpine Heathland	No Data	S1	1		1			2
		Rich Mesic Forest	No Data	S3	1	1	1			3
M212 Total					20	14	7	1	15	57
M221	PA	Acidic shrub swamp community	G5	S3		1				1
		Mesic central forest community	G?	S2			1			1
		Pitch pine-scrub oak barren community	G2G3	S2			1			1
	VA	Eutrophic forest	No Data	No Data		1	1			2
		Eutrophic saturated forest	No Data	No Data		1				1
		Eutrophic saturated scrub	G1	S1		1				1

APPENDIX D. Biodiversity Assessment. Summary of Species and Communities Tracked by Natural Heritage Programs in NETN Parks.

		Mesotrophic forest	No Data	No Data		1				1
		Mesotrophic scrub	G2G3	S3	3	1	2			6
		Oligotrophic forest	G3	S1	2	1				3
		Oligotrophic herbaceous vegetation	G2	S1		1				1
		Oligotrophic saturated forest	No Data	No Data	1	1	1			3
		Oligotrophic saturated scrub	G2	S1		2	2			4
		Oligotrophic scrub	G2	S2	2	1	1			4
		Oligotrophic seasonally flooded herbaceous vegetation	No Data	No Data		1	1			2
		Oligotrophic woodland	No Data	No Data	1	1				2
		Permesotrophic forest	No Data	No Data		2	1			3
		Submesotrophic forest	No Data	No Data	1	1	1			3
		Submesotrophic scrub	G2G3	S2S3	1	2	1			4
M221 Total					11	19	13			43
Grand Total					38	42	25	2	15	122

APPENDIX E: Invasive plant species known to occur within and in close proximity to Northeast Temperate Network Parks

List of the primary invasive plant species (n = 94) known to occur within Northeast Temperate Network Parks as of September 2003. Not all known invasive species are listed, and some species known to occur in network parks are listed by their accepted synonym. Each species is linked to the USDA, Natural Resource Conservation Service Plants Database (http://plants.usda.gov). This database provides a comprehensive profile for each species, including its distribution, weedy or invasive tendencies, and other useful information. A listing of invasive plant species known to exist in the northeast, but that have not been identified in any of the Northeast Temperate Network Parks follows in a separate table. The noxious weed list field identifies those states where a particular species appears on the state noxious weed list. This listing is not comprehensive. For an up-to-date comprehensive listing of all states that identify a species as 'noxious,' follow the 'USDA Link' for that particular listing.

Genus / Species	Common Name	link	Noxious Weed List	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
Acer														
plantanoides	Norway maple	USDA Link		X	X	X	X	X	X	X	X	X	X	
achillea														
millefolia	yarrow	USDA Link						X				X		
Aegopodium														
podagragia	goutweed	USDA Link					X							
Aesculus														
hippocastanum	horse chestnut	USDA Link						X				X		
Ailanthus														
altissima	tree-of-heaven	USDA Link				X					X	X		
Alliaria														
petiolata	garlic mustard	USDA Link		X	X	X	X	X	X	X	X		X	X
Allium														
vineale	wild garlic	USDA Link				X	X							
Ambrosia														
artemisiifolia	ragweed	USDA Link						X				X		
Anthriscus														
sylvestris	wild chervil	USDA Link					X							
Artemisia														
vulgaris	mugwort/common wormwood	USDA Link				X						X	X	
Berberis														
ottawensi		USDA Link		X										
thunbergii	Japanese barberry	USDA Link		X	X	X	X	X	X	X	X	X	X	X
vulgaris	common barberry	USDA Link				X								
Bromus														

Genus / Species	Common Name	link	Noxious Weed List	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
inermis	smooth brome/awnless brome	USDA Link		X		X						X		
Catalpa														
bignonoides	catalpa	USDA Link						X						
Celastrus														
orbiculata	oriental bittersweet	USDA Link		X	X		X	X	X	X	X	X		X
Centaurea														
biebersteinii	spotted knapweed	USDA Link		X				X	X		X		X	X
jacea	brown knapweed	USDA Link											X	
maculosa	spotted knapweed	USDA Link				X							X	
Chelidonium														
majus	celandine	USDA Link				X	X	X						
Chenopodium														
album	lambs quarter	USDA Link						X				X		
Chrysanthemum														
leucanthemum	oxeye daisy	USDA Link						X				X		
Cichorium														
intybus	chickory	USDA Link						X				X		
Cirsium														
arvense	Canadian thistle	USDA Link	DE, PA, RI	X									X	
vulgare	bull thistle	USDA Link						X				X		
Convallaria														
majalis	lily of the valley	USDA Link						X						
Cynanchum														
louiseae	black swallow-wort	USDA Link					X	X			X		X	
Dactylis														
glomerata	cocksfoot/ orchardgrass	USDA Link		X		X							X	
Daucus														
carota	queen anne's lace	USDA Link						X				X		
dipsacus														
	teasel	USDA Link										X		
Elaeagnus														
umbellate	autumn olive	USDA Link	WV	X	X	X	X	X	X		X		X	X
Euonymus														
alata	winged euonymus	USDA Link		X	X		X	X	X	X	X			X
fortunei	creeping euonymus	USDA Link						X						
Euphorbia														
esula	leafy spurge	USDA Link				X						X	X	
Forsythia														
viridissima	forsythia	USDA Link						X						
Fragaria														

Genus / Species	Common Name	link	Noxious Weed List	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
vesca	woods strawberry	USDA Link						X						
Frangula														
alnus	glossy buckthorn	USDA Link		X	X		X	X			X		X	
Glechoma														
hederacea	gill-over-the-ground	USDA Link				X		X						
Hedera														
helix	English Ivy	USDA Link						X						
Hemerocallis														
fulva	day-lily	USDA Link						X				X		
Hesperis														
matronalis	dame's rocket	USDA Link				X		X				X		
Hieracium														
pratense	yellow hawk weed	USDA Link				X		X						
Hypericum														
perforatum	st. johnswort	USDA Link						X				X		
Iris														
pseudacorus	yellow flag	USDA Link				X		X			X		X	
Lepidium														
	pepperweeds	USDA Link						X						
Ligustrum														
	privet	USDA Link						X						
Linaria														
vulgaris	toad flax	USDA Link				X		X						
Lonicera														
bella	Bell's honeysuckle	USDA Link		X			X	X			X			X
canadensis	American fly honeysuckle	USDA Link											X	
dioica	limber honeysuckle	USDA Link											X	
japonica	Japanese honeysuckle	USDA Link				X	X				X			
morrowii	Morrow's honeysuckle	USDA Link		X	X	X	X	X	X	X	X		X	X
tatarica	tatarian honeysuckle	USDA Link				X							X	
Lythrum														
salicaria	purple loosestrife	USDA Link	NH, OH, TN	X	X	X	X	X		X	X	X	X	X
Microstegium														
vimineum	Japanese stiltgrass	USDA Link							X		X		X	
Myriophyllum														
heterophyllum	two-leaf water-milfoil	USDA Link	NH								X			
spicatum	Eurasian water-milfoil	USDA Link	NH, NC, SC								X			
Pachysandra														

Genus / Species	Common Name	link	Noxious Weed List	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
	pachysandra	USDA Link						X						
Phalaris														
arundinacea	reed canarygrass	USDA Link						X						
Phragmites														
australis	common reed	USDA Link	NH, SC								X	X	X	
Picea														
abies	Norway spruce	USDA Link						X						
Plantago														
Lanceolata	buckthorn plantain	USDA Link						X				X		
Major	broadleaf plantain	USDA Link						X				X		
Polygonum														
aviculare	prostrate/yard knotweed	USDA Link				X							X	
cuspidatum	Japanese knotweed	USDA Link				X	X				X	X	X	
erectum	erect knotweed	USDA Link					X				X	X	X	
prolificum	Small bushy knotweed	USDA Link		X							X		X	
Populus														
alba	white poplar	USDA Link						X						
Potamogeton														
crispus	curly-leaved pondweed	USDA Link	NH									X	X	
Prunella														
vulgaris	heal all	USDA Link						X						
Rhamnus														
cathartica	common buckthorn	USDA Link				X	X				X		X	
frangula	columnar buckthorn	USDA Link				X						X		
Robinia														
pseudoacacia	yellow/black locust	USDA Link				X					X			
Rosa														
multiflora	multiflora rose	USDA Link	OH, PA, WV	X	X	X	X	X	X	X	X	X	X	X
Rumex														
acetosella	field sorrel	USDA Link				X		X						
crispus	curly dock	USDA Link						X						
Saponaria														
officinalis	bouncing bet	USDA Link						X						
Solanum														
dulcamara	bittersweet	USDA Link		X		X							X	
Sonchus														
arvenis	sow-thistle	USDA Link		X		X								
Stellaria														
graminea	lesser stitchwort	USDA Link						X						

Genus / Species	Common Name	link	Noxious Weed List	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
Syringa														
reticulate	Japanese tree lilac	USDA Link									X			
Syringia														
vulgaris	lilac	USDA Link						X				X		
Tanacetum														
vulgare	common tansy	USDA Link										X		
Trapa														
natans	water chestnut	USDA Link	NC, NH, SC								X		X	
trifolia														
repens	white clover	USDA Link						X				X		
Trifolium														
aureum	yellow hop clover	USDA Link						X						
pratense	red clover	USDA Link						X				X		
Tussilago														
farfara	colts foot	USDA Link		X		X							X	
Verbascum														
thapsus	flannel mullein/velvet dock	USDA Link				X						X	X	
Viburnum														
sieboldi	Siebold's arrowwood	USDA Link							X					
vicia														
	vetch	USDA Link						X				X		
Vinca														
minor	periwinkle	USDA Link					X	X						
vitis														
	wild grapes	USDA Link						X				X		
Yucca														
filamentosa	yucca	USDA Link						X						

Invasive plant species known to exist in the northeast, but not known to exist within any Northeast Temperate Network parks (N = 53).

Genus / Species		Common Name	link	State Noxious Weed List
Acer				
	ginnala	amur maple	USDA Link	
	pseudoplatanus	sycamore maple	USDA Link	
Aira				
	caryophyllea	silver hairgrass	USDA Link	
Alnus				
	glutinosa	European black alder	USDA Link	
Amorpha				
	fruticosa	false indigo	USDA Link	
Ampelopsis				
	brevipedunculata	porcelainberry	USDA Link	
Arthraxon				
	hispidus	hairy jointgrass	USDA Link	
Bromus				
	tectorum	drooping brome grass	USDA Link	
Butomus				
	umbellatus	flowering rush	USDA Link	NH
Cabomba				
	caroliniana	fanwort	USDA Link	NH
Callitriche				
	stagnalis	pond water-starwort	USDA Link	
Cardamine				
	impatiens	narrowleaf bittercress	USDA Link	
Carex				
	kobomugi	japanese sedge	USDA Link	
Celastrus				
	orbiculata	oriental bittersweet	USDA Link	
Cirsium				
	palustre	marsh thistle	USDA Link	
Cynanchum				
	rossicum	pale swallow-wort	USDA Link	
Datura				
	stramonium	jimsonweed	USDA Link	PA
Egeria				
	densa	Brazilian waterweed	USDA Link	NH, SC
Elaeagnus				
	angustifolia	Russian olive	USDA Link	

Elsholtzia				
	ciliata	crested late-summer mint	USDA Link	
Epilobium				
	hirsutum	hairy willow-herb	USDA Link	
Euphorbia				
	cyparissias	cypress spurge	USDA Link	
Fallopia				
	japonica	Japanese knotweed	USDA Link	
Froelichia				
	gracilis	slender snake cotton	USDA Link	
Glaucium				
	flavum	yellow hornpoppy	USDA Link	
Glyceria				
	maxima	reed mannagrass	USDA Link	
Heracleum				
	mantegazzianum	giant hogweed	USDA Link	PA
Hydrilla				
	verticillata	hydrilla	USDA Link	NH, SC
Hydrocharis				
	morsus-ranae	European frogbit	USDA Link	NH
Impatiens				
	glandulifera	ornamental jewelweed	USDA Link	
Lepidium				
	latifolium	broadleaved pepperweed	USDA Link	
Lonicera				
	maackii	amur honeysuckle	USDA Link	
	xylosteum	dwarf honeysuckle	USDA Link	
Lysimachia				
	nummularia	moneywort	USDA Link	
	vulgaris	garden loosestrife	USDA Link	
Marsilea				
	quadrifolia	European water clover	USDA Link	
Myosotis				
	scorpioides	forget-me-not	USDA Link	
Myriophyllum				
	aquaticum	parrotfeather	USDA Link	NH
Najas				
	minor	brittle water-nymph	USDA Link	NH, SC
Nasturtium				
	officinale	watercress	USDA Link	
Nymphoides				
	peltata	yellow floating heart	USDA Link	NH

Ornithogalum				
	umbellatum	star-of-Bethlehem	USDA Link	
Paulownia				
	tomentosa	princess tree	USDA Link	
Polygonum				
	caespitosum	bristled knotweed	USDA Link	
	perfoliatum	mile-a-minute vine	USDA Link	OH, NC, PA
Pueraria				
	Montana	Kudzu	USDA Link	PA
Ranunculus				
	ficaria	fig buttercup	USDA Link	
	repens	creeping buttercup	USDA Link	
Rorippa				
	nasturtium-aquaticum	watercress	USDA Link	
Rosa				
	rugosa	rugosa rose	USDA Link	
Rubus				
	phoenicolasius	wineberry	USDA Link	
Senecio				
	jacobaea	tansy ragwort	USDA Link	
Vincetoxicum				
	rossicum	European swallow-wort	USDA Link	

APPENDIX F: Air Quality Monitoring Summary for NETN

Prepared by: Tonnie Maniero, NPS-Air Resources Division

Introduction

The NPS Air Resources Division (ARD) contracted with the University of Denver (DU) to produce GIS-based maps and an associated look-up table that provide baseline values for a set of air quality parameters for all Inventory and Monitoring parks in the U.S. These maps and table will serve as the Air Quality Inventory for the parks. ARD used preliminary DU products to help develop a strategy for expanding NPS ambient air quality monitoring with increased funding from the Natural Resources Challenge. At this time, ARD does not intend to fund additional monitoring at any NPS units in the Northeast Temperate Network. The air monitoring strategy will be revisited in FY 2004 if additional funding becomes available. Draft Air Quality Inventory products are available on the NPS Intranet (at http://www2.nrintra.nps.gov/ard/ under "Air Atlas") and are provided in an attachment to this report. Final products will be available on the NPS Internet site in a few months.

Data from the Air Quality Inventory, national air monitoring programs described below, and other air quality sources, were used in conjunction with park-specific resource information to evaluate the following needs relative to the Northeast Temperate Network: 1) the need for additional ambient air quality monitoring at any Network park, i.e., wet deposition, dry deposition, visibility, and/or ozone monitoring, and 2) the need for air quality effects-related monitoring at any Network park. The results of this evaluation, as well as a brief summary of results of past air quality monitoring at relevant sites, are discussed below.

Wet Deposition

The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) is a nationwide network of precipitation monitoring sites. The network is a cooperative effort between many different groups, including the U.S. Environmental Protection Agency (EPA), U.S. Geological Survey, U.S. Department of Agriculture, and private entities. The NPS is a major participant in NADP/NTN, and the ARD recommends that any new wet deposition site installed in a park meet NADP/NTN siting criteria and follow NADP/NTN protocols. There are currently more than 200 NADP/NTN sites spanning the continental U.S., Alaska, Puerto Rico, and the Virgin Islands.

The purpose of the network is to collect data on the chemistry of precipitation to monitor geographical and temporal long-term trends. The precipitation at each station is collected weekly according to strict clean-handling procedures. It is then sent to the Central Analytical Laboratory in Illinois where it is analyzed for hydrogen (acidity as pH), sulfate, nitrate, ammonium, chloride, and base cations (such as calcium, magnesium, potassium and sodium). NADP/NTN's excellent quality assurance programs ensure that the data remain accurate and precise. The National Atmospheric Deposition Program has also expanded its sampling to include the Mercury Deposition Network (MDN), which currently has over 35 sites. The MDN was formed in 1995 to collect weekly samples of precipitation, which are analyzed for total

mercury. The objective of the MDN is to monitor the amount of mercury in precipitation on a regional basis.

Acadia National Park (NP) currently has a NADP/NTN monitor on-site; the rest of the parks in the Northeast Temperate Network have a monitor within 55 miles. Therefore, in terms of distance, the parks are well represented by current NADP/NTN monitoring. Intervening terrain or a difference in meteorology would affect how representative a site's data are for a park. In case the Network is interested in installing a NADP/NTN site, a site costs $5,000 to $8,000 for equipment purchase and installation, and operating costs (including site operation, chemical analysis, and reporting) are about $7,000 per year.

Acadia NP has an MDN site (site #ME98), plus there are three additional MDN sites in Maine: Freeport (site #ME96), Bridgton (site #ME02), and Greenville (site #ME09). The other closest MDN sites to the Northeast Temperate Network parks are in Milford, Pennsylvania, (site #PA72) and Newcomb, New York, (site #NY20). Adding mercury sampling to a NADP/NTN site increases annual costs by about $3,000.

Deposition varies with the amount of annual on-site precipitation, and is useful because it gives an indication of the total annual pollutant loading at the site. Concentration is independent of precipitation amount, therefore, it provides a better indication of whether ambient pollutant levels are increasing or decreasing over the years. In general, annual average wet deposition and concentration of sulfate, nitrate, and ammonium are higher in the eastern than in the western U.S. (see attached Draft Air Inventory maps; also see NADP/NTN maps at http://nadp.sws.uiuc.edu). At many NADP/NTN sites across the U.S., concentration and deposition of sulfate have declined in recent years as sulfur dioxide emissions have decreased. Trends have been variable for nitrate and ammonium, with concentration and deposition at various sites increasing, decreasing, or showing no overall change. Results from NADP/NTN sites in and near Northeast Temperate Network parks are summarized below.

Quabbin Reservoir, MA

Quabbin Reservoir, Massachusetts, has had an NADP/NTN site (site #MA08) since 1982. Data show a decrease in concentration and deposition of wet sulfate; a slight decrease in concentration and deposition of wet nitrate; and no overall trend in concentration and deposition of wet ammonium.

Lexington, MA

The Lexington, Massachusetts, NADP/NTN site (site #MA13 (East)) has been operating since 1982. While wet sulfate deposition has steadily decreased at the site, wet sulfate concentration decreased from 1985 through 1995, then increased since 1995. There has been no overall trend in concentration and deposition of wet nitrate. Data show a slight increase in concentration and deposition of wet ammonium.

Bridgton, ME

An NADP/NTN site has been operating at Bridgton, Maine, (site #ME02) since 1980. Site data show a decrease in concentration and deposition of wet sulfate; no overall trend in concentration and deposition of wet nitrate; and no overall trend in concentration and deposition of wet ammonium.

Carrabassett Valley, ME

The Carrabassett Valley, Maine, NADP/NTN site (site #ME04) was installed in 2002. Trend data are not yet available for the site.

Gilead, ME

The Gilead, Maine, NADP/NTN site (site #ME08) was installed in 1999. Trend data are not yet available for the site.

Greenville, ME

The NADP/NTN site has been operating at Greenville, Maine, (site #ME09 (Greenville Station)) since 1979. Site data show a decrease in concentration and deposition of wet sulfate; no overall trend in concentration and deposition of wet nitrate; and no overall trend in concentration and deposition of wet ammonium.

Acadia NP, ME

An NADP/NTN site has been operating at Acadia NP, Maine, (site #ME98) since 1991. Site data show a decrease in concentration and deposition of wet sulfate; no overall trend in concentration and deposition of wet nitrate; and no overall trend in concentration and deposition of wet ammonium.

Hubbard Brook, NH

The Hubbard Brook, New Hampshire, NADP/NTN site (site #NH02) has been operating since 1978. Data show a decrease in concentration and deposition of wet sulfate; a slight decrease in concentration and deposition of wet nitrate; and no overall trend in concentration and deposition of wet ammonium.

Pennington, NJ

Pennington, New Jersey, has had an NADP/NTN site (site #NJ99 (Washington Crossing)) since 1981. Site data show a decrease in concentration and deposition of wet sulfate; no overall trend in concentration and deposition of wet nitrate; and no overall trend in concentration and deposition of wet ammonium.

Claryville, NY

An NADP/NTN site has been operating at Claryville, New York, (site #NY68 (Biscuit Brook)) since 1983. Site data show a decrease in concentration and deposition of wet sulfate; no overall trend in concentration and deposition of wet nitrate; and no overall trend in concentration and deposition of wet ammonium.

West Point, NY

The West Point, New York, NADP/NTN site (site #NY99) was installed in 1983. Site data show a decrease in concentration and deposition of wet sulfate; a decrease in concentration and deposition of wet nitrate; and an increase in concentration and deposition of wet ammonium.

Bennington, VT

Bennington, Vermont, has had an NADP/NTN site (site #VT01) since 1981. Site data show a decrease in concentration and deposition of wet sulfate; no overall trend in concentration and deposition of wet nitrate; and no overall trend in concentration and deposition of wet ammonium.

Dry Deposition

The Clean Air Status and Trends Network (CASTNet) is considered the nation's primary source for atmospheric data to estimate dry acidic deposition. Established in 1987, CASTNet now comprises over 70 monitoring stations across the U.S. The majority of the monitoring stations are operated by EPA; however, approximately 20 stations are operated by the NPS in cooperation with EPA. Each CASTNet dry deposition station measures: weekly average atmospheric concentrations of sulfate, nitrate, ammonium, sulfur dioxide, and nitric acid; hourly concentrations of ambient ozone; and meteorological conditions required for calculating dry deposition rates. Dry deposition rates are calculated using atmospheric concentrations, meteorological data, and information on land use, vegetation, and surface conditions. CASTNet complements the database compiled by NADP/NTN. Because of the interdependence of wet and dry deposition, NADP/NTN wet deposition data are collected at or near all CASTNet sites. Together, these two long-term databases provide the necessary data to estimate trends and spatial patterns in total atmospheric deposition. The ARD recommends that all new dry deposition sites installed in parks use CASTNet siting criteria and follow CASTNet protocols.

Acadia NP has a CASTNet monitor on-site; all other Northeast Temperate Network parks have a monitor within 80 miles. Again, in terms of distance, the parks are well represented by current CASTNet monitoring. Given the expense of dry deposition monitoring, unless there is a particular need to better quantify dry deposition in a park, the ARD does not recommend the Network fund CASTNet monitoring. Installation and annual operating costs for a CASTNet site are about $50,000 and $15,000, respectively.

Because CASTNet uses different monitoring and reporting techniques than NADP/NTN, the dry deposition amounts are reported here as nitrogen and sulfur, rather than nitrate, ammonium, and sulfate. In addition, because CASTNet calculates dry deposition based on measured ambient concentrations and estimated deposition velocities, there is greater uncertainty in the reported

values. Due to the small number of CASTNet sites nationwide, use of dry deposition isopleth maps is not advised at this time. CASTNet data collected near Northeast Temperate Network parks is summarized below.

Abington, CT

The Abington, Connecticut, CASTNet site (site #ABT147) has been in operation since 1993. There have been decreasing trends in both dry nitrogen and dry sulfur deposition at the site. Total nitrogen deposition at Abington is composed of 24 percent dry deposition and 76 percent wet deposition, while total sulfur deposition is 21 percent dry and 79 percent wet.

Acadia NP, ME

A CASTNet site has been operating in Acadia NP, Maine, (site #ACA416) since 1998. Data have not been collected long enough to detect trends or quantify the composition of nitrogen and sulfur deposition.

Ashland, ME

The Ashland, Maine, CASTNet site (site #ASH135) has been operating since 1989. Site data indicate a decrease in both nitrogen and sulfur dry deposition. CASTNet estimates total nitrogen deposition at the site is composed of 17 percent dry deposition and 83 percent wet deposition, while total sulfur deposition is 22 percent dry and 78 percent wet.

Howland, ME

Howland, Maine, has had a CASTNet site (site #HOW132) since 1993. Site data show no trend in either nitrogen or sulfur dry deposition. Data indicate total nitrogen deposition is composed of 21 percent dry deposition and 79 percent wet deposition, while total sulfur deposition is 22 percent dry and 78 percent wet.

Hubbard Brook, NH

The Hubbard Brook, Hew Hampshire, CASTNet site (site #WST109 (Woodstock)) has been operating since 1989. Data show no trend in dry nitrogen or sulfur deposition. Site data show both total nitrogen and total sulfur deposition are composed of 8 percent dry deposition and 92 percent wet deposition.

Pennington, NJ

A CASTNet site has been operating at Pennington, New Jersey, (site #WSP144 (Washington Crossing)) since 1988. Site data indicate a decrease in dry sulfur deposition, but no trend in dry nitrogen deposition. CASTNet estimates total nitrogen deposition at the site is composed of 38 percent dry deposition and 62 percent wet deposition, while total sulfur deposition is 49 percent dry and 51 percent wet.

Claryville, NY

The Claryville, New York, CASTNet site (site #CAT175) has been operating since 1994. Data show a decrease in dry nitrogen deposition, but no trend in dry sulfur deposition. Total nitrogen deposition at Claryville is composed of 35 percent dry deposition and 65 percent wet deposition, while total sulfur deposition is 29 percent dry and 71 percent wet.

Lye Brook, VT

Lye Brook, Vermont, has had a CASTNet site (site #LYE145) since 1994. Data show no trend in dry nitrogen deposition, but an increase in dry sulfur deposition. Site data indicate total nitrogen deposition is composed of 34 percent dry deposition and 66 percent wet deposition, while total sulfur deposition is 26 percent dry and 74 percent wet.

Surface Water Chemistry

The Water Resources Division's (WRD) *Baseline Water Quality Data Inventory and Analysis* reports were reviewed for seven of the Northeast Temperate Network parks and other information was reviewed for an eighth park. Those data are summarized below. In general, acid-sensitive surface waters have a pH below 6.0 and an acid neutralizing capacity (ANC) below 100 microequivalents per liter (μeq/l).

Acadia NP

Acadia NP has been the site of an intensive water quality monitoring program since 1979. Lake and stream chemistry data indicate many surface waters in the park have low ANC. In fact, episodic acidification—when ANC drops below zero--has been documented during snowmelt and runoff. In spite of reductions in sulfate deposition in recent years, there has not been an improvement in pH or ANC of park lakes and streams. Also of concern is a regional decline in base cation concentrations in surface waters, which has resulted in a decrease in buffering capacity of some sensitive surface waters in the Northeast. The cause of the base cation decline is unclear, but may be associated with atmospheric deposition.

Marsh-Billings-Rockefeller NHP

A review of the 1997 *Baseline Water Quality Data Inventory and Analysis* report for Marsh-Billings-Rockefeller National Historical Park (NHP) showed a shortage of recent observations in the study area. The pH values on the Ottauquechee River in 1984 averaged 8.4. One water quality sample from Pogue Lake in 1984 had a pH of 8.0 and an ANC value of 1370 μeq/l, and one sample from an unnamed spring in 1977 had a pH of 7.3 and an ANC of 760 μeq/l. While these data indicate surface waters in the park are not susceptible to acidification from atmospheric deposition, given the limited nature and age of the data, it would be desirable to confirm this with data that are more recent.

Minute Man NHP

A review of the 1996 *Baseline Water Quality Data Inventory and Analysis* report for Minute Man NHP indicated no data had been collected in the park, and no pH or ANC data had been collected in the study area since 1971. Therefore, it is not possible to assess the sensitivity of park surface waters to acidification from atmospheric deposition.

Morristown NHP

A review of the 1994 *Baseline Water Quality Data Inventory and Analysis* report for Morristown NHP showed no data had been collected in the park, and no pH or ANC data had been collected in the study area since 1980. Therefore, it is not possible to assess the sensitivity of park surface waters to acidification from atmospheric deposition.

Roosevelt-Vanderbilt NHS

A review of the 1995 *Baseline Water Quality Data Inventory and Analysis* report for Roosevelt-Vanderbilt National Historic Site (NHS) indicated a fair amount of data had been collected in the park. Samples were collected at various locations along Fall Kill from 1979 to 1995. Average pH values ranged from 7.1 to 7.9, and average ANC values ranged from 640 to 930 μeq/l. Samples collected in Fall Kill Pond in 1979 had an average pH of 7.1 and an average ANC of 660 μeq/l. Samples collected at Meriches Kill in 1994 and 1995 had average pH values of 7.4 to 7.8 and average ANC values of 1200 to 1400 μeq/l. Samples collected at Crum Elbow Creek in 1994 and 1995 had an average pH of 7.4 and an average ANC value of 860 μeq/l. These data indicate surface waters in Roosevelt-Vanderbilt NHS are not sensitive to acidification from atmospheric deposition.

Saratoga NHP

A review of the 1997 *Baseline Water Quality Data Inventory and Analysis* report for Saratoga NHP showed pH data were collected at a number of locations in the park from 1987 to 1990. Sampled sites included Lower Kroma Kill, Upper Kroma Kill, Upper Kroma Kill Tributary, Lower Mill Creek, Mill Creek, Robbie's Ditch, American's Creek, Lower Devil's Hollow and Upper Devil's Hollow. Average pH values at the sites ranged from 7.9 to 8.3. These data indicate surface waters in Saratoga NHP are not sensitive to acidification from atmospheric deposition.

Saugus Iron Works NHS

A review of the *Baseline Water Quality Data Inventory and Analysis* report for Saugus Iron Works NHS showed some sampling has taken place in the park. A spring (CXS2) was sampled in 1988 and had a pH of 6.6. Blow-Me-Up Brook was sampled from 1982 to 1991 and 1997 to 1998. Average pH values ranged from 7.2 to 8.0, and the average ANC value for the 1982 to 1991 sampling period was 400 μeq/l. Average pH values in Blow-Me-Down Pond in 1997 and 1998 were 8.0, while average pH values in Blow-Me-Down Brook were 7.9. These data indicate surface waters in Saugus Iron Works NHS are not sensitive to acidification from atmospheric deposition.

Weir Farm NHS

A review of the 1997 *Baseline Water Quality Data Inventory and Analysis* report for Weir Farm NHS indicated no data had been collected in the park. Therefore, it is not possible to assess the sensitivity of park surface waters to acidification from atmospheric deposition.

Visibility

In 1985, in response to the mandates of the Clean Air Act, Federal and regional/state organizations established the Interagency Monitoring of Protected Visual Environments (IMPROVE) program to protect visibility in Class I air quality areas. Class I areas are national parks greater than 5,000 acres and wilderness areas greater than 6,000 acres, that were established prior to August 7, 1977. All other NPS areas are designated Class II. The objectives of the IMPROVE program are: to establish current visibility conditions in all Class I areas; to identify pollutants (particles and gases) and emission sources responsible for existing man-made visibility impairment; and to document long-term trends in visibility. In 1999, there were 30 official IMPROVE sites and 40 protocol sites. Because of recently enacted regulations that require improving visibility in Class I areas, the number of visibility monitors is increasing. Protocol sites are being upgraded to full IMPROVE sites and 80 new sites are being added to the IMPROVE network.

While the IMPROVE program has focused on Class I air quality areas, a great deal of visibility monitoring has been conducted in Class II areas. The ARD recommends that new visibility monitoring in NPS areas be conducted in coordination with the IMPROVE program (the IMPROVE program is managed out of the NPS ARD office in Fort Collins, Colorado). Installation and annual operating costs for a full IMPROVE site are about $15,000 and $30,000, respectively; however, partial monitoring, such as a camera-only site, is much less expensive.

There are ten IMPROVE sites in or near parks in the Northeast Temperate Network. A full IMPROVE site has been operating at Acadia NP (site #ACAD1) since 1988. Other IMPROVE sites have been operated by the U.S.D.A. Forest Service at the Lye Brook Wilderness Area, Vermont, (site #LYBR1) since 1991, and the Great Gulf Wilderness Area, New Hampshire, (site GRGU1) since 1995, and by the U.S. Fish and Wildlife Service at the Edwin B. Forsythe National Wildlife Refuge (NWR), New Jersey, (site #BRIG1) since 1991. States have been operating the following protocol sites: Mohawk Mountain, Connecticut, (site #MOMO1); Cape Cod National Seashore, Massachusetts, (site #CACO1); Martha's Vineyard, Massachusetts, (site #MAVI1); Quabbin Reservoir, Massachusetts (site #QURE1); and Bridgton, Maine (site #BRME1). The Penobscot Tribe operates the Old Town, Maine, protocol site (site #OLTO1). Therefore, all parks in the Northeast Temperate Network have an IMPROVE monitor within 85 miles. This is sufficient to provide a Network-wide assessment of visibility. If parks are interested in more site-specific monitoring, e.g., monitoring the plume from a nearby source, ARD can advise Network staff on how best to conduct this type of monitoring.

Data have been collected at Acadia NP long enough to assess long-term visibility trends. Unfortunately, the data show that views on the best, worst, and average visibility days decreased between 1988 and 1998. Not enough data have been collected and analyzed at the other sites to

perform trend analyses. 1996-1998 data show that, as with previous years, standard visual range is substantially lower in the eastern, than in the western, U.S. (see attached map). As for the sources of visibility impairment, 1996-1998 aerosol data from Acadia NP, Edwin B. Forsythe NWR, and Lye Brook Wilderness Area are consistent with data from other eastern U.S. IMPROVE sites. These data show that, on an annual basis, visibility impairment is primarily due to sulfates (sources include coal combustion and oil refineries), then organics (sources include automobiles), then nitrates (sources include coal and natural gas combustion and automobiles), then light absorbing carbon (sources include wood burning), then soil (from windblown dust).

Ozone

Acadia NP and Saratoga NHP have ozone monitors on-site, the other parks in the Northeast Temperate Network have one or more monitors within 35 miles. Existing monitoring is, therefore, adequate to represent ozone conditions in the parks. With the exception of Marsh-Billings-Rockefeller NHP, Saint-Gaudens NHS, Saratoga NHP, and parts of the Appalachian National Scenic Trail, all parks in the Northeast Temperate Network are in ozone nonattainment areas (see attached maps), meaning that the ozone levels in those areas exceed EPA's human health-based 8-hour National Ambient Air Quality Standard (NAAQS). In areas with high ozone concentrations, an ozone nonattainment designation can actually benefit the parks, because the designation requires the local or state air pollution control agency to take measures to reduce ozone levels. In case the Network is interested, installation and annual operating costs for an ozone monitoring site are about $90,000 and $14,000, respectively.

Vegetation

For vegetation, the focus is on ozone sensitivity because 1) ozone is a regional pollutant and is, therefore, more likely to affect park resources than other gaseous pollutants such as sulfur dioxide and nitrogen oxide which quickly convert to other compounds, and 2) the literature on ozone sensitivity is more recent and more reliable than that for other pollutants. Park vascular plant lists contained in the May 2001 NPSpecies database were compared to the lists of Ozone-Sensitive Plant Species contained in the NPS Synthesis information management system (see attached Synthesis species lists). The Synthesis lists were developed by an expert in the field of ozone effects on vegetation. Note that the Synthesis lists provide a general guide to ozone sensitivity. Differences in plant genetics, weather conditions, soil water availability, and ozone concentrations will affect whether or not a species exhibits injury in a particular park. In particular, studies have shown that plants will not take up ozone unless there is sufficient soil moisture. Ozone sensitive species of natural vegetation were identified for nine of the parks in the Northeast Temperate Network (see attached tables of sensitive species for Network parks). A vascular plant list was not available for either Appalachian National Scenic Trail or Boston Harbor Islands National Recreation Area (NRA) in the NPSpecies database.

It is generally agreed that plant foliar injury occurs after a cumulative exposure to ozone. One ozone statistic that is used to evaluate the risk of plant injury is SUM06. SUM06 is the sum of all hourly average ozone concentrations greater than or equal to 60 parts per million (ppm). In 1997, a group of ozone effects experts recommended 3-month, 8:00 a.m. to 8:00 p.m., SUM06

effects endpoints for natural vegetation, i.e., 8 to12 ppm-hrs for foliar injury to natural ecosystems and 10 to 15 ppm-hrs for growth effects on tree seedlings in natural forest stands. According to a SUM06 map generated by DU, some Northeast Temperate Network parks have ozone concentrations, during some years, that are high enough to harm native vegetation. 1995 to1999 seasonal average SUM06 values at Morristown NHP were 30-38 ppm-hrs; and at Boston Harbor Islands NRA, Minute Man NHP, Roosevelt-Vanderbilt NHS, Saratoga NHP, Saugus Iron Works NHS, and Weir Farm NHS, concentrations were 15-23 ppm-hrs. Concentrations along the Appalachian National Scenic Trail ranged from 0-6 to 23-30 ppm-hrs. It is not clear if ozone injury would be observed in Acadia NP, Marsh-Billings-Rockefeller NHP, or Saint-Gaudens NHS given that 1995 to 1999 seasonal average SUM06 values were 6-15 ppm-hrs. Ozone injury surveys in the early 1990s in Acadia NP did detect some injury, but the amount of injury per plant was slight, and it was on less than one percent of the plants examined in field surveys. Nevertheless, Network staff may want to conduct foliar injury surveys on sensitive plant species, at least in those parks with high SUM06 ozone values. Good survey species are black cherry (*Prunus serotina*) and milkweed (*Asclepias spp*) because 1) ozone injury symptoms for these species are well described and 2) standardized survey protocols and training manuals have been developed and can easily be adapted for Network parks. Based on the NPSpecies lists, black cherry and milkweed are presumed to occur in nine of the eleven Northeast Temperate Network parks.

Conclusions

Acadia NP currently has a NADP/NTN monitor on-site; the rest of the Northeast Temperate Network parks have a monitor within 55 miles. Current monitoring is likely adequate to represent wet deposition in Network parks.

Acadia NP has a CASTNet monitor on-site; the rest of the Northeast Temperate Network parks have a monitor within 80 miles. Given this distance and the adequacy of NADP/NTN monitoring, installation of additional dry deposition monitors is not recommended.

Water quality information was reviewed for eight of the parks in the Northeast Temperate Network. The information indicated surface waters at Roosevelt-Vanderbilt NHS, Saratoga NHP, and Saugus Iron Works NHS are not sensitive to acidification from atmospheric deposition. It would be necessary to collect pH and ANC data from Marsh-Billings-Rockefeller NHP, Minute Man NHP, Morristown NHP, and Weir Farm NHS to determine the sensitivity of the surface waters in those parks to atmospheric deposition. Lakes and streams at Acadia NP are currently being affected by atmospheric deposition. It is important that the long-term surface water chemistry monitoring program continue at the park.

Acadia NP has an IMPROVE monitor on-site; the rest of the Northeast Temperate Network parks have a monitor within 85 miles. This is sufficient to provide a Network-wide assessment of visibility.

Acadia NP and Saratoga NHP have ozone monitors on-site, the other parks in the Northeast Temperate Network have one or more monitors within 35 miles. Existing monitoring is,

therefore, adequate to represent ozone conditions in the parks. Seven of the parks, plus parts of the Appalachian National Scenic Trail, are in designated ozone nonattainment areas.

Ozone sensitive vascular plant species have been identified for nine of the parks in the Northeast Temperate Network. Ozone concentrations are high enough in many units to warrant foliar injury surveys. Black cherry and milkweed are good candidates for such surveys.

Relevant Websites

NADP - http://nadp.sws.uiuc.edu/

CASTNet - http://www.epa.gov/castnet/

IMPROVE - http://vista.cira.colostate.edu/improve/

Ozone - http://www.epa.gov/air/data/index.html

Pollution sources and air quality data - http://www.epa.gov/air/data/index.html

Pollution sources and monitors (maps and data) - http://www.epa.gov/ttnotag1/areas/

Summary of Ambient Air Quality Data Collected in and near National Park Service Units in the Northeast Temperate Network

PARK	NADP/NTN		CASTNet		IMPROVE		OZONE	
	LOCATION	SITE #	LOCATION	SITE #	LOCATION	SITE #	LOCATION	SITE #
ACAD	On-site	ME98	On-site	ACA416	On-site	ACAD1	On-site Cadillac Mountain	230090102
							On-site McFarland Hill	230090103
APPA	West Point, NY 5 miles NW of Bear Mountain State Park, NY	NY99	Claryville, NY 55 miles W of Kent, CT	CAT175	Mohawk Mountain, CT within 5 miles	MOMO1	Montgomery, NY 15 miles NW of Bear Mountain State Park, NY	360715001
	Claryville, NY 55 miles W of Kent, CT	NY68	Abington, CT 65 miles E of Cornwall Bridge, CT	ABT147	Quabbin Reservoir, MA 45 miles E of Dalton, ME	QURE1	Milbrook, NY 10 miles W of APPA	360270007
	Quabbin Reservoir, MA 45 miles E of Dalton, MA	MA08	Lye Brook, VT about 10 miles SE of Glastenbury Mountain, VT	LYE145	Lye Brook, VT about 10 miles SE of Glastenbury Mountain, VT	LYBR1	Putnam County, NY Location unknown	360790005
	Bennington, VT about 10 miles SW of Glastenbury Mountain, VT	VT01	Hubbard Brook, NH, about 10 miles S of Mt. Moosilauke, NH	WST109	Glen House, NH within 5 miles of Mt. Washington, NH	GRGU1	Mohawk Mountain, CT within 5 miles	090050005
	Hubbard Brook, NH, about 10	NH02	Howland, ME	HOW132	Bridgton, ME 30 miles S of	BRME1	Mt. Greylock, MA	250034002

PARK	NADP/NTN		CASTNet		IMPROVE		OZONE	
	LOCATION	SITE #	LOCATION	SITE #	LOCATION	SITE #	LOCATION	SITE #
	miles S of Mt. Moosilauke, NH		45 miles E of Monson, ME		Goose Eye Mountain, ME		within 5 miles	
	Gilead, ME, 10 miles S of Goose Eye Mountain, ME	ME08	Ashland, ME 60 miles NE of Mt. Katahdin, ME	ASH135	Old Town, ME 50 miles E of Monson, ME	OLTO1	Bennington, VT 5 miles W of APPA	500030004
	Bridgton, ME 30 miles S of Goose Eye Mountain, ME	ME02					Conway, NH 20 miles SE of Crawford Notch, NH	330031002
	Carrabassett Valley, ME, 5 miles S of Mt. Bigelow, ME	ME04					Coos County, NH Location unknown	330074002
	Greenville, ME 15 miles W of Barren Mountain, ME	ME09					Haverhill, NH 10 miles W of Mt. Moosilauke, NH	330090008
							North Lovell, ME 20 miles S of Goose Eye Mountain, ME	230173001

PARK	NADP/NTN		CASTNet		IMPROVE		OZONE	
	LOCATION	SITE #	LOCATION	SITE #	LOCATION	SITE #	LOCATION	SITE #
							Dover-Foxcroft, ME 15 miles SE of Monson, ME	230210003
BOHA	Lexington, MA 15 miles NW	MA13	Abington, CT 60 miles SW	ABT146	Cape Cod NS, MA 60 miles SE	CACO1	Many in Essex, Norfolk, and Suffolk Counties	Many
					Quabbin Reservoir, MA, 60 miles W	QURE1		
					Martha's Vineyard, MA, 65 miles S	MAVI1		
MABI	Hubbard Brook, NH, about 55 miles NE	NH02	Hubbard Brook, NH, about 55 miles NE	WST109	Lye Brook, VT About 55 miles SW	LYBR1	Sullivan County, NH within 35 miles	330190003
	Bennington, VT 60 miles SW	VT01	Lye Brook, VT about 55 miles SW	LYE145				
MIMA	Lexington, MA within 5 miles E	MA13	Abington, CT 50 miles SW	ABT146	Quabbin Reservoir, MA, 50 miles W	QURE1	Many in Norfolk and Suffolk Counties	Many
					Cape Cod NS, MA 75 miles SE	CACO1		

PARK	NADP/NTN		CASTNet		IMPROVE		OZONE	
	LOCATION	SITE #	LOCATION	SITE #	LOCATION	SITE #	LOCATION	SITE #
					Martha's Vineyard, MA, 75 miles S	MAVI1		
MORR	Washington Crossing, NJ 35 miles SW	NJ99	Washington Crossing, NJ 35 miles SW	WSP144	Edwin B. Forsythe NWR, NJ 85 miles S	BRIG1	Many in Essex County, NJ within 15 miles E	Many
ROVA	West Point, NY 30 miles S	NY99	Claryville, NY 35 miles W	CAT175	Mohawk Mountain, CT, 30 miles E	MOMO1	Poughkeepsie, NY within 5 miles S	360271003
	Claryville, NY 35 miles W	NY68					Millbrook, NY 15 miles E	360270007
SAGA	Hubbard Brook, NH, about 55 miles NE	NH02	Lye Brook, VT About 50 miles SW	LYE145	Lye Brook, VT About 50 miles SW	LYBR1	Sullivan County, NH, within 25 miles	330190003
	Bennington, VT 60 miles SW	VT01	Hubbard Brook, NH about 55 miles NE	WST109				
SAIR	Lexington, MA 10 miles W	MA13	Abington, CT 65 miles SW	ABT146	Quabbin Reservoir, MA, 65 miles W	QURE1	Many in Essex, Norfolk, and Suffolk Counties	Many
					Cape Cod NS, MA 65 miles SE	CACO1		

PARK	NADP/NTN		CASTNet		IMPROVE		OZONE	
	LOCATION	SITE #	LOCATION	SITE #	LOCATION	SITE #	LOCATION	SITE #
					Martha's Vineyard, MA, 75 miles S	MAVI1		
SARA	Bennington, VT 25 miles SE	VT01	Lye Brook, VT about 35 miles SE	LYE145	Lye Brook, VT about 35 miles SE	LYBR1	On-site	360910004
WEFA	West Point, NY 30 miles W	NY99	Abington, CT 80 miles NE	ABT146	Mohawk Mountain, CT, 40 miles N	MOMO1	Many in Fairfield County, CT within 15 miles	Many

NADP/NTN = National Atmospheric Deposition Program/National Trends Network

CASTNet = Clean Air Status and Trends Network

IMPROVE = Interagency Monitoring of Protected Visual Environments

NWR = U.S. Fish and Wildlife Service National Wildlife Refuge

Freshwater Issues for National Parks of the Northeastern United States

PHASE I: A Scoping Report for the Northeast Temperate Network (NETN)

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LIST OF ACRONYMS

ACAD	Acadia National Park
BOHA	Boston Harbor Island National Recreation Area
CFU	Fecal coliform units
GIS	Geographic Information System
FCA	Fish Consumption Advisory
LDC	Legacy Data Center
MABI	Marsh-Billings-Rockefeller National Historical Park
DEP	Department of Environmental Protection
MIMA	Minute Man National Historical Park
MORR	Morristown National Historical Park
MPN	Most probable number
NAWQA	National Water-Quality Assessment Program
NHP	National Historical Park
NHS	National Historic Site
NP	National Park
NPS	National Park Service
NRA	National Recreation Area
NETN	Northeast Temperate Network
NWI	National Wetland Inventory
NWIS	National Water Information System
PCBs	Polychlorinated Biphenyls
PRIMENet	Park Research and Intensive Monitoring of Ecosystems
ROVA	Roosevelt-Vanderbilt National Historic Site
SAGA	Saint-Gaudens National Historic Site
SAIR	Saugus Iron Works National Historic Site
SARA	Saratoga National Historical Park
STORET	U.S. Environmental Protection Agency’s storage and retrieval database
TMDL	Total Maximum Daily Load
USFWS	U.S. Fish and Wildlife Service
USEPA	U.S. Environmental Protection Agency

USGS	U.S. Geological Survey
WEFA	Weir Farm National Historic Site

EXECUTIVE SUMMARY

An inventory of freshwater resources in the Northeast Temperate Network (NETN) parks is created as a basis for the design of long-term freshwater-resources monitoring efforts. This inventory includes a description of monitoring programs related to freshwater resources and water quality in each park, descriptions of current and emerging threats for NETN ecosystems, and network-wide water-quality objectives and candidate monitoring variables. Conceptual models integrate freshwater ecosystems with potential threats at each park.

Although baseline freshwater-quality data is being collected in some NETN parks, these parks generally do not have long term data-collection programs that include systematic quality control and (or) data management. These types of data-collection programs are important in evaluating the effect of threats to freshwater ecosystems in the parks. Threats common to all parks include climate change, atmospheric deposition, visitor use, and invasive species. In addition, urban and residential development, and agriculture have the potential to degrade freshwater resources in most of the parks. Core monitoring variables that would assist in detecting ecosystem responses to these threats include alkalinity, pH, conductivity, dissolved oxygen, temperature, surface-water flow, toxic elements such as mercury, turbidity, nitrate/nitrogen, phosphate/phosphorus, chlorophyll, sulfates, and bacteria.

INTRODUCTION

The Northeast Temperate Network (NETN) is made up of the following 10 National Parks (NP), National Historical Parks (NHP), National Recreation Areas (NRA), and National Historic Sites (NHS):

1. Acadia NP, Maine (ACAD)
2. Boston Harbor Island NRA, Massachusetts (BOHA)
3. Marsh-Billings-Rockefeller NHP, Vermont (MABI)
4. Minute Man NHP, Massachusetts (MIMA)
5. Morristown NHP, New Jersey (MORR)
6. Roosevelt-Vanderbilt NHS, New York (ROVA)
7. Saint-Gaudens NHS, New Hampshire (SAGA)
8. Saugus Iron Works NHS, Massachusetts (SAIR)
9. Saratoga NHP, New York (SARA)
10. Weir Farm NHS, Connecticut (WEFA)

In all NETN parks, freshwater resources are subjected to natural and anthropogenic impacts and alterations, which, in some cases, have imposed stress on these resources for many years. Current and historic threats facing aquatic ecosystems in National Park Service (NPS) units throughout the northeastern U.S. have led to specific physical, biological, or chemical stressors to the freshwater ecosystems. These stressors include organic and inorganic contaminants from agricultural practices and septic system leachate; hydrologic and hydraulic alterations, such as the installation and renovations of bridges, roads, culverts, and drainages; ground-water withdrawals; erosion from road

runoff; deposition of atmospheric contaminants; encroachments by invasive and non-native species; and industrial contaminants in the watersheds.

The amount of available water-quality and water-quantity data is variable for the NETN parks. Although sparse water-quality monitoring has been done in each of the parks, no systematic water-quality and water-quantity data has been collected with adequate quality assurance over a period of record sufficient to characterize baseline conditions and evaluate spatial and temporal changes in freshwater resources throughout a park. The documentation of baseline water-quality and quantity conditions is critical to the long-term maintenance of freshwater resources in the parks. Changes in baseline conditions will assist natural resource managers in identifying and managing stressors in park freshwater ecosystems.

An Inventory and Freshwater-resources Monitoring Design Project will be conducted in three phases.

PHASE I: Produce a Scoping Report for the NETN parks.

PHASE II: Design prototype guidance for monitoring freshwater resources in the NETN parks. This includes prioritizing the list of candidate monitoring variables into a final list of variables (vital signs) that will be measured in all NETN parks.

PHASE III: Conduct feasibility (pilot) testing of recommended freshwater-quality/aquatic-resource monitoring components at select NETN parks in order to finalize the freshwater-resource-monitoring design for the network.

This report is limited to phase I, which will create a resource inventory for freshwater resources in the NETN upon which the design of long-term freshwater-resource monitoring efforts can be based. The purpose of this report is to locate and reference existing baseline data in the NETN parks, and to identify potential candidate monitoring variables that could be used to (1) characterize the condition of freshwater resources in

the NETN parks (2) determine the natural range of variability in water quality in the NETN parks, and (3) establish whether the natural range of variability is changing due to anthropogenic threats. The report includes the following:

1. Description of ongoing inventory or monitoring programs related to park freshwater resources and water quality
2. Draft conceptual models of key ecosystems in the NETN parks
3. Descriptions of current and emerging threats for NETN ecosystems and relevant agents of change that could affect NETN aquatic resources
4. Description of the types of freshwater bodies present in the parks using published information such as classifications from National Wetland Inventory (NWI) and bathymetry maps
5. Summary of information from State reports to the U.S. Environmental Protection Agency (USEPA) regarding the Clean Water Act sections 305(b) and 303(d).
6. Identification of specific freshwater resources that are of unique importance on watershed or regional scales
7. Freshwater body area statistics based on GIS coverages, NWI databases, and State coverages
8. Network-wide water-quality objectives and candidate monitoring variables

METHODS AND APPROACH

Developing this scoping report required the compilation of all information regarding freshwater resources, freshwater-quality data, and the drivers, threats, and stressors operating on freshwater ecosystems in each of the 10 parks in the NETN. Drivers are defined as major, naturally occurring forces of change on freshwater ecosystems, operating both inside and outside the park boundaries. Threats are natural or anthropogenic forces of change that impose stress on ecosystems by occurring at an excessive (or deficient) level. Threats to freshwater resources in NETN parks include climate change, atmospheric deposition, development, visitor use, agriculture, invasive species, industry, and forestry. Threats are divided into those that affect water flowing into the park, those that affect freshwater in the park, or both. Stressors are the specific physical, biological, or chemical results of the threats that cause significant changes to

the freshwater ecosystem, such as road runoff, leachate from septic systems, and nutrient loading. Relations between freshwater bodies and the threats and stressors to these freshwater bodies were identified, and conceptual models were developed. These models are useful to identify the relations between threats to freshwater ecosystems and ecosystem responses, and to identify measures that can be used to monitor changes in the attributes of the freshwater ecosystems. The data are compiled by park; each park summary includes descriptions of freshwater bodies, historic and current water-quality and water-quantity monitoring, water-quality and -quantity issues in the park, and current and emerging aquatic ecosystem threats.

Data Compilation

NPS natural resource managers assisted in the identification of historic and current water-quality monitoring by the NPS, as well as in identifying natural-resource partners involved in water-quality monitoring (table 1). They identified general management plans and natural-resource management plans that were helpful in identifying the freshwater resources and many of the freshwater ecosystem threats.

The USEPA maintains two data-management systems that contain water-quality information for the nation's waters: the Legacy Data Center (LDC), and Storage and Retrieval (STORET). The LDC is a static, archived database, and STORET is a current system that has been in operation since January 1, 1999. Both systems contain biological, chemical, and physical data on surface- and ground-water collected by federal, state, and local agencies, Indian tribes, volunteer groups, academic institutions, and others (U.S. Environmental Protection Agency, 2003). There is no guarantee that all data collected in the parks have been entered into the database.

The LDC was queried by the NPS in order to produce baseline water-quality data inventory and analysis reports for many of the NHSs and NHPs from 1994 to 2000. All but two of the sites in the NETN (BOHA and SAIR) have these baseline reports. Baseline reports contain locations of historical water-quality monitoring stations for each park in an area extending at least 3 miles upstream and 1 mile downstream from the park boundary (National Park Service, 1994a). Monitoring station locations that were within park boundaries were identified. In association with the Baseline Water Quality Data Inventory and Analysis Program of the NPS, some parks in the NETN (MIMA and WEFA) were found to have depauperate water-quality databases, thereby requiring Level I water-quality inventories. A Level I water-quality inventory, as defined by the NPS Inventory and Monitoring Program, includes sampling basic water-quality parameters including alkalinity, pH, conductivity, dissolved oxygen, temperature, flow, and a rapid bioassessment baseline for fish and macro invertebrates for key waterbodies within park boundaries. Optional or case-by-case parameter groups include toxic elements, turbidity, nitrate/nitrogen, phosphate/phosphorus, chlorophyll, sulfates, and bacteria (National Park Service, 1997c). Key waterbodies are either those essential to the cultural, historical, or natural resources management themes of the park, or those that provide habitat for rare plants or animals. Level I water-quality inventories also identify water-quality management issues at each park and recommend appropriate long-term water-quality monitoring strategies. MIMA and WEFA had Level I surveys conducted in 1999.

Although USGS data associated with NPS water-quality monitoring were in the LDC at the time of the Baseline Data Inventory and Analysis reports, USGS data have now been removed from the LDC and will no longer be entered into STORET. USGS

maintains a separate database, National Water Information System (NWIS) on the internet, in which surface-water, ground-water and water-quality data collected by the USGS are stored, and can be queried or searched (U.S. Geological Survey, 2003).

As a part of this scoping report, the STORET database and USGS NWIS database were searched for data that was more recent than that catalogued in the NPS baseline reports. Only stations that are within park boundaries were included, except where there is no USGS streamflow gaging-station within park boundaries, in which case a representative streamflow gaging-station that could be used to estimate discharge of streams and (or) rivers in the park was included. Criteria used to select the most appropriate gage include length of record, drainage area, and proximity to the park. None of the parks (except ACAD) have a continuous-record streamflow gaging-station within their boundaries (appendix 1). Tables of representative streamflow gaging-stations are presented in appendix 1 for ACAD and in appendix 2 for all other NETN parks. In parks such as SAIR, the representative gage is on the same waterbody that flows through the park and is close to park boundaries. In other cases (such as SAGA and SARA), the gage may be in a different watershed with an entirely different drainage area than any of the surface-water bodies in the park.

Water-quality standards must be established by states for all freshwater bodies according to The Clean Water Act, section 305b. Water-quality standards define the goals for a waterbody by designating its uses, setting criteria to protect those uses, and establishing provisions to protect water quality from pollutants as outlined on the USEPA website, http://www.epa.gov/waterscience/standards/about/. The Clean Water Act also mandates, under section 303d that states, territories, and authorized tribes list impaired

and threatened waters and develop Total Maximum Daily Loads (TMDLs) for waters on this list. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water-quality standards, and an allocation of that amount to the pollutant's sources. The calculation must include a margin of safety to ensure that the waterbody can be used for the purpose designated. The calculation also must account for seasonal variation in water quality. USEPA's 305b and 303d water-quality reports were searched for freshwater bodies in the parks that were on these lists (http://www.epa.gov/waters/), and TMDLs were referenced for park waterbodies. The 305b reports of water-quality standards and the 303d lists and attainment status for each freshwater body in each park are summarized in appendix 3. There are gaps in these lists in cases where known waterbodies in the parks were not yet assessed. For example, the most recent 305b reports from New York and New Jersey were not available.

Various NPS and state Geographic Information System (GIS) data layers were used from state offices of GIS (http://www.geo-one-stop.gov/StateLinks/index.html) and the NPS Data Clearinghouse website (http://www.nps.gov/gis/data_info/clearinghouse.html) to make the park maps included in this report. Because these layers are already compiled by the NPS and the state offices of GIS, they are not included in this report. GIS layers used include park boundaries, the NWI, streams, rivers and lakes, roads, county and town boundaries. Freshwater body area statistics for the parks described in this report are listed in appendix 4.

Conceptual Model Development

Conceptual models for the parks are based on the NPS guidelines for the Inventory and Monitoring Program that were presented on the following website:

http://science.nature.nps.gov/im/monitor/index.htm, accessed on August 5, 2003. The models developed here are designed to articulate the relations among drivers, threats, ecosystem attributes (or conditions), ecological processes, and focal resources. The relations common to all NETN parks are shown in figure 1. Maps of individual parks are shown in figures 2,4,6,8,10,12,14,16,18,20; and individual park conceptual models are shown in figures 3,5,7,9,11,13,15,17,19,21. Conceptual models will be used in phases II and III of this project to prioritize vital signs and aid in the development of a monitoring plan.

IDENTIFICATION OF NETWORK-WIDE WATER-QUALITY OBJECTIVES, AND CANDIDATE MONITORING VARIABLES

Network-wide water-quality objectives were determined on the basis of the conceptual models of the individual parks. Common threats to water resources as well as freshwater aquatic ecosystem attributes will be considered as vital signs for tracking the physical and biological integrity of freshwater resources in the NETN parks.

Network-Wide Water-Quality Objectives

The goal of monitoring water quality in the NETN parks is to define the normal limits of variation in freshwater resources in the parks. Monitoring will help managers in the parks determine if changes in water-quality parameters are within natural levels of variability or are a result of anthropogenic actions, and to adjust their management appropriately. Ideally, parks would measure all water-quality parameters; however, limited resources necessitate the selection of a subset of parameters that are significant indicators of ecological conditions (vital signs). Vital signs for a park or a network are chosen on the basis of ecological threats or stressors that have been documented in or

around the parks, or have the potential to threaten freshwater resources on in the park because of surrounding land uses and (or) trends.

Natural resource managers at each of the NETN parks initially prioritized potential threats through a questionnaire. Stressors resulting from these threats were defined and prioritized according to degree of influence and potential to damage the freshwater resources during phone interviews between natural resource managers in the parks and regional water-resource professionals (table 2).

Climate change, atmospheric deposition, invasive species, and visitor use are threats or potential threats identified in all NETN parks; however atmospheric deposition, visitor use, and invasive species are greater current management concerns at the parks than climate change. Nonpoint-source pollution, including sedimentation from soil erosion, is the major stressor resulting from visitor use in the parks. In all parks except BOHA, road runoff is identified as one of the primary sources of sedimentation. Development outside the park, leading to issues with septic systems, water withdrawals, lawn chemicals, wastewater treatment, road runoff, and hydrologic alterations caused by land-use conversions are issues in all parks except MABI and WEFA, which are in primarily self-contained watersheds. Agricultural runoff is identified as a concern in about half of the NETN parks including ACAD, MABI, MIMA, SAGA, SARA, and ROVA. Industry is identified as a threat at MIMA, MORR, ROVA, SAIR, SARA, and SAGA.

Water-quality objectives at NETN parks include the early identification of water-quality degradation due to any of the above listed stressors. Vital signs monitoring also will be broad enough so any new threats or stressors to the freshwater ecosystem can be identified and managed proactively.

Candidate Monitoring Variables

A set of core water-quality monitoring parameters was identified by a NPS workgroup (National Park Service, 2002). These parameters include temperature, specific conductance, pH, dissolved oxygen, and an estimate of flow/discharge for flowing waterbodies or a stage/level of non-flowing waterbodies. These parameters can be collected in the field and will be collected at all water-quality monitoring stations. Additional water-quality monitoring parameters, including turbidity, nutrients, pathogens, and metals, will be considered at each monitoring station depending on the potential threats and (or) stressors for that park, and the cost involved. Descriptions of water-quality monitoring variables can be found in the USGS National Field Manual for the Collection of Water-Quality Data (U.S. Geological Survey, 1998).

PARK DESCRIPTIONS

This section describes 10 parks in the NETN. Water-quality and water-quantity monitoring and research, and current (2004) and emerging threats to freshwater aquatic ecosystems are discussed.

Acadia National Park

Acadia National Park (ACAD) in downeast coastal Maine protects 47,498 acres including 30,300 acres on Mount Desert Island, 2,728 acres on Isle Au Haut, and 2,194 acres on Schoodic Peninsula. There are more than 24 streams, 14 great ponds and lakes (greater than 10 acres), and 9 smaller ponds partially or entirely within Acadia National Park (ACAD) (fig. 2) (Kahl and others, 2000). Lakes and ponds cover approximately 2,600 acres. Wetlands cover approximately 4,100 acres, of which approximately 2,600 are palustrine wetlands. Outstanding Resource Waters for ACAD include all brooks, streams, and segments of those brooks and streams that are within the boundaries of

Acadia National Park. The coastal lakes of Mount Desert also are considered Outstanding Resource Waters. Although ACAD is part of the NETN, it also has been included in the Coastal Barrier Network of the NPS because it shares many management concerns with the coastal parks. In-depth descriptions of the estuarine and marine wetlands and threats to these resources can be found in the Coastal Barrier Network Scoping report (M.J. James-Pirri, University of Rhode Island, written commun., 2003).

A water-resources management plan for ACAD was completed in April 2000 (Kahl and others, 2000). The plan outlines the majority of the water-quality and water-quantity monitoring that has been done on freshwater resources in the park and on Mount Desert Island through year 2000, and should be consulted before additional monitoring is proposed. Additionally, an ACAD water-resource program factsheet outlines research and monitoring that has been conducted by ACAD and its collaborators (Acadia National Park, 2000).

WATER-QUALITY AND WATER-QUANTITY MONITORING

ACAD freshwater monitoring program objectives are to (1) provide baseline data on water resources in the park; (2) serve as an early warning system for anthropogenic impacts and threats such as nonpoint-source pollution, acid deposition, and climate change; (3) assist in identifying potential sources of pollution; and (4) track trends (Acadia National Park, 2000). The summary of freshwater-quality monitoring at ACAD in this section is divided into lake monitoring, stream monitoring, ground-water monitoring, and wetlands monitoring.

Lake Monitoring : Lake monitoring by park staff began in the late 1970's, in cooperation with the Maine Department of Environmental Protection (DEP) to monitor

change due to eutrophication and atmospheric deposition. Monitoring included secchi disk water-column transparency and surface temperature in selected lakes on Mount Desert Island. The program continues today (2004), with monitoring expanded to include measurement of a larger variety of chemical and physical parameters including pH, specific conductance, temperature and dissolved oxygen profiles, alkalinity, and color (Breen and others, 2002). Some of the lakes also have been analyzed for concentrations of chlorophyll-a, total phosphorus, light penetration, and total nitrogen.

Stream Monitoring: Two active USGS continuous-record, streamflow gaging-stations are in the park: Cadillac Brook near Bar Harbor, Maine (USGS station 01022835), and Hadlock Brook near Cedar Swamp Mountain near Northeast Harbor, Maine (USGS station 01022860). Both have been gaged from 1999 through the present (2004). All other stream discharge measurements were one-time measurements or estimates related to specific projects (Kahl and others, 2000).

Water-quality parameters including benthic macroinvertebrates, habitat characterization, stream temperature, pH, dissolved oxygen, specific conductance, color, and flow rate have been measured since 1997 on Duck Brook, Stanley Brook, Canon Brook, and Hunters Brook, and since 1998 on Lurvey Spring Brook and Heath Brook (Breen and others, 2001). This monitoring has been conducted by park staff in cooperation with the Maine DEP. This water-quality information provides baseline information on numbers and diversity of macroinvertebrates in six ACAD streams, representing a range of sizes and levels of anthropogenic impacts.

Ground-Water Monitoring: The USGS, in cooperation with ACAD, installed four ground-water wells in 2003 to monitor water levels and water quality. Two are near

Southwest Harbor, and two are near Bar Harbor (USGS well numbers 441516068194101, 441650068210801, 442238068154101, and 442450068175201, respectively). Three of these wells are within park boundaries.

Wetlands Monitoring: Development of a freshwater wetland monitoring protocol for Acadia National Park was proposed in 2003 (H. Neckles and G. Guntenspergen, U.S. Geological Survey, oral commun., 2003). The freshwater wetland monitoring protocol project will produce an operational wetland monitoring protocol for ACAD by 2006, and provide a model that can be used in other NETN parks.

WATER-QUALITY AND WATER-QUANTITY RESEARCH

A summary of freshwater-quality research projects through 2000 is presented in Acadia's Water Resources Management Plan (Kahl and others, 2000). The plan summarizes hydrological, chemical, and biological projects conducted on streams, lakes, and ground water in ACAD. The following summary primarily documents water-quality research that has been conducted since that time and is divided into research related to lakes, streams, ground water, wetlands, and other.

Lake Research: In 1995 and 1998, a comprehensive assessment of the chemistry of more than 24 lakes in ACAD was conducted. The sampling complemented work done in 1982-1984 by Kahl and others (1985), and provided the post-Clean Air Act Amendments status for the lakes sampled during the early 1980s, a period of high atmospheric deposition.

Stream Research: Hydrologic data, including continuous streamflow and water chemistry, collected in 14 small watersheds on Mount Desert Island was recently published by the USGS (Nielsen and others, 2002). These data include nutrients, major

ions, some metals, and basic water-quality parameters including dissolved oxygen, temperature, and pH from 1999 to 2001. A water budget for and nitrogen loads to Northeast Creek has been recently published (Nielsen, 2002b).

Stream-related research at the park that is being conducted by ACAD in collaboration with the George J.Mitchell Research Center at the University of Maine includes the following topics: (1) a sampling of Hadlock and Cadillac Brook 1998-02, inferring regional patterns and responses in nitrogen and mercury biogeochemistry using paired-watersheds; (2) correlating predictive contaminant deposition maps with streamwater chemistry at Acadia National Park including the monitoring of Hadlock and Cadillac Brook and developing an atmospheric deposition model for 2002-2005; (3) correlating predictive contaminant deposition maps with streamwater chemistry at ACAD; and (4) the impact of vehicle traffic on water quality in ACAD.

In addition, in 1999 and 2000, 44 stream sites at Acadia National Park were sampled for major-ions and total mercury concentrations to determine whether mercury concentrations were related to watershed conditions, including the fire of 1947, and relative discharge. The project provides baseline mercury data for the Park and general water chemistry for sites that had been sampled in the early 1980s (Peckenham and others, 2004).

Ground-water Research: In a recent USGS publication, Nielsen (2002a) estimated the quantity of water in fractured bedrock units on Mount Desert Island, and provided an estimate of ground-water use and recharge and dilution of nitrogen in septic waste in Bar Harbor. The four ground-water wells installed in 2003 (see ground-water monitoring section) will provide data necessary for ground-water hydrology projects in the park

including a ground-water degradation project to examine the significance of ground-water related nutrient enrichment to Bass Harbor and Northeast Creek, and a ground-water wetlands project to examine the hydrologic relations between freshwater wetlands and the underlying ground-water-flow systems.

Wetlands Research: A comprehensive study to describe the size and distribution of the freshwater wetlands at ACAD included information about wetland soils, hydrology, vegetation, fauna, and ecological and cultural value (Calhoun and others, 1994). Current freshwater wetland-related research projects being conducted in collaboration with the USGS at Acadia include a project developing indicators of freshwater wetland integrity (G. Gunterspergen and H. Neckles, U.S. Geological Survey, oral commun., 2003), and a project to determine wetland susceptibility to hydrologic stresses at ACAD (M.G. Nielsen, U.S. Geological Survey, oral commun., 2003).

Other: Park Research and Intensive Monitoring of Ecosystems (PRIMENet) is a cooperative program between the USEPA and the NPS to assess the ecological effects of atmospheric deposition of nitrogen and mercury in watersheds. The program includes the sampling of Hadlock and Cadillac Brooks from 1998 to 2000 at ACAD for mercury and nitrogen, and involves air-quality monitoring of ozone, wet and dry deposition, visibility, meteorology, and Ultraviolet-B (UVB) monitoring to assess the potential impacts of UVB on amphibian populations (Acadia National Park, 2000).

Geographic Information System (GIS) Applications : ArcView databases at ACAD include shoreline, lakes, streams, watersheds, soils, vegetation, land use/ownership, wetlands, topography, roads, and trails for park lands and surrounding environs. A

watershed atlas is being developed to link water quality and spatial data and allow analysis of the effects of watershed characteristics on water quality.

Current and Emerging Threats to the Freshwater Aquatic Ecosystem

Acadia's ponds are generally oligotrophic (nutrient poor) and low in alkalinity. There are a few examples of lakes with acidification due to atmospheric deposition and (or) organic matter (Kahl and others, 2000). High levels of mercury are an issue in many lakes and streams. All freshwaters are listed as impaired by the state due to the presence of elevated mercury levels in fish tissue from atmospheric deposition. An additional concern in many wetland systems is the occurrence of amphibian diseases.

Ground water is generally of sufficient quantity and quality for domestic use, although increased development could affect the sustainability of water quantity and the level of water quality due to increased nitrogen/nitrate concentrations in the future (Nielsen, 2002a). High concentrations of radon-222 in the ground water, although naturally occurring, are a potential human health issue.

Additional water-resources issues of concern to ACAD park management include water-quality impacts of development, visitor use and boat discharges, hazardous waste spills, fisheries management including impacts of non-native fish on the integrity of native aquatic ecosystems, and the management and protection of wetlands and riparian zones.

Boston Harbor Islands National Recreation Area

Boston Harbor Islands National Recreation Area (BOHA) includes 34 islands that lie within the large "C" shape of Boston Harbor. The land mass of the park totals approximately 1,600 acres. Although BOHA is part of the NETN, it also has been

included in the Coastal Barrier Network because it shares many management concerns with the coastal parks. In-depth descriptions of the estuarine and marine wetlands and threats to these resources can be found in the Coastal Barrier Network Scoping report (M.J. James-Pirri, University of Rhode Island, written commun., 2003). Maps and conceptual models for BOHA are not included in this scoping report.

A total of 1,276 acres of wetlands were inventoried for BOHA (Tiner and others, 2003). These wetlands are dominated by marine and estuarine intertidal types, which are predominately non-vegetated unconsolidated shores (i.e., tidal flats). In addition to the tidal flats, 82 acres of estuarine vegetated wetlands (i.e., salt/brackish marshes), 87 acres of intertidal blue mussel reefs, and 31 acres of freshwater wetlands were inventoried. Most of the freshwater wetlands are small ponds. The BOHA wetlands perform numerous functions including surface-water detention, sediment retention, coastal storm surge detention and shoreline stabilization, fish and shellfish habitat, and waterfowl and waterbird habitat (Tiner and others, 2003).

Palustrine (Freshwater) Wetlands: Palustrine wetlands occur in areas where the salinity, due to ocean-derived salts, is less than 0.5 parts per thousand (Cowardin and others, 1979). Within the national park recreation area, these are limited to a few small areas of freshwater marsh and (or) small ponds on Deer Island, Thompson Island, World's End, Long Island, Lovells Island, and Great Brewster Island (Tiner and others, 2003). Although small in area, these freshwater resources may be of significant biological value. For example, Ice Pond, a small, shallow pond at World's End is the only surface freshwater source on the island.

Ground-water Resources: In 1996, the USGS conducted a geohydrologic investigation to assess the potential for water-supply development for six of the Boston Harbor islands including Bumpkin, Gallops, Georges, Grape, Lovell, and Peddocks Islands (Masterson and others, 1996). The primary purpose of the investigation was to assess the possibility of developing permanent, small-capacity water supplies capable of supporting recreational activities such as hiking, camping, and swimming.

Masterson and others (1996) found that the hydrology of each of the six islands studied was characterized by hydraulically independent freshwater-flow systems that occur in about 10 to 30 feet of weathered till with a dense substratum near the land surface that may perch water. The freshwater-flow systems of each island is underlain by either impermeable bedrock or bedrock containing saltwater, and they also are laterally separated from one another by the saline waters of Boston Harbor (Masterson and others, 1996). Thus, the sole source of freshwater to each of the islands studied is the infiltration of precipitation into the soils of the island.

The amount of precipitation that reaches the saturated zone (recharge) would be expected to vary spatially and temporally in response to climatic factors, such as precipitation, and biologic factors such as evapotranspiration, as well as to the local topography. The recharge rates also would be affected by local differences in the infiltration capacity and other hydraulic properties in the unsaturated zone. Using estimates of recharge rates from previous investigations in similar hydrogeologic settings, Masterson and others (1996) were able to model approximate ground-water flow for the six islands.

Masterson and others (1996) determined that ground-water flow generally is radial from the center of the island towards the coast. Topographically high areas, such as the upper slopes and crests, are typically the recharge areas with downward vertical gradients. Ground-water discharge would typically occur at the lower slope areas of the drumlins, the topographically low areas, such as coastal marshes or ponds, or directly along the coast (Masterson and others, 1996).

WATER-QUALITY AND WATER-QUANTITY MONITORING AND RESEARCH

The U.S. Fish and Wildlife Service (USFWS) NWI Program conducted a comprehensive survey of all coastal, brackish, and freshwater wetlands in the park. Wetland habitats were delineated and mapped on the basis of the national vegetation classification system (Cowardin and others, 1979).

The NPS Water Resources Division identified and analyzed major water-resource issues and management concerns, summarized existing hydrologic information, and developed management recommendations for the Harbor Islands. The work includes water-related environments (ponds, salt marshes, freshwater marshes, tidal flats and pools, and ground water) and water-related infrastructure issues, which occur at or above mean low water level for all 34 islands. The 2-year project was completed in 2002. The report was accepted and the recommendations endorsed by unanimous vote of the Boston Harbor Islands Partnership on December 17, 2002 (Flora, 2002).

Currently (2004), no freshwater-quality monitoring is being conducted in the park. The Massachusetts Water Resource Authority continues its saltwater monitoring of chemical, physical, and biological parameters in Boston Harbor as a part of the regulatory compliance for its new discharge outfall diffuser. The Coastal Barrier scoping report

summarizes this monitoring program in Boston Harbor and the environs (M.J. James-Pirri, University of Rhode Island, written commun., 2003).

GIS wetland data are available for BOHA from the NWI. In 2001, the NPS provided funds to the USFWS to update the NWI maps of BOHA based on the most current available aerial photography, which was 1995 color infrared at 1:40,000 (Tiner and others, 2003). These GIS maps were completed in 2003 and will soon be available via the NWI website (Tiner and others, 2003).

Current and Emerging Threats to the Freshwater Aquatic Ecosystem

Concerns regarding freshwater resources on the islands were identified at a scoping workshop in 2000 (Flora, 2002). The most important freshwater-quality concern identified at this workshop was a lack of baseline information for ponds and freshwater marshes. The major water quantity concern was the lack of adequate freshwater drinking supplies on most of the islands. Infrastructural impacts due to septic systems and sewage disposal are a potential aquatic ecosystem threat (Flora, 2002). Due to the relatively small amount of fresh surface-water resources on the islands, and the logistical problems with monitoring them, there is no immediate plan to initiate freshwater resources monitoring in BOHA. Saltwater resources are the highest priority in BOHA, and thus maps and conceptual models for the islands are not included in this scoping report, but are included in the Coastal Barrier scoping report (M.J. James-Pirri, University of Rhode Island, written commun., 2003).

Marsh-Billings-Rockefeller National Historical Park

MABI was created in 1992 and encompasses 643 acres in the Connecticut River watershed in central Vermont, including 550 acres of forest. Freshwater bodies in the

park consist of a pond (The Pogue) formed by an earthen dam, a perennial stream (Pogue Hole Brook), many intermittent streams, four wetlands, and several seeps (Lautzenheiser, 2002) (fig.4). The Pogue is a 15-acre pond, near the summit of the park that receives water from rainfall and two intermittent streams that flow off the West Ridge near the Pogue's southwestern boundary. Pogue Hole Brook flows eastward out of the Pogue and empties into Barnard Brook outside of the park, which in turn empties into the Ottauquechee River. The Ottauquechee River flows along the eastern boundary of the park and eventually flows into the Connecticut River. Barnard Brook flows close to the northeastern boundary of the park, but is entirely outside the park. Four wetlands east of the Pogue are formed by runoff and ground-water seeps that intermittently drain into Pogue Hole Brook. Additional intermittent streams drain the northern slope of Mt. Tom (Lautzenheiser, 2002).

WATER-QUALITY AND WATER-QUANTITY MONITORING AND RESEARCH

Seven stations were inside the park boundaries during the Baseline Water-Quality Inventory and Analysis conducted in 1997 for MABI (National Park Service, 1997a). None of these stations was considered long-term, (defined as having at least 6 parameters with 1 or more measurement per year over at least 2 years [National Park Service, 1997a]). Four of the stations were established in 1994 by the Water Resources Division of the NPS and had one measurement each of concentrations of total nitrogen, nitrite, fecal coliform bacteria, and phosphorus. The four locations were the Watering Trough, Pogue Hole Brook leaving the cow pasture (identified in the report as the unnamed creek leaving the cow pasture), Pogue Hole Brook entering the cow pasture (identified as the unnamed creek entering the cow pasture), and the Pogue shoreline. Eleven water-quality

parameters were measured at an additional Park Service station at an unnamed spring once in 1977. The USEPA measured concentrations of chloride and chlorine in the summer of 1984 at one station on the Ottauquechee River, and measured a number of water-quality parameters at one station on the Pogue on a single day in 1984.

Currently (2004) no water-quality monitoring is being conducted in the park (C. Marts, National Park Service, oral commun., 2003). The closest streamflow gaging-station is on the Ottauquechee River at North Hartland, Vermont (USGS station 01151500). It has a drainage area of 221 square miles, and a period of daily discharge record from 1930 to the present.

Current and Emerging Threats to the Freshwater Aquatic Ecosystem

MABI is mostly a headwater watershed. Intermittent headwater streams initiate in the park and drain the park (fig. 5). For this reason, no major surface-water ecosystem threats come from outside the park. Potential stressors that could adversely affect water quality in the park include forestry in the park, runoff from visitor use, and *E.coli* bacteria, due to livestock, in Pogue stream. Although no livestock were grazing in the park in 2002 and 2003, they potentially will be grazing in the park in the future. A fence has been constructed so that any future grazing will be outside the channel of the stream (C. Marts, National Park Service, oral commun., 2003).

Although all rivers and lakes in Vermont are on the USEPA's 303(d) list for fish consumption advisory (FCA) because of mercury, neither Pogue Pond nor Pogue Hole Brook are specifically listed on either the 305(b) or 303(d) list for the state.

Minute Man National Historical Park

MIMA is approximately 15 miles northwest of Boston, Massachusetts. It contains 967 acres distributed in three parcels. The North Bridge Unit contains approximately 112 acres, the Wayside Unit contains approximately 6 acres, and the Battle Road Unit contains approximately 849 acres (National Park Service, 2003a). The Concord River flows through the North Bridge Unit. Route 2A traverses the Wayside and Battle Road Units. The park is bordered by Hanscom Civilian Air Field and Air Force Base, privately held land, and a number of public and conservation lands.

The park supports a variety of habitats. Forest is the dominant land cover, covering approximately 500 acres of the park, including about 200 acres of forested wetland. Non-forested wetlands, including several ponds, cover approximately 180 acres. Meadows and fields cover an additional 250 acres, including approximately 100 acres farmed under the park's agricultural leasing program. Shrub land also is present at the park, particularly at the interface of fields and forests. Developed areas including roads, parking lots, and buildings cover the remainder of the park (National Park Service, 2003a).

MIMA includes numerous waterbodies including sections of the Concord River, Elm Brook, Mill Brook, several ponds, and approximately 200 acres of wetlands (fig. 6). The park supports several types of wetlands, including forested wetlands, seasonal ponds, swamps, bogs, and emergent wetlands.

Water-Quality and Water-Quantity Monitoring and Research

The Baseline Water-Quality Data Inventory and Analysis (National Park Service, 1996) does not include any water-quality or quantity monitoring sites in the park. For

this reason, a level I water-quality inventory was conducted in 1999 by the NPS (Farris and Chapman, 2000a).

A nutrient TMDL evaluation was conducted from June 2001 through September 2002 on the Concord River (ENSR, 2003). Measurements of the hydrology, water quality, and aquatic biology of the Concord River were conducted in 12 surveys. Although no sites were inside the park boundaries, one site was in Concord, just outside the boundary.

A rapid bioassessment using macroinvertebrates was conducted at Mill Brook in Concord in 1996 (Art Johnson, Maine Department of Environmental Protection, oral commun., 2003). The Organization for the Assabet River has monitored water quality since 1992 on the Assabet River in the lower reach, just upstream from the confluence with the Sudbury River (where it becomes the Concord River) below Dakins Brook. See http://www.assabetriver.org/wq/ for data and annual reports.

No water-quality or quantity monitoring is currently (2004) taking place inside the park (Chris Davis, National Park Service, oral commun., 2003). There is a USGS streamflow gaging-station on the Concord River below River Meadow Road at Lowell, Massachusetts (USGS station 01099500), which is downstream from the park. Its drainage area is 400 square miles, and its period of record is 1936 to the current year. Low flows are regulated by dams associated with upstream mills.

Current and Emerging Threats to the Freshwater Aquatic Ecosystem

Stressors affecting water quality at the park include road runoff, agricultural practices, residential developments, and industrial deposition of heavy metals (fig. 7). Leachate from septic systems both inside and outside the park pose a threat to water quality. There

are Superfund sites upstream from the Concord River (North Bridge Unit) on the Assabet and Sudbury Rivers (Chris Davis, National Park Service, oral commun., 2003).

Nutrient loading due to industrial and residential development, including septic systems, municipal waste, and lawn chemicals is the main water-quality issue in the park according to the Level I survey (Farris and Chapman, 2000a). Agricultural and industrial runoff also are concerns.

The Baseline Water-Quality Data Inventory and Analysis showed that sites outside the park boundaries on the Concord River and its tributaries occasionally exceed USEPA water-quality criteria for dissolved oxygen, pH, and dissolved copper. Total coliform and fecal coliform concentrations exceeded screening limits for freshwater bathing (National Park Service, 1996). The results of the TMDL investigation indicate that the Concord River is eutrophic. It receives enough phosphorus and nitrogen to support the growth of aquatic vegetation at a level that impairs water quality and designated uses (ENSR, 2003).

The Concord River is listed on Massachusetts' State 303(d) List from the confluence of the Assabet and Sudbury Rivers to Billerica, which includes the section of the river that flows through the park's North Bridge Unit. Pollutants of concern noted on the 303(d) list are metals, nutrients, and pathogens (National Park Service, 2003b). Elm Brook is on the 305(b) list, with nutrients, pathogens and turbidity listed as impairments. All rivers and lakes in the state are on the 303(d) list for Fish Consumption Advisory (FCA) mercury.

Morristown National Historical Park

Morristown National Historical Park (MORR) is 30 miles west of New York City. It contains approximately 1,711 acres and is made up of four separate units. The Jockey

Hollow Unit is 1,320 acres, the New Jersey Brigade Unit is 321 acres, the Washington's Headquarter Area is 10 acres, and the Fort Nonsense Area is 35 acres. Significant waterbodies in MORR include parts of the East and West Branches of Primrose Brook and Jersey Brook in the Jockey Hollow Unit, and parts of the Upper Passaic River and Indian Grave Brook in the New Jersey Brigade Units (fig.8). The Washington Headquarters area and Fort Nonsense Area are not shown on figures 8.

Although most of the springs that contribute water to Primrose Brook surface in the park near Sugar Loaf and Mount Kemble, the source spring of the East Branch Primrose Brook is in an area known as Military Hill, on private land just outside the northeastern boundary of the park. The 0.25-mile-long headwaters of Jersey Brook, a tributary of Primrose Brook, originate from springs in the southwestern part of the Jockey Hollow Unit. The Upper Passaic River is impounded at Leddell's Pond about 1 mile before it passes through this unit (National Park Service, 2003c).

The Jockey Hollow Unit and the New Jersey Brigade Unit are in the upper reaches of the 55.6-square miles Great Swamp watershed, a subunit of the Upper Passaic River Basin. The park includes major tributaries to the Great Swamp National Wildlife Refuge and important sources of drinking-water supply for the region. Passaic River and Primrose Brook are designated as waters of statewide importance and ecologically linked to the Great Swamp National Wildlife Refuge, and other parts of the Upper Passaic River watershed (National Park Service, 2003c).

A small artificial pond, Cat Swamp Pond, and two small marshes also are in the upper Primrose Brook drainage. Cat Swamp Pond is a remnant of the water collection and storage system that was built as part of the Morristown Aqueduct Water System. The

pond is surrounded by a construction berm and has no natural surface-water drainage. Its water level is maintained by the water table. Although the pond has no natural surface-water outlet, it is connected to East Branch Primrose Brook by an overflow outlet pipe along the eastern edge of the berm. Another small marsh is found adjacent to Indian Grave Brook in the New Jersey Brigade unit.

Many small wetland and riparian areas in the park are associated with streams and minor tributaries and make up approximately 64 acres based on indicator plants such as skunk cabbage. The most extensive riparian areas in the Jockey Hollow Unit border Primrose Brook. Wetland and riparian areas are found along the flood plain of Indian Grave Brook in the New Jersey Brigade unit. A small forested wetland lies at the intersection of Indian Grave Brook and a small feeder stream that runs southwest from Patriots Path.

Aquifers provide the primary water supply to many of the communities around the park. The Precambrian gneiss that underlies the park is fairly impermeable to water but does contain ground water in scattered locations. Park visitor facilities, administrative buildings, and seven park residences rely on drilled wells for water supply. Both the Jockey Hollow and New Jersey Brigade Units contain numerous natural springs and seeps emanating from a shallow aquifer (Mele and Mele, 1983).

WATER-QUALITY AND WATER-QUANTITY MONITORING AND RESEARCH

A water resources scoping report was completed by MORR in 1993 (National Park Service, 1993). The report summarizes water resources in the park, monitoring that has been completed, and proposed water-resource-related monitoring. Furthermore, an aquatic biologist with the NPS is in the process of evaluating all water-quality data in the

park (Jeff Runde, National Park Service, oral commun., 2003). These sources should be consulted before any water-quality monitoring plans are initiated.

The results of the retrievals for the MORR study area from the Baseline Water-Quality Data Inventory and Analysis include four industrial/municipal dischargers, no drinking water intakes, one USGS gaging station, and 787 observations for 64 separate water-quality parameters collected by 4 federal and state government agencies at 6 water-quality stations (National Park Service, 1994a). No stations are within the park boundary. Most of the sampling stations represent either one-time or intensive single-year sampling efforts by the collecting agencies. One station 500 feet downstream from the outlet of Pocahontas Lake (NPS Station MORR 0006) has long-term records consisting of multiple observations for several important water-quality parameters. STORET data exist for all Level I parameter groups in the study area except for the USEPA priority toxic pollutants. Limited data were retrieved for most of the required chemical parameters. All data were collected before 1985.

Mele and Mele (1983) conducted quarterly monitoring of fecal coliform bacteria at five stream locations from the fall of 1982 through the fall of 1983. Selected physical, chemical and biological characteristics of the five major stream systems in MORR were monitored quarterly from the summer of 1986 through the summer of 1987 (Trama and Galloway, 1988).

A 1992 water-quality inventory, Macroinvertebrate Sampling Study (United States Department of Agriculture, 1992), with one sampling site for Primrose Brook near the park boundary was conducted by the U.S. Department of Agriculture Natural Resources Conservation Service.

The Great Swamp Watershed Association completed a watershed management plan with several water-quality monitoring sites measured downstream from the park in the Great Brook, Primrose Brook, and Passaic River watersheds. Water-quality parameters were measured between 1999 and 2001.

A section of the Passaic River that runs through the New Jersey Brigade Unit is the only part of the park lying within a 100-year flood plain (National Park Service, 2003c).

Currently (2004), the park monitors key water-quality parameters including temperature, pH, conductivity, and salinity; and concentrations of dissolved oxygen, chloride, total dissolved solids, and fecal coliform on a monthly basis at 11 stations. The confluence of the East and West Branches of Primrose Brook is used as a water-quality monitoring site by several state and federal agencies including the USFWS and USGS. The State of New Jersey, Department of Environmental Protection, Division of Watershed Monitoring, conducts macroinvertebrate sampling on the West Branch of Primrose Brook near the Trail Center parking lot (National Park Service, 2003c). Dr. Lee Pollock, of Drew University, is studying the number and variety of macroinvertebrates, as indicators of the water quality of a stream. Dr. Neil Borman, of the College of St. Elizabeth, is measuring bacterial concentrations along Loantaka Brook, including Kitchell Pond.

The USFWS initiated a program in 1991 to monitor 15 physical, chemical, and biological parameters at 16 sites in the Great Swamp Watershed (Chalmers and Skutnik, 1997). One site (FWS station ID 165) is on Primrose Brook (NPS Station E-1) in the park. This is an excellent baseline water-quality site because it is relatively unimpacted and represents natural conditions.

The New Jersey Department of Environmental Protection and Energy has recently initiated a Level II Rapid Bioassessment Program throughout New Jersey including several sites along the Upper Passaic River, Indian Grave Brook, and Primrose Brook (National Park Service, 1993).

A USGS gage (station 01378690) on the Passaic River near Bernardsville, New Jersey, just downstream from the park has historical flow record, but is not currently in operation. It had a drainage area of 8.83 square miles and was gaged from 1965-1971. Two stage-gages were installed at the confluence of the East and West Branch of Primrose Brook in 2003 (USGS station 01378775 and USGS station 01378778). The closest continuous-record streamflow gaging-station is on the Passaic River near Millington, New Jersey (USGS station 01379000) with a drainage area of 55.4 square miles.

The USGS has installed a National Water-Quality Assessment (NAWQA) site to assess surface water and groundwater in the region of New Jersey that includes MORR.

Current and Emerging Threats to the Freshwater Aquatic Ecosystem

Fecal coliform is a considerable ecosystem threat in the park (Robert Masson, National Park Service, oral commun., 2003). Development just outside the park, including the construction of townhouses, is a concern to Park Service staff. A part of the park also is downstream from a Girl Scout camp on the Passaic River. Additional sources of nonpoint-source pollution include highway runoff (total suspended solids, heavy metals, hydrocarbons, and road salts); application of fertilizers, pesticides, and lime to lawns, gardens and golf courses; septic system leachate from visitor facilities, administrative

buildings, and employee residences in the park; new and existing development surrounding the park; and leaking underground petroleum-storage tanks (fig. 9).

The results of the MORR water-quality criteria screen for the baseline water-quality report completed in 1994 (National Park Service, 1994a) found three parameters that exceeded screening criteria at least once in the study area. The pH exceeded the USEPA criteria for the protection of aquatic life. Indicator bacteria (total coliform and fecal coliform) concentrations exceeded NPS Water Resources Division screening limits for primary body-contact recreation.

The pH was measured 35 times at 5 monitoring stations in the study area (but outside the park boundary) from 1965 through 1980. Two observations were outside the pH range of 6.5 to 9.0 (USEPA criteria for freshwater aquatic life). Total coliform and fecal coliform concentrations were determined 23 and 22 times, respectively, at 3 monitoring stations from 1969 through 1980. Twelve observations exceeded the 1,000 most probable number/ colony forming units (MPN/CFU) per 100 mL total coliform criteria, and the 200 MPN/CFU per 100 mL fecal coliform criteria. The criteria were exceeded at three stations in Indian Grave Brook and the Whippany River (MORR 0002, MORR 0005, MORR 0006).

Based on the few data inventories and analyses contained in the baseline report, surface waters in the MORR study area generally appear to be of good quality, with some indications of effects from development. Results indicate that the streams in the park generally show very good to excellent water quality, and are well-oxygenated at all times, neutral in pH, low to moderate in alkalinity, and contain low to moderate nutrient concentrations. Concentrations of total suspended solids, total dissolved solids, and

chloride, and specific conductance were relatively low in all streams, but were slightly higher in Jersey Brook, Indian Grave Brook, and the Passaic River than they were in Primrose Brook (Trama and Galloway, 1988). Increases in these parameters may be associated with the proximity of Tempe Wick Road to Jersey Brook and the low-density residential development in the uppermost reaches of the Upper Passaic and Indian Grave Brook subwatersheds.

Fecal coliform bacteria levels in some locations in the park exceed standards determined by the State of New Jersey Ground-water and Safe Drinking Regulations. (Trama and Galloway, 1988). In the early 1990s, the park closed a public potable water source at the Pennsylvania Line parking lot due to continual high levels of fecal coliform. The source of bacteria found in the water samples of this study was determined to be fecal matter from warm-blooded animals. The park does not have any untreated public drinking sources, and there are no official areas for swimming.

Trama and Galloway (1988) reported very low concentrations of total recoverable aluminum in the stream water that would not pose a threat to aquatic life. Further analysis revealed high aluminum content in local soils. Although it is unlikely that the aluminum poses a threat to aquatic organisms, aluminum from the soil, if mobilized, could affect both water quality and aquatic biota. The water in Cat Swamp Pond is tannin-stained and has a heavy influx of leaf litter and a negligible rate of water exchange.

The New Jersey Surface Water-Quality Standards (as amended, May 1998) designate all surface waters of the park as trout production freshwaters. None of the waterbodies flowing through the park are on USEPA's 305(b) or 303(d) lists for the state.

Primrose Brook and the section of the Passaic River that flows through the park are also recognized by the state of New Jersey as Category One "Antidegradation" Waters. One of the highest-quality streams in the Great Swamp watershed, Primrose Brook, is the least human-influenced stream in the park (Trama and Galloway, 1988).

The good water quality generally found in the streams flowing through the park can be attributed largely to the upper watershed location of the Jockey Hollow and New Jersey Brigade Units. No permitted National Pollutant Discharge Elimination System discharges are known to occur into any of the streams upstream from the park.

Roosevelt-Vanderbilt National Historic Site

NPS sites in Hyde Park, New York, include the Home of Franklin D. Roosevelt, the Vanderbilt Mansion, and Eleanor Roosevelt National Historic Site (also referred to as Val-Kill). Collectively, these are called Roosevelt-Vanderbilt National Historic Site (ROVA) and total 682 acres. Both the Home of Franklin D. Roosevelt and Vanderbilt Mansion National Historic Sites border the Hudson River. The river is tidal from the coast to a dam at Troy, New York, 75 miles to the north. The estuary provides a marine influence far inland, resulting in unique plant communities and animal species.

The aquatic resources of ROVA consist of 4.35 miles of streams, 14 acres of permanent ponds, 40 acres of non-tidal wetlands, and numerous small, unmapped vernal pools and intermittent streams. Major rivers in the park include Fall Kill in the Eleanor Roosevelt NHS, Crum Elbow Creek in the Vanderbilt Mansion NHS, and Meriches (Maritje) Kill in the Franklin D. Roosevelt NHS (fig.10). A 25-acre tidal marsh lies between the Home of Franklin D. Roosevelt NHS and the Hudson River (National Park Service, 2003d).

The Fall Kill, the major stream at the Eleanor Roosevelt NHS, flows from north to south through Hyde Park. The damming of Fall-Kill Creek by the Roosevelt family in 1925 created a 7-acre wetlands complex at Eleanor Roosevelt NHS. This pond/wetland area has silt deposits of as much as 4 ft (Pandullo-Quirk Associates, 1979). A series of permanent and seasonal woodland ponds occur on the site, as well as mature second-growth hardwood forest, numerous rock outcrops, a sphagnum swamp, and a wet sedge meadow. The streams at Val-Kill are low gradient.

The New York Department of Environmental Conservation is the agency responsible for protecting and regulating water resources in New York state. Under state law, waterbodies must meet specific water-quality criteria based on their rating in a classification system. All waters in the park are classified as Class C (suitable for fish propagation and fishing) or Class D (suitable for fishing). At present, all park streams currently rated Class D have been proposed for upgrading to Class C (National Park Service, 2003d).

WATER-QUALITY AND WATER-QUANTITY MONITORING AND RESEARCH

The park initiated a water-quality monitoring program in 1994. Basic data such as temperature, pH, dissolved oxygen, salinity, and conductivity are being collected at all three units on a monthly basis. Data on additional parameters, including concentrations of chloride, phosphate, and nitrate, and measurements of turbidity and alkalinity, are being collected quarterly. Starting in 1998, this work has been contracted to a laboratory (National Park Service, 2003d).

The Baseline Water-Quality Data Inventory and Analysis search of ROVA (National Park Service, 1995a) resulted in information on 11 water-quality stations within the three

units that make up the park; all were NPS monitoring stations. Eight of these stations were at the Eleanor Roosevelt NHS. Six of the eight stations are on Fall Kill, a tributary of the Hudson River; one is on a pond of Fall Kill, and one is on a wetland near the park caretaker's house. Five of these stations (including the pond and the wetland) were sampled seven times in 1978-1979, and the remaining three stations were sampled seven times in 1994-1995. Dissolved-oxygen concentrations were below the USEPA criteria for the protection of aquatic life one time at each of four stations. pH exceeded USEPA criteria for freshwater aquatic life one time at each of three stations. The highest reported pH was 11.3 in Fall Kill site two (National Park Service ROVA06) in February 1995. Total chloride concentration exceeded the USEPA drinking-water criteria at the pond on Fall Kill in December 1978 (National Park Service, 1995a). Two sites on Meriches Kill in the Franklin D Roosevelt NHS and two sites on Crum Elbow Creek in the Vanderbilt Mansion NHS were measured for pH as many as seven times from 1994 to 1995. The pH for one observation at each site exceeded USEPA criteria for freshwater aquatic life.

Eleanor Roosevelt NHS has more data than the other two sites in ROVA, including data on water quality and aquatic biological resources (Pandullo-Quirk Associates, 1979); however, these data are 11 years old. Although the 1979 data were not collected in a way to provide evidence to justify a classification upgrade, Fall-Kill Creek met the water-quality standards for Class A streams (suitable for drinking and all other uses) at the time of collection. Any effort to upgrade stream classification would require additional data collection. William Bode with the Water Division of the Department of Environmental Conservation in Albany completed two macroinvertebrate studies in the park (David Hayes, National Park Service, oral commun., 2003).

A bathymetric study of the impounded part of Fall-Kill Creek was conducted by Pandullo-Quirk Associates (1979). Water-quantity data are not available for Vanderbilt Mansion NHS or for the Home of Franklin D. Roosevelt NHS. The closest streamflow gaging-stations that are still in continuous operation are Rondout Creek at Rosendale, New York (USGS station 01367500) and Wappinger Creek near Wappingers Falls New York (USGS station 01372500) with drainage areas of 383 and 181 square miles respectively. There was a streamflow gaging-station on Crum Elbow Creek at Hyde Park New York with a drainage area of 17.3 square miles that was in operation from 1960-1962.

Currently, there is an effort to restore Val-Kill Pond, which was created by a dam. An environmental assessment for this effort has been initiated, and water-quality monitoring for this project probably will be done by Park Service staff.

Current and Emerging Threats to the Freshwater Aquatic Ecosystem

Water quality in the park is considered good. The major potential polluters of park waters are municipal water treatment plants, leach field runoff from nearby homes, salt used in road maintenance, agricultural runoff, and the release of toxic material from industrial or commercial facilities (fig. 11). Contamination of private wells along Haviland Road (north of Val-Kill) by benzene, a petroleum compound, has occurred. It is possible that the material could enter either the natural or domestic water supplies at Val-Kill. There are currently no water-quantity issues in the park. Flow levels are adequate to preserve natural processes and cultural features. There are no known flow reductions by upstream landowners.

Septic systems and residential development are a considerable threat to water quality at the park, according to David Hayes (National Park Service, oral commun., 2003). Most of the 25,000 people in Hyde Park have houses with septic systems, which may be contributing to eutrophication of the surfacewater. Agriculture is much less of an issue, as there is only one active farm left on the western edge of Hyde Park. None of the waterbodies flowing through the park are on USEPA's 305(b) or 303(d) lists for the state.

Saint-Gaudens National Historic Site

SAGA is a 150-acre rural park approximately 15 miles south of Lebanon in Cornish, New Hampshire. Freshwater bodies inside the park boundaries include Blow-Me-Down Brook, Blow-Me-Up Brook, Blow-Me-Down Pond, wetlands surrounding Blow-Me-Down Pond, and a farm pond (fig.12). Roughly half of the park is bordered by stream and pond habitats. Blow-Me-Up Brook winds along the northern edge of the property through steep ravines before it merges with the larger Blow-Me-Down Brook, which then flows into Blow-Me-Down Pond. Both Blow-Me-Down Pond and the farm pond are manmade and have impoundments at their outlets. Blow-Me-Down Pond is 5-acre body of water and water depths are 7-8 ft by the dam and average 3.8 ft over the pond as a whole (Cronan and Associates, 1981).

WATER-QUALITY AND WATER-QUANTITY MONITORING AND RESEARCH

A Baseline Water-Quality Data Inventory and Analysis for SAGA was completed in August 2000 (National Park Service, 2000). This inventory of data in STORET shows that historic water-quality monitoring in the park has been sporadic and(or) one-time efforts. There are 13 surface-water locations and one ground-water well where water-quality monitoring has occurred. The USGS has two historical stations in the park-- a

surface-water-quality station on Blow-Me-Up Brook where 27 water-quality parameters were measured one time in 1967 and a ground-water well where 86 water-quality parameters were measured one time in 1988 (U.S. Geological Survey, 2003).

Cronan and Associates (1981) mapped the pond bathymetry and the wetlands and measured approximately 13 water-quality parameters four times during 1 year at six locations in the park in 1980. The NPS measured 22 water-quality parameters in the discharge from Blow-Me-Down Pond from 1 to 3 times each from 1982 to1991 (Roman, 1992). The Soil Conservation Service mapped the 10-, 100- and 500-year flood plain of Blow-Me-Down Pond in 1977. A water-resources monitoring study plan by Brenan Zubricki was completed in 1995 (Zubricki, 1995).

Currently (2004), the NPS has a water-quality monitoring program in place at five stations inside the park and one station just upstream from the park on Blow-Me-Down Brook. Inside the park, three stations are on Blow-Me-Down Brook, one station is on Blow-Me-Up Brook, and one station is on Blow-Me-Down Pond. This network has been in place since 1997; data from this network are reported annually (Walasewicz, 2002). Fifteen to twenty water-quality parameters, including water temperature, water depth, dissolved oxygen, conductivity, pH, and turbidity are measured monthly at all stations from May to November. Instantaneous discharge is measured monthly at three stations in the park from May to November. Inorganic nutrients (nitrogen and phosphorus) are measured monthly from June to November. Fecal coliforms are measured three times at four stations and biological assessments (The Izaak Walton League of America's Stream Quality Surveys) are conducted four times at four stations each year. These data and the annual report are all prepared and reviewed internally by SAGA park staff.

The closest active continuous-record streamflow gaging-station is the Ottauquechee River at North Hartland, Vermont (USGS station 01151500). This station is approximately 5 miles north of park, has a drainage area of 221 square miles, and a period of record from 1930 to the present (2004). The Sugar River at West Claremont, New Hampshire (USGS 01152500) is approximately 10 miles south of park, has a drainage area of 269 square miles, and a period of record from 1928 to the present (2004).

Current and Emerging Threats to the Freshwater Aquatic Ecosystem

Roman (1992) identified increased residential and commercial development in the watershed and atmospheric-deposition effects documented in the vicinity (i.e. Hubbard Brook) as potential threats to the aquatic ecosystem in the park (fig.13). Both Blow-Me-Up Brook and Blow-Me-Down Brook have headwaters adjacent to land uses such as residential septic systems, agriculture, logging, and development (Cronan and Associates, 1981; Walasewicz, 2002). Significant use of deicing chemicals on Route 12A and other areas also may pose a threat to SAGA aquatic resources (Cronan and Associates, 1981; Walasewicz, 2002). Blow-Me-Down Brook has been stocked with several thousand brook trout per year for the past 40 years, but there is little evidence of a sustained trout fishery, indicating that there is a close balance between stocking and removal and mortality (Cronan and Associates, 1981). There are no known industrial dischargers in or upstream from the park.

Cronan and Associates (1981) found relatively high levels of coliform bacteria and fecal streptococci. Biological health of the park's aquatic resources produced index values indicating that on average, the streams are in the upper end of the "fair" condition

category (Walasewicz, 2002). No waterbodies in the park are currently listed on the USEPA's 303(d) or 305(b) lists for the state.

Saugus Iron Works National Historic Site

SAIR is a 9-acre park in eastern Massachusetts on the Saugus River in the town of Saugus. The Saugus River watershed extends approximately 45 miles and encompasses the park and several neighboring towns. The park area is a glacial outwash plain in the Boston Basin.

The Saugus River at SAIR is a tidally influenced perennial stream at the head of a riverine estuary with a watershed of 23.3 square miles. A small segment of the river and wetland surrounding it make up a large part of SAIR (fig. 14). The tidal influence is 1 ft, with storm surges to approximately 3 ft. A dam breach in 1957 caused a massive amount of silt and sediment to alter the river's open water condition at the industrial area that is now the NHS, and created a wetland marsh (National Park Service, 2003e).

Two freshwater springs are in the park. A natural spring yielding 35 gallons per minute and a well, fed from a second natural spring yielding 5 to 6 gallons per minute, are near the industrial buildings (National Park Service, 2003e).

Water-Quality and Water-Quantity Monitoring and Research

The USGS maintains a streamflow gaging station just north of the park, Saugus River at Saugus Iron Works (USGS station 01102345) (U.S. Geological Survey, 2003). The period of record for this site is 1994 to present (2004) and the drainage area is 23.3 miles. Stage, discharge, specific conductance, air and water temperature, precipitation, wind speed, and wind direction are currently reported in real time on the USGS website (http://waterdata.usgs.gov/ma/nwis/). In 2001, a cooperative project between the NPS and

the USGS was conducted to update the existing streamflow gaging station to provide real-time flow data. A weather station was installed on the site's museum roof to work in conjunction with the updated streamflow gage to provide environmental information on the Saugus River Watershed. The weather station does not meet National Weather Service standards for station location, but is used by the Park for interpretive work. The USGS conducted discrete water-quality testing including concentrations of organic compounds, major, minor and trace inorganic compounds, physical properties, and radiochemicals between 1994 and 2001 (http://waterdata.usgs.gov/ma/nwis/).

Water-quality testing along the Saugus River, and specifically at SAIR's stone bridge over the Saugus River, has been conducted monthly (May through October) since 1998 by the Saugus River Watershed Council. Parameters sampled include bacteria, pH, turbidity, and dissolved oxygen (Joan LaBlanc, Saugus River Watershed Council, written commun., 2003).

In 1989 through 1990, Hudsonia Limited conducted a baseline assessment of the Saugus River system (Tashiro and others, 1991), analyzing physical, chemical and biological parameters from 10 stations along the river, including one station at Saugus Iron Works that had been documented by Sandy Wignot (SAIR seasonal Park Ranger), in a student report "Baseline Water-Quality Data for the Saugus River" in spring 1988.

The Massachusetts Division of Water Pollution Control assessed water quality of the Saugus River at 12 sampling stations in 1982. The Army Corps of Engineers sampled the estuarine reaches (lower 4.7 miles) during the period 1982-1984 and again in 1986 (U.S. Army Cops of Engineers, 1989).

Massachusetts DEP conducted an extensive water-quality assessment of the North Coastal Basin in Massachusetts, including the Saugus River Basin (Massachusetts Department of Environmental Protection, 1998). Massachusetts DEP collected background water-quality data and macroinvertebrate samples during 1997 and 1998. One sampling location was just east of the park.

Environmental consultant firm, Gomez and Sullivan completed a Saugus River water budget and instream flow study in 2002 for the Massachusetts Department of Environmental Management (Gomez and Sullivan, 2002) in order to evaluate the relation between streamflow regulation in the Saugus River and aquatic habitat needs. The section of the river that runs through SAIR is included.

The following summary describes various surveys, analyses, and reviews of the contaminated sediments in NHS area (Daniel Noon, National Park Service, written commun., 2003): In November 1993, Goff-Chem, Inc. collected three soil cores at five depths near the dock and slag pile (Goff-Chem, Inc, 1994). The metal concentrations for this area generally exceeded "average" geologic concentrations, suggesting an anthropogenic source. Arsenic concentrations exceeded Imminent Hazard criteria at depths of 3.0 and 5.0 feet (Woodard and Curran environmental Services, 1995).

In addition, an initial site investigation was conducted by Goff-Chem, Inc. (1996). This investigation included sediment samples from the wetland and slag pile, well borings, and water-quality samples. The study concluded that the wetland on the western side of the Saugus River is contaminated with polyaromatic hydrocarbons, the slag pile has arsenic levels above the Imminent Hazard threshold, and that particulate from the slag pile is the likely source of arsenic in the wetland (Goff-Chem, 1996).

The USGS, in cooperation with the Massachusetts DEP, is currently conducting a study to sample sediments for heavy metals in eight coastal-Massachusetts locations (R.F. Breault, USGS, written comm, 2003). One of the sediment samples was collected on the Saugus River just downstream from SAIR. Results for this study are not yet published.

Current and Emerging Threats to the Freshwater Aquatic Ecosystem

The Saugus River in an urban area in Massachusetts has been affected by human activities for over 300 years (Gomez and Sullivan, 2002). Over the last three and a half centuries, the navigability of the Saugus River from the coast to the Iron Works has significantly changed with the construction and repair of bridges, the removal of dams, and the invasion of non-native plant species.

In 1957, a dam was breached upriver from the Iron Works. This breach deposited a large amount of sediment into the basin. In subsequent years, vegetation began to grow upon the sediment throughout the Iron Works site. The mudflats and fringing wetlands that were once prevalent along the Saugus River are now replaced with large stands of phragmites, purple loosestrife, and narrow-leaved cattail. Currently, about 4 acres of the river are choked with invasive plants, displacing native species, contributing to the channeling (narrowing and deepening) of the riverway, and threatening the health of wetland habitats. The most prolific invasive species are common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), Japanese knotweed (*polygonum cuspidatum*), multiflora rose (*Rosa multiflora*), curly pondweed (*Potamogeton crispus*), mugwort (*Artemisia vulgaris*), and Norway maple (*Acer platanoides*).

Sewage is another threat to water quality in the Saugus River. A new sewage pumping station was installed by the town of Saugus in 1987 to pump sewage from homes previously served by septic systems: however, many older septic systems in the watershed continue to leach their contents into the river.

Seasonal flooding of the Saugus River also is a potential ecosystem threat. Although periodic flooding is present in a healthy freshwater ecosystem, the extent of the pavement and other impermeable surfaces prevalent in the urban areas surrounding the Saugus River leads to scouring of the river channel and contributes large pollution loads to the river. Household waste is carried from upstream, some of which is deposited in park boundaries as the waters recede (Tashiro and others, 1991).

The NPS is proposing to restore the Saugus Iron Works area and adjacent riverbed and wetlands within the historic site (Daniel Noon, National Park Service, written commun., 2003). An important goal of this restoration project is control of invasive plants.

A number of additional efforts are underway to improve the quality of the Saugus River. The Saugus River Advocacy Group has received technical support from the NPS. The Saugus River is registered with the Massachusetts Adopt-A-Stream Program, through which the group hopes to improve the quality of the river environment for ecological and recreational purposes. The Massachusetts Department of Environmental Management (DEM) is working in cooperation with the Lynn Water and Sewer Commission to better control and time withdrawals of freshwater from the Saugus River, which are used as the drinking supply for the city of Lynn. The Massachusetts Department of Environmental Management also is seeking funding to install a fish ladder at the Lynn Water and Sewer Commission diversion dam, at the Colonial Hilton in

Lynnfield, to return alewives to their natural spawning areas at Lake Quannapowet, Wakefield (National Park Service, 2003e).

The Saugus River, which runs through SAIR, is included on the Massachusetts 303(d) list. The specific concern in this river is the level of fecal coliform bacteria. The Saugus River is currently classified by the state as a B/SB river, which means it is suitable for fishing and swimming, but some evidence exists that the Saugus River may be exceeding the limits for a B/SB rating (Tashiro and others, 1991).

Saratoga National Historical Park

SARA which is in Saratoga County, New York, contains 3,406 acres along the Hudson River and is composed of four non-contiguous sites. The Battlefield Unit is in Stillwater and is what many people think of as the park. The Old Saratoga Unit, in the villages of Schuylerville and Victory, contains the Schuyler Estate, the Saratoga Monument, and Victory Woods, a 22-acre wooded tract locally known as the Garber Tract. Victory Woods was added to the park in the 1960s through a donation by its owners. It has never been open to visitors, and no programs or interpretive services are offered there. Only the Battlefield Unit is shown in figures 16 and 17.

Tributaries to the Hudson River drain SARA, including Kroma-Kill, Mill Creek, American's Creek, and Devil's Hollow (fig.16). Originating northeast of the park, Kroma Kill drains the largest area and flows through the park. All of the Mill Creek drainage is contained within park boundaries. American's Creek is the name given by the park to a small stream entering the Hudson River just south of the Mill Creek confluence with the Hudson River. Devil's Hollow (locally used name) in the southern end of the park flows through a hemlock-laden cascade with a gradient drop of more than

100 feet. Devil's Hollow was historically called Great Fall Creek (Vana-Miller and others, 2001). The Champlain Canal connects the city of Troy to Lake Champlain and was completed in 1823. It runs along Route 4 on the eastern edge of the park.

The park has 176 acres of palustrine wetlands making up approximately 6 percent of the park (Tiner and others, 2000). Two small farm ponds and 4 springs are in the park.

Water-Quality and Water-Quantity Monitoring and Research

NPS's Water Resources Division in cooperation with SARA staff developed a Water Resources Management Plan in January 2001 (Vana-Miller and others, 2001). This plan includes an inventory of existing freshwater resources, the monitoring that has been done on these resources, identification of potential threats to the freshwater ecosystem, and a proposed water-quality monitoring plan. It has an extensive reference list that includes references for all freshwater-quality or quantity data that has been collected near the park, and summarizes most of these data. This document is at the park and should be used to guide any water-quality monitoring conducted in the park.

A Baseline Water-Quality Data Inventory and Assessment was completed for SARA in 1997 (National Park Service, 1997b). Sixteen water-quality stations inside the park were found in STORET; all are monitored internally by the NPS. For 11 stations, data collection occurred between 1987 and 1990, and included 8 water-quality parameters (water temperature, specific conductance, dissolved oxygen, pH, salinity, nitrate, lead, and phosphate). Water-quality monitoring at these stations also occurred during 1991; these data were not entered into STORET, but are available in files at the park. Five additional stations were tested for polychlorinated biphenyls (PCBs) and (or) lead one time in 1987. These data are stored at the park (Chris Martin, National Park Service,

written commun., 2003). Currently (2004), no water-quality monitoring is taking place in the park.

One monitoring well (USGS station 430013073370401) was monitored for water quality by the USGS from 1959 to 1995. Although USGS no longer maintains this well, park staff continue to record monthly water levels (Chris Martin, National Park Service, written commun., 2003). The Hudson River Basin was the subject of a USGS National Water-Quality Assessment Program (NAWQA) study. Although no monitoring sites were inside the park, other sites in the Hudson Basin may be helpful in identifying potential natural and anthropogenic water-quality issues in the park. The major findings of the NAWQA study from 1992-1995 are summarized in Wall and others (1998).

A wetland inventory for the park (Tiner and others, 2000) was conducted by the USFWS in conjunction with the NWI. An intensive investigation of the ground-water resources in the park was conducted by Heath and others (1963). The results of this investigation are summarized in a water resources management plan for the park (Vana-Miller and others, 2001).

Other than the Hudson River, no fluvial system in or adjacent to SARA has been monitored for discharge on a consistent basis. Heath and others (1963) measured the flow from the two major springs in the park. The nearest USGS station that is most representative of streamflow conditions at the park is the Hudson River at Stillwater (USGS station 01331095). The difference between the size of the drainage area of the Hudson River (3,773 square miles) at this location and any of the small streams in the park is significant.

Current and Emerging Threats to the Freshwater Aquatic Ecosystem

An extensive summary of water-quality issues in and around SARA can be found in the water resources management plan for the park (Vana-Miller and others, 2001). A brief summary of issues in the park follows. A considerable threat to aquatic ecosystems in the park is nonpoint-source pollution, including agriculture (dairy farms) and residential development upstream from the park (Chris Martin, National Park Service, oral commun., 2003) (fig. 17). In the case of Mill Creek, the stream flows out of the park boundary, across agricultural land and then back into the park. Specific stressors to the freshwater ecosystem include atmospheric deposition, road salt from road runoff, failing septic systems, beaver re-colonization of Mill Creek, and the potential risk of zebra mussel colonization (Vana-Miller, 2001).

The park is bounded by the Hudson River, into which all of its streams drain. Although the Park boundary is the mean high-water mark of the Hudson River, backwater into Vyle Pond and other areas affects the park. The Hudson River is a Superfund site and if the Hudson is dredged for PCBs, as is planned (Chris Martin, National Park Service, oral commun., 2003), backwater would have an even greater effect on the park. There are no industrial or municipal facilities in the park or in the watersheds that drain into the park.

The results of the SARA water-quality criteria screen found that four groups of parameters exceeded USEPA screening criteria at least once within the park. Concentrations of dissolved oxygen, pH, fecal coliform, and lead exceeded the respective USEPA criteria for the protection of freshwater aquatic life. Lead exceeded the drinking-water criteria in three locations: (1) on the Old Champlain Canal 0.5 mile north of where

Kroma Kill enters the canal (NPS SARA0042), (2) just downstream from the confluence of Kroma Kill and a tributary to Kroma Kill (NPS SARA0049) at the northern boundary of the park, and (3) in an area of backwater created by the Hudson River near where American Creek enters Hudson River (NPS SARA058). Fecal coliform exceeded NPS Water Resources Division screening limits for freshwater bathing at two locations: (1) NPS station SARA0049 and (2) on Mill Creek, just downstream from the confluence of Robbie's Ditch and Mill Creek (NPS station SARA0053). Dissolved-oxygen concentrations exceeded the USEPA standards at two locations on Mill Creek (NPS stations SARA0061 and SARA0054), one location on Devil's Hollow (NPS station SARA0062), and one location on American Creek near where it enters the Hudson River (NPS station SARA0057). pH exceeded the screening criteria at NPS stations SARA0061 and SARA0057. None of the waterbodies flowing through the park are on USEPA's 305(b) or 303(d) lists for the state.

Weir Farm National Historic Site

WEFA is a historic farmstead and reserve in the towns of Wilton and Ridgefield in western Connecticut that is in the Norwalk River watershed (fig. 18). It consists of 60 acres including two new parcels of land, one-half a mile away, totaling 11 acres that have recently been added to the park.

Water resources at WEFA include 15 acres of aquatic habitat, including an artificial pond just under 4 acres (Weir Pond), and herbaceous or shrub/scrub wetlands. The entire park is in a geologic region known as the Connecticut Western Uplands, an area of upland hills and valleys with granitic soils and underlying schist and gneiss bedrock (Canavan and Siver, 1995). This geology influences the chemical composition of the

major waterbodies making them more alkaline with a higher pH and conductivity than other Connecticut lakes. Freshwater bodies include Weir Pond, an unnamed pond, an unnamed stream, some intermittent streams, seven wetland areas, and ground water. Ground water appears to contribute the majority of the base flow to the pond, which is 7 ft at its deepest point (U.S. Department of Agriculture, 1995).

The park lies in the Norwalk River watershed and drains north to the Cooper Pond Brook, which flows into the Norwalk River, and to the south to the Barrets Brook, which flows into Streets Pond. Streets Pond empties into Comstock Brook and into the Norwalk River. Several springs and streams, some intermittent, drain into the 4-acre pond, which was artificially impounded in 1896 (U.S. Department of Agriculture, 1995).

WATER-QUALITY AND WATER-QUANTITY MONITORING AND RESEARCH

A Baseline Water-Quality Data Inventory and Assessment was completed for this park in 1997 (National Park Service, 1997c). None of the monitoring stations found in STORET were in or upstream from the park. A Level I water-quality inventory was completed for WEFA because of the lack of water-quality data in the park (Farris and Chapman, 2000b). Additional Level I water-quality data was collected by park staff in the summer of 2000 (G. Waters and L. Skibiel, National Park Service, written commun., 2000).

Currently (2004), no long-term monitoring sites for water quality or water quantity are in the park, in the watershed upstream from the park, or in the study area as defined by the Baseline Water-Quality Data Inventory and Assessment (3 miles upstream or 1 mile downstream from the park). The closest USGS streamflow gaging-station is in South Wilton (USGS station 01209700) with a drainage area of 30 square miles.

A water-quality resource evaluation of the park was completed in 1995 (U.S. Department of Agriculture, 1995). Seven wetlands were identified and mapped on the site. Wetland areas drain into the Norwalk River or into Weir Pond.

Current and Emerging Threats to the Freshwater Aquatic Ecosystem

A concern regarding water quality in the park is the effect of adjacent residential development on the Weir Pond watershed and the various wetlands (fig. 19). Residential development can lead to nutrient loading in the watershed from septic systems, landscaping activities, and tree cutting that increases runoff. A proposed highway expansion project could affect the watershed of the wetlands in the northeastern corner of the park. Development projects in the Park, including a proposed restroom building, also may influence the water quality of aquatic resources. Other threats include atmospheric deposition, visitor use, and road runoff from development in the park. Land use adjacent to Weir Farm is low-density residential; many of the private residences are on 2- to 5-acre lots, are extensively landscaped, and are serviced by septic systems. This type of land use tends to be associated with increased nutrient loading from ground-water input and surface-water runoff.

Weir Pond has high seasonal levels of chlorophyll and turbidity and low seasonal levels of dissolved oxygen and secchi depth. The pond is approaching eutrophic conditions and is vulnerable to increased nutrient loading. It has a relatively low pH, and water clarity ranges from 4 to 5 ft (Farris and Chapman, 2000b). The intermittent stream and the one wetland monitored in the Level I Inventory showed high concentrations of dissolved nitrogen (Farris and Chapman, 2000b).

Although all rivers and lakes in Connecticut are on the USEPA's 303(d) list for FCA mercury, Weir Pond is not specifically listed on either the 305(b) or 303(d) list for the state.

SUMMARY

Freshwater resources in all parks in the NETN are subject to natural and anthropogenic threats. The overall goal of this project is to identify the natural range of variability in the park systems and to ascertain whether anthropogenic alterations to the ecosystems are driving water quality and (or) water quantity outside the normal range of variability. The purpose of this first phase of the project described in this report was to identify threats common to all parks as well as threats unique to individual parks. In addition, sources of baseline information on the freshwater aquatic resources in the parks were compiled, and current baseline monitoring was identified. Information regarding freshwater resources and threats to the water quality of these resources is integrated into conceptual models.

Common threats or stressors to freshwater resources in the parks in all cases include climate change, atmospheric deposition, development, visitor use, and invasive species, and commonly include agriculture. Threats that are an issue in some parks include industry and forestry.

None of the parks except ACAD have a streamflow gaging station or an active monitoring well within their boundaries. With the exception of SAIR, the parks do not have nearby streamflow gaging-stations with drainage areas similar enough to waterbodies in the park to use for estimating flow in the park.

Half of the NETN parks (ACAD, MORR, ROVA, SAGA, and SAIR) currently have a baseline water-quality monitoring program in place. Little or no baseline freshwater-

quality monitoring is occurring in BOHA, MABI, MIMA, SARA or WEFA. Although limited lake monitoring has been done in ACAD for more than 30 years, the period of record in other parks where baseline monitoring has been done ranges from 5 to 20 years, and the level of quality assurance is variable. In several cases, additional monitoring variables have been added in recent years. Network wide aquatic monitoring variables (vital signs), justifications for these vital signs, and protocols will be selected in phase two of this project.

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Table 1. Summary of current freshwater-quality and -quantity monitoring in Northeast Temperate Network parks. [DOC, dissolved organic carbon; DIC, dissolved inorganic carbon; USGS, U.S. Geological Survey]

Park	Water-quality Monitoring	Parameters	Number of stations	Agency conducting monitoring	Frequency	Period of record
ACAD	lakes	Secchi disk, temperature, pH, dissolved oxygen, specific conductance, alkalinity	8 lakes	park staff	monthly (May-October)	Current program 1997-2004(some parameters since 1970)
	lakes	Secchi disk, temperature, pH, dissolved oxygen, specific conductance, color, DOC, total phosphorus, total nitrogen, chlorophyll a, ANC, DIC, major ions, epilimnetric core sample, bottom grab sample, light penetration	5	park staff	twice per summer	Current program 1997-2004(some parameters since 1970)
	streams	Benthic macroinvertebrates, habitat, temperature, pH, dissolved oxygen, specific conductance, color, flow	3	park staff and Maine Department of Environmental Protection	once per year	1997 –2004: 4 streams 1998 –2004: 6 streams
	ground water			USGS	continuous	2003-2004
BOHA	none	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
MABI	none	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
MIMA	none	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
MORR	streams	Temperature, pH, dissolved oxygen, specific conductance, chloride, total dissolved solids, salinity, fecal coli form	11	park staff	monthly (weekly in summer)	1982-2004
ROVA	streams	Temperature, pH, dissolved oxygen, salinity, specific conductance, chloride, alkalinity,	3	park staff (lab work contracted out since 1998)	monthly	1994- 2004
		phosphate, turbidity, nitrate			quarterly	
SAGA	streams	Temperature, dissolved oxygen, turbidity, pH, specific conductance, total nitrogen, total phosphorus, fecal coli form	5 in park (1 out)	park staff	monthly (May-November)	1997- 2004
SAIR	river-just outside park	Bacteria, turbidity, pH, dissolved oxygen	1 just outside park	Saugus River Watershed Council	monthly (May-October)	1998- 2004
SARA	none	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
WEFA	none	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

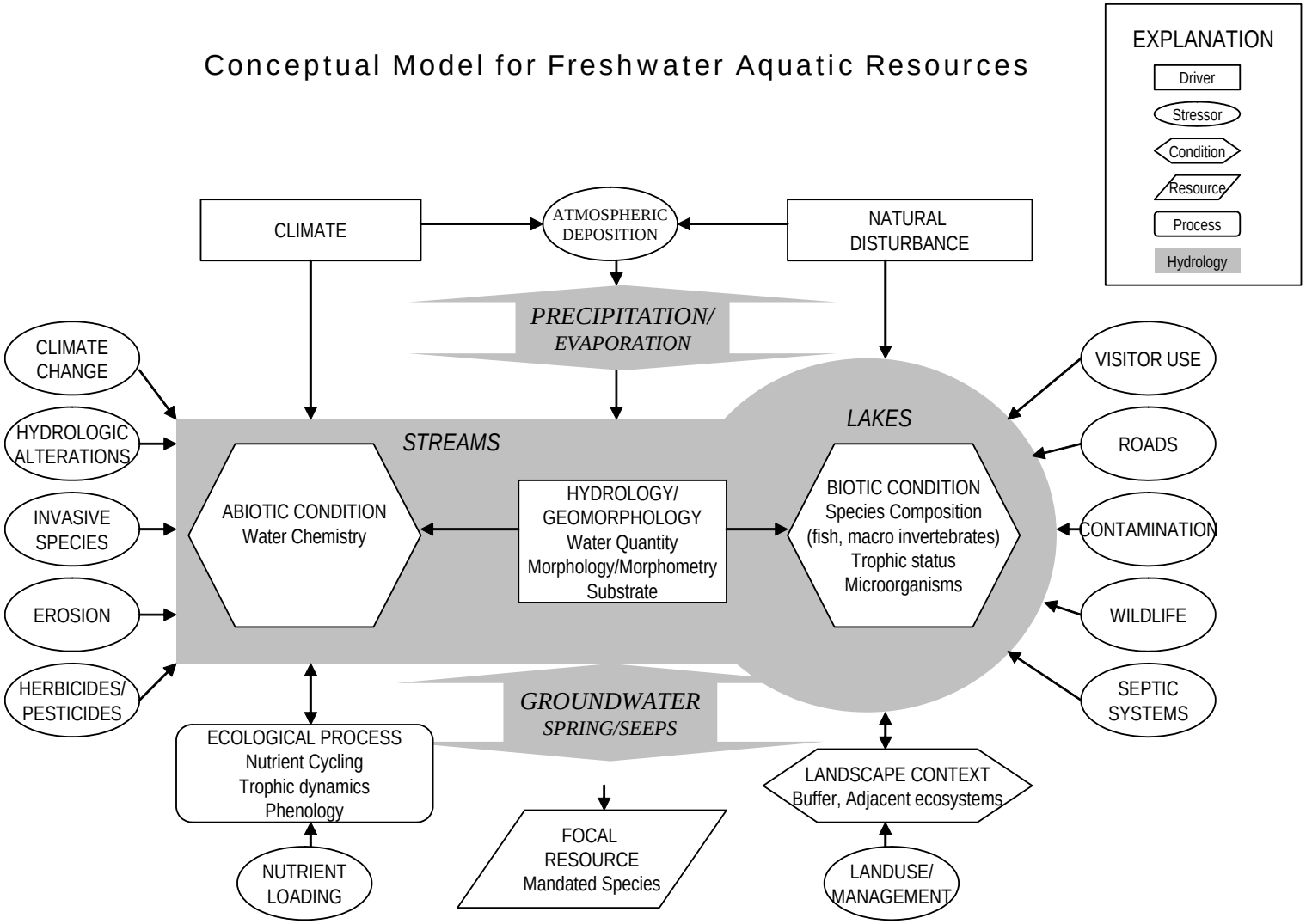


Figure 1. Conceptual relations among drivers, threats and attributes of freshwater ecosystems at Northeast Temperate Network Parks.

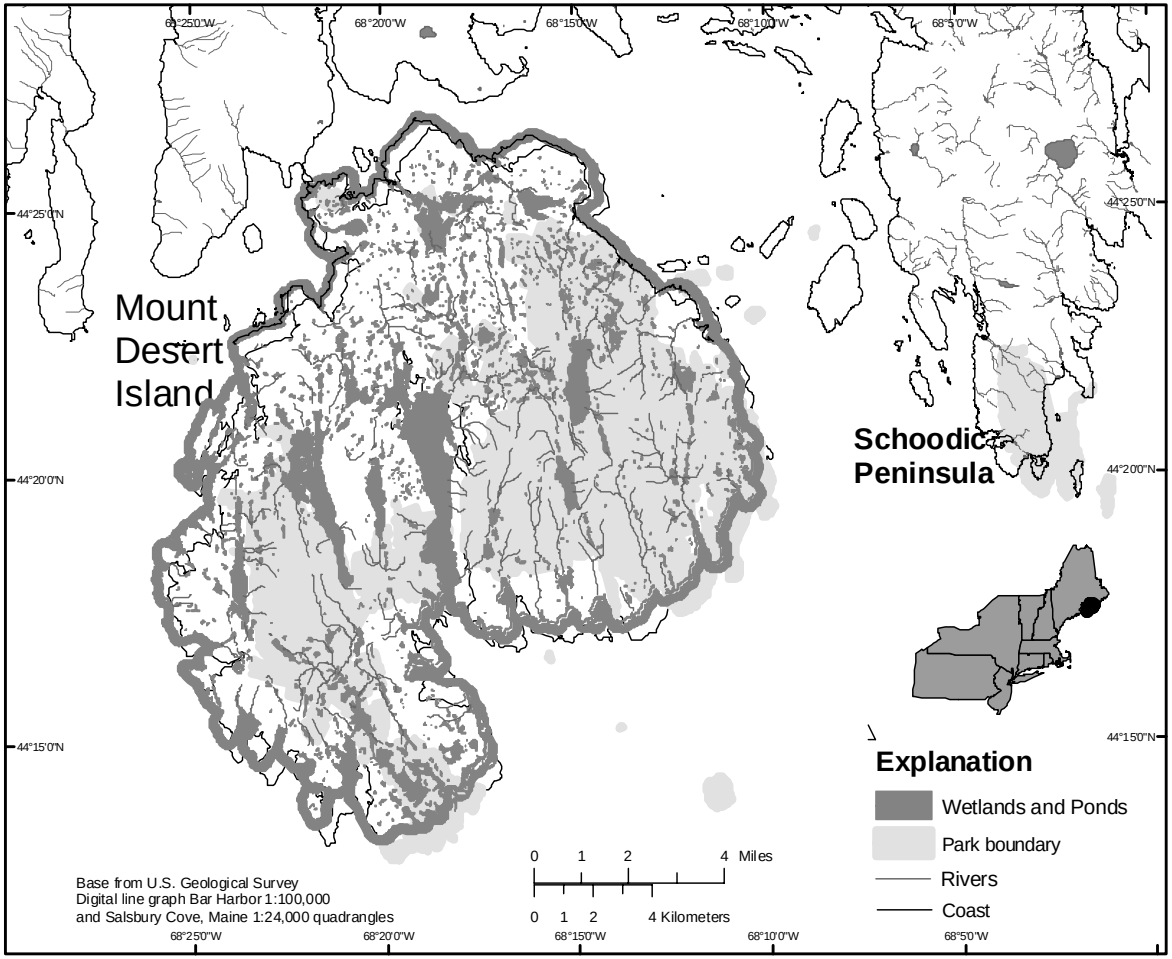


Figure 2. Freshwater resources at Acadia National Park, Maine [note: Isle au Haut not shown].

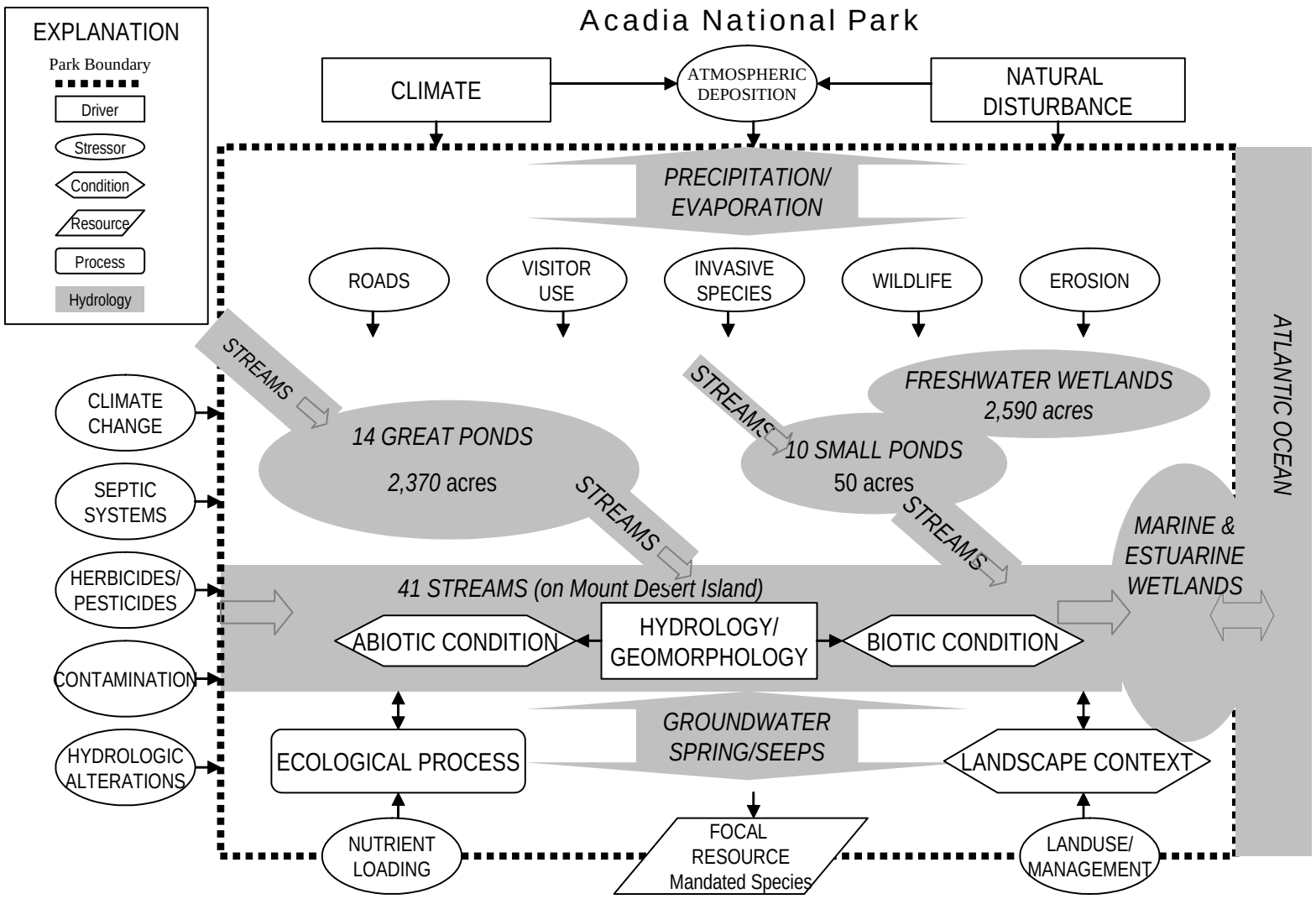


Figure 3. Conceptual model of freshwater ecosystems at Acadia National Park, Maine.

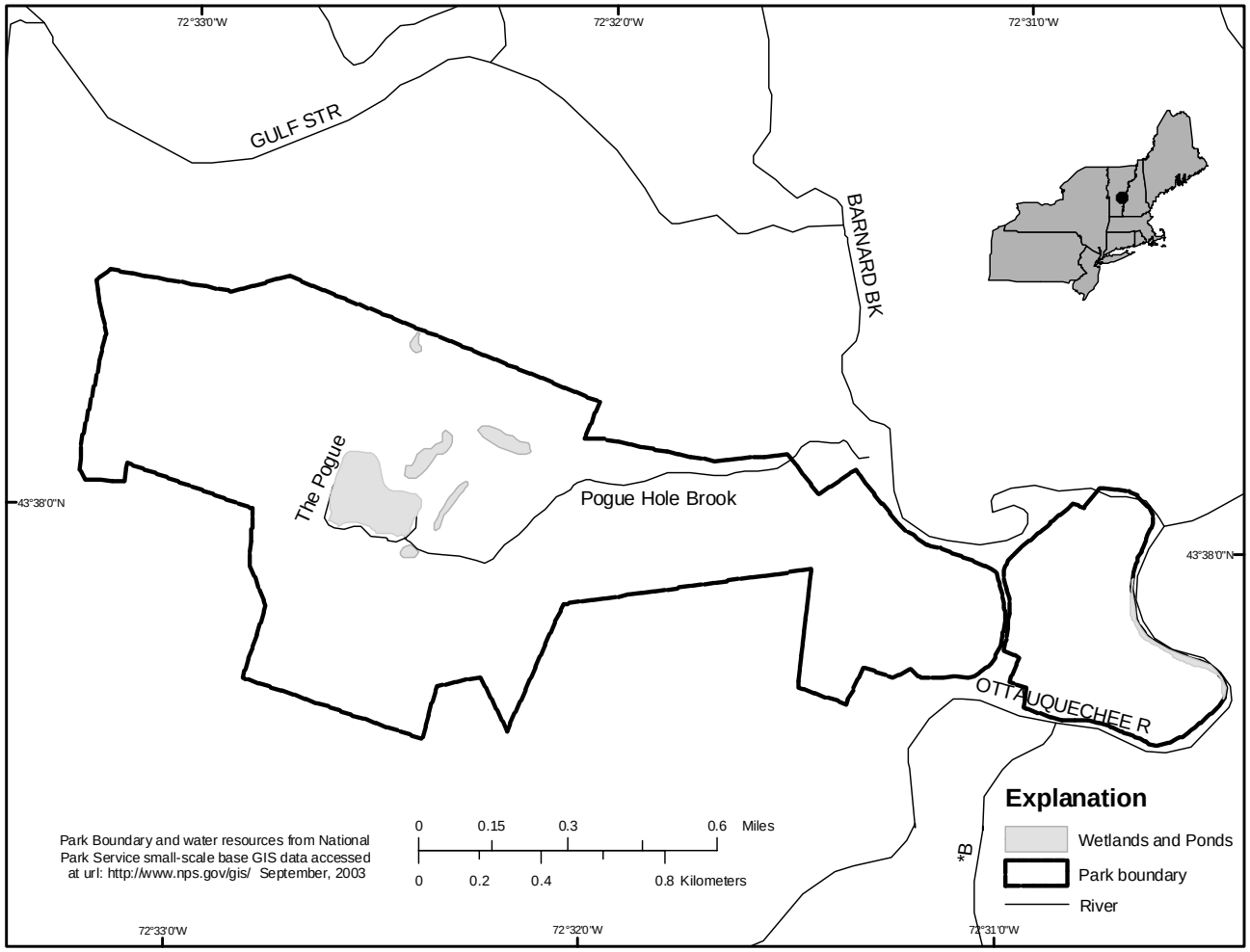


Figure 4. Freshwater resources at Marsh-Billings-Rockefeller National Historical Park, Vermont.

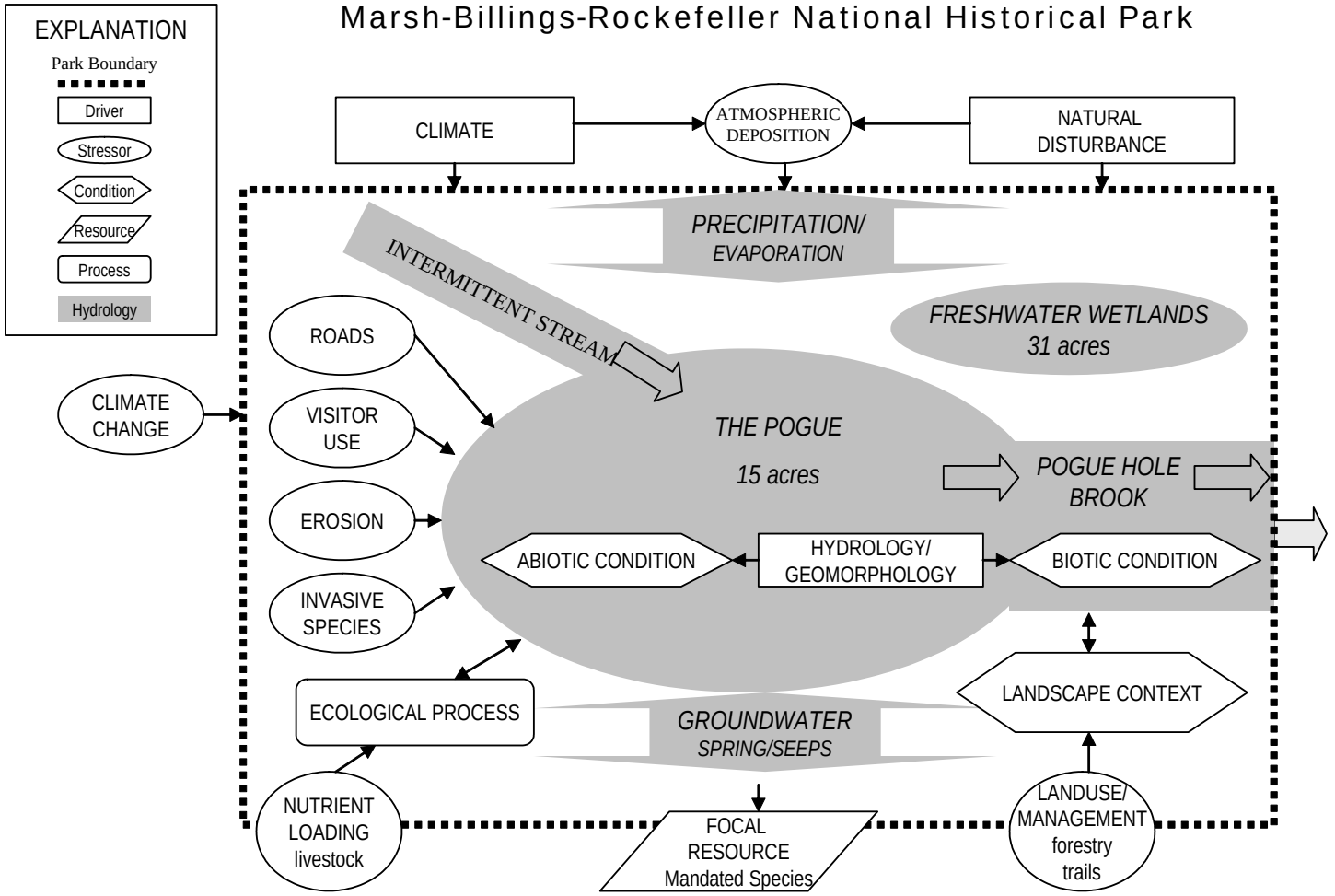


Figure 5. Conceptual model of freshwater ecosystems at Marsh-Billings-Rockefeller National Historical Park, Vermont.

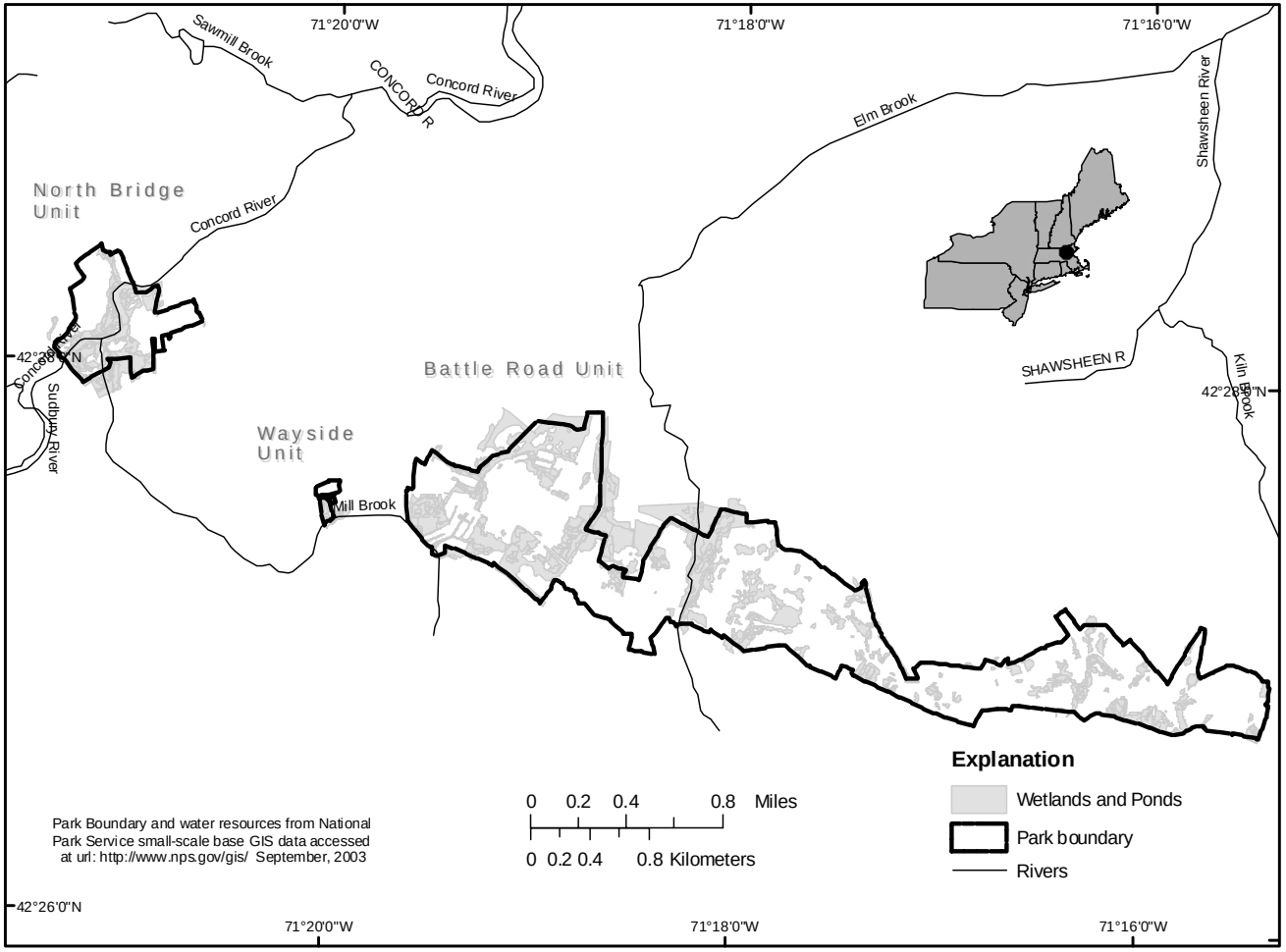


Figure 6. Freshwater resources at Minute-Man National Historical Park, Massachusetts.

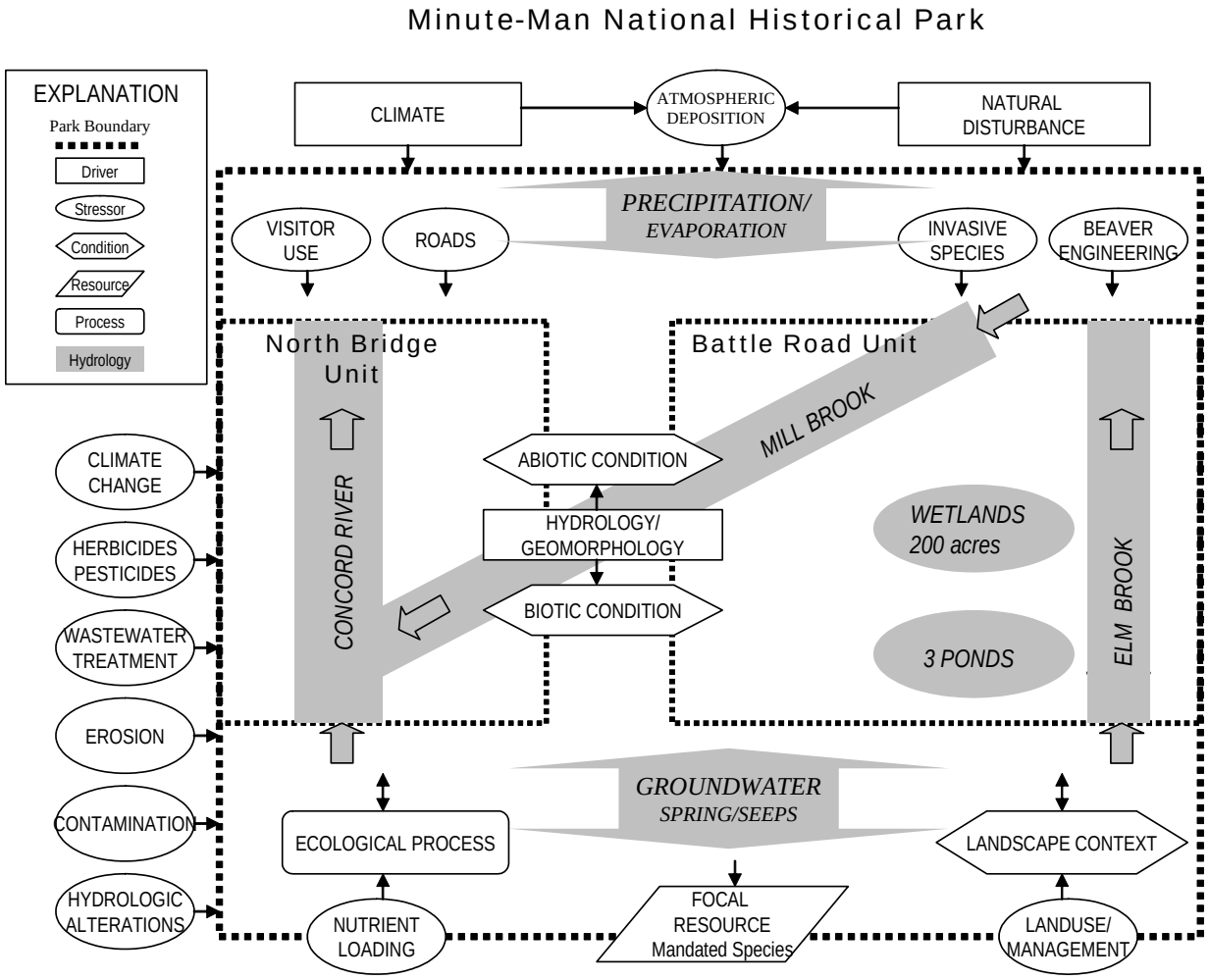


Figure 7. Conceptual model of freshwater ecosystems at Minute-Man National Historical Park, Massachusetts. [note: Wayside Unit not shown].

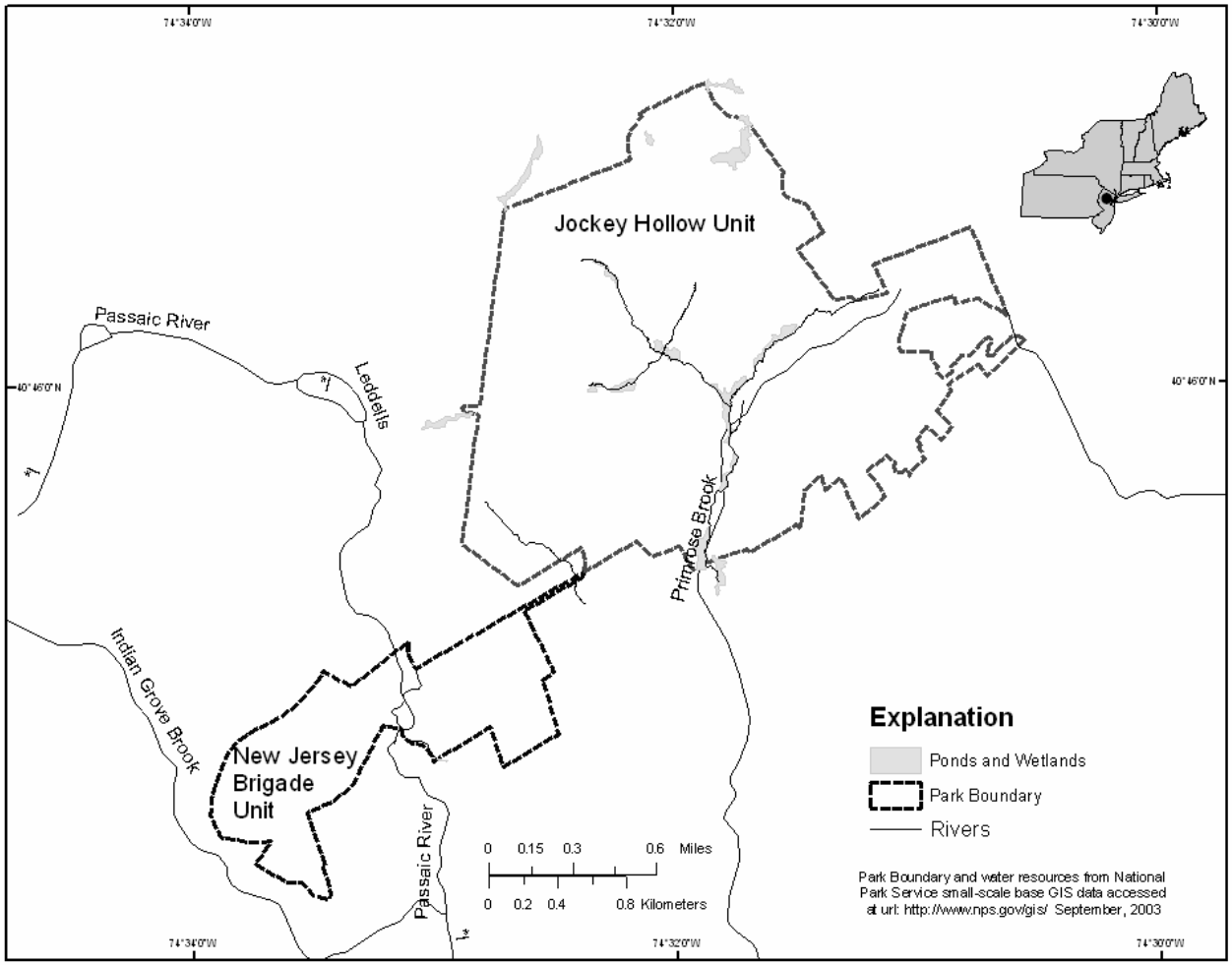


Figure 8. Freshwater resources at Morristown National Historical Park, New Jersey [note: Washington's headquarters Unit and Fort Nonsense Unit not shown].

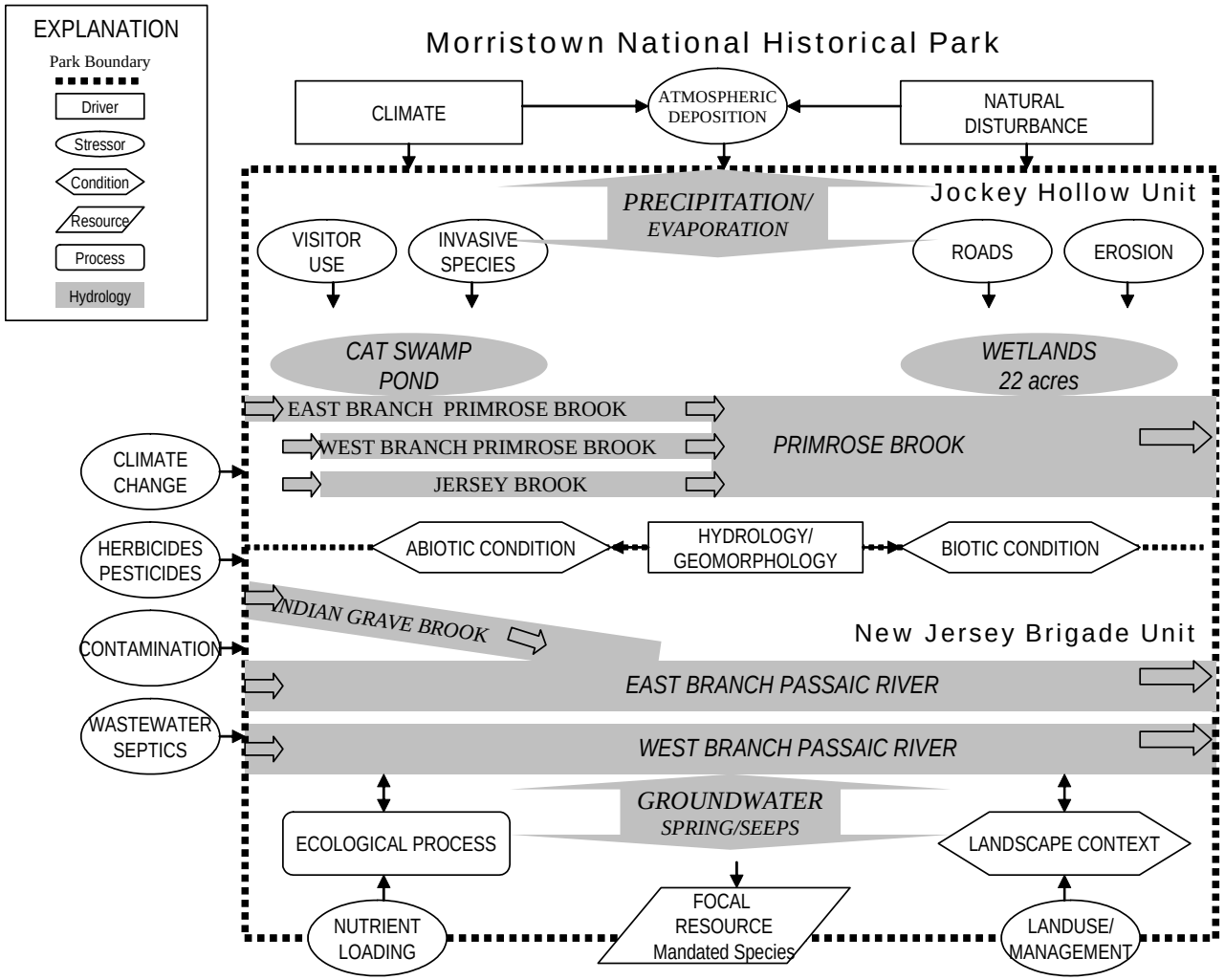


Figure 9. Conceptual model of freshwater ecosystems at Morristown National Historical Park, New Jersey.

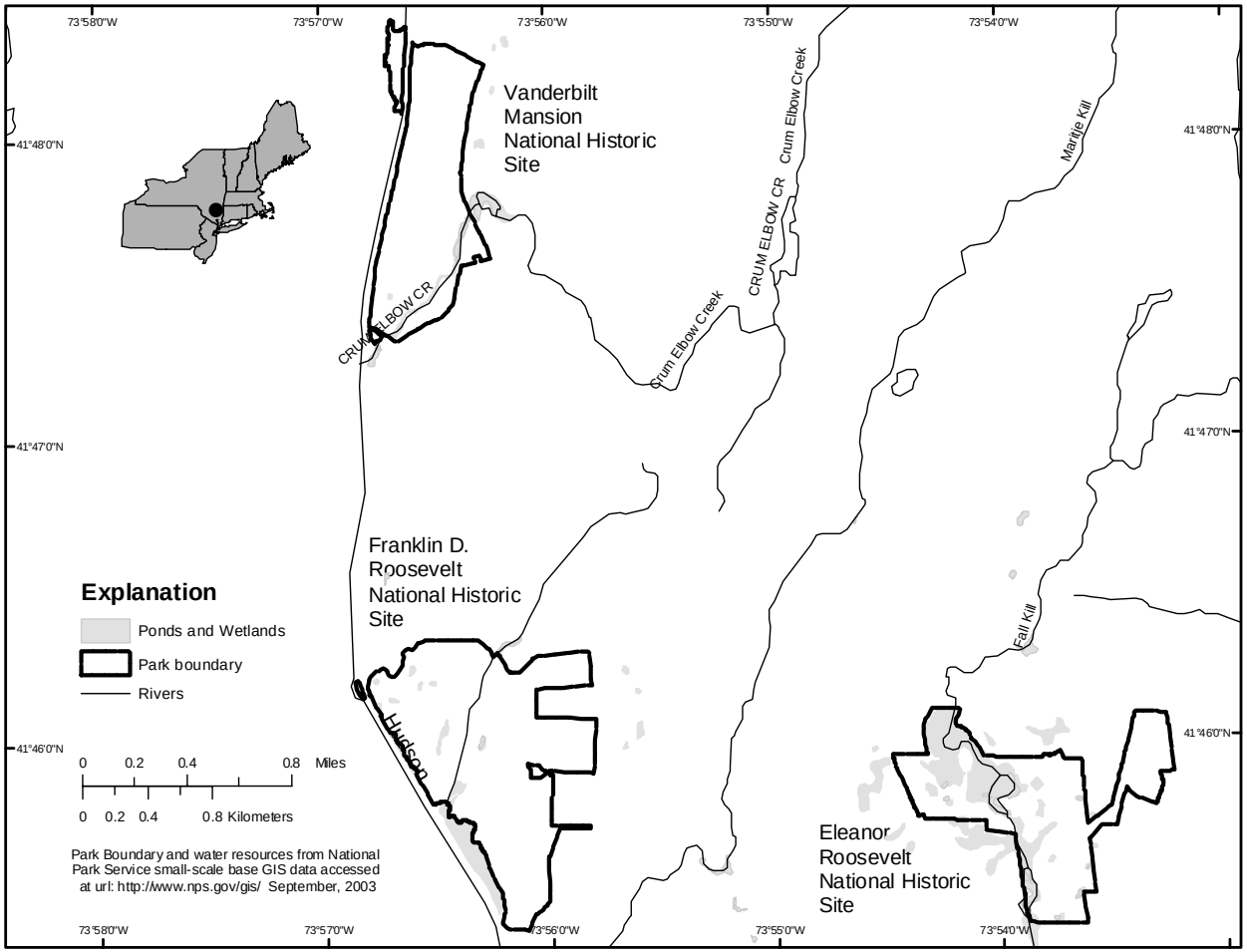


Figure 10. Freshwater resources at Roosevelt-Vanderbilt National Historic Sites, New York.

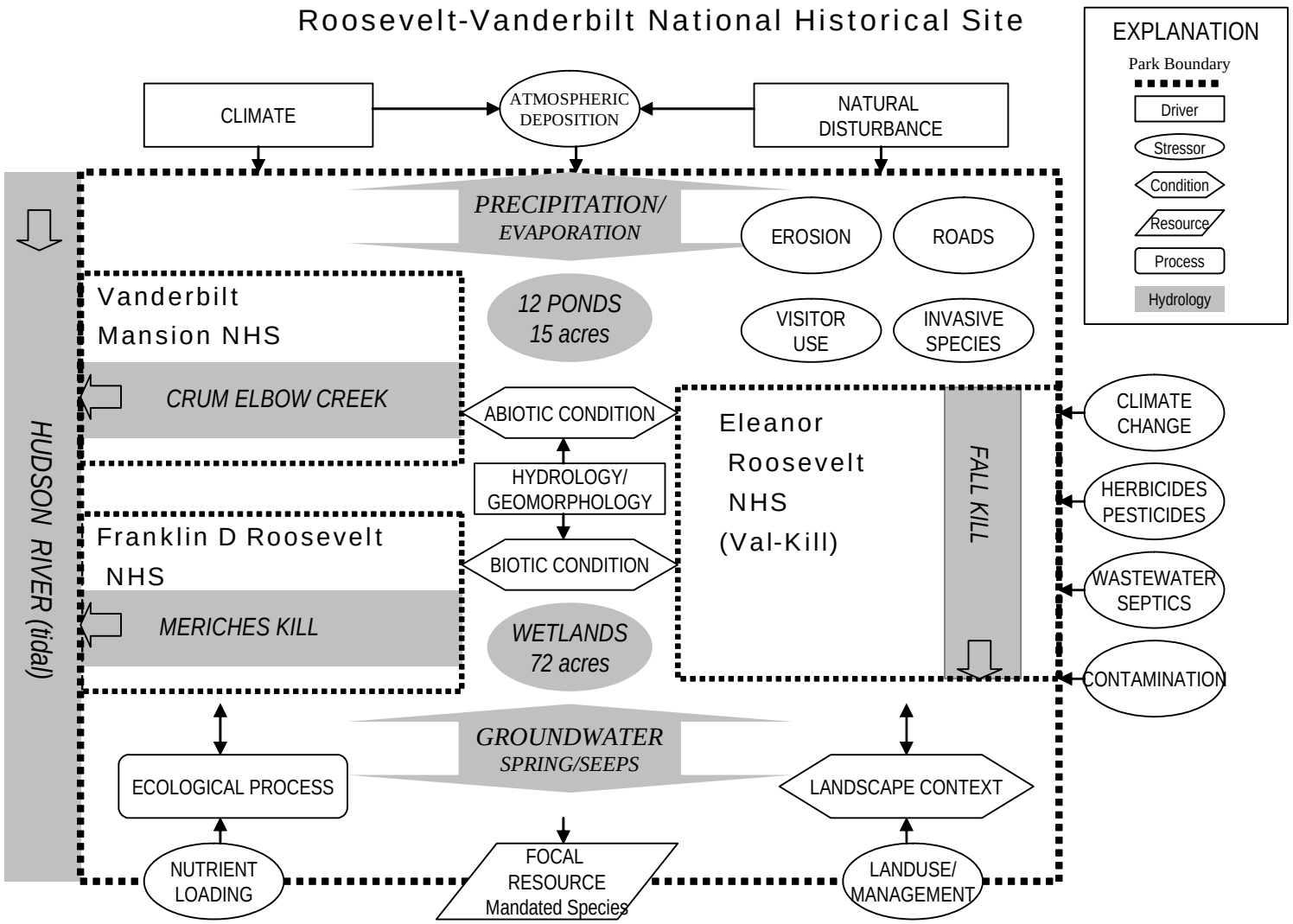


Figure 11. Conceptual model of freshwater ecosystems at Roosevelt-Vanderbilt National Historical Site, New York.

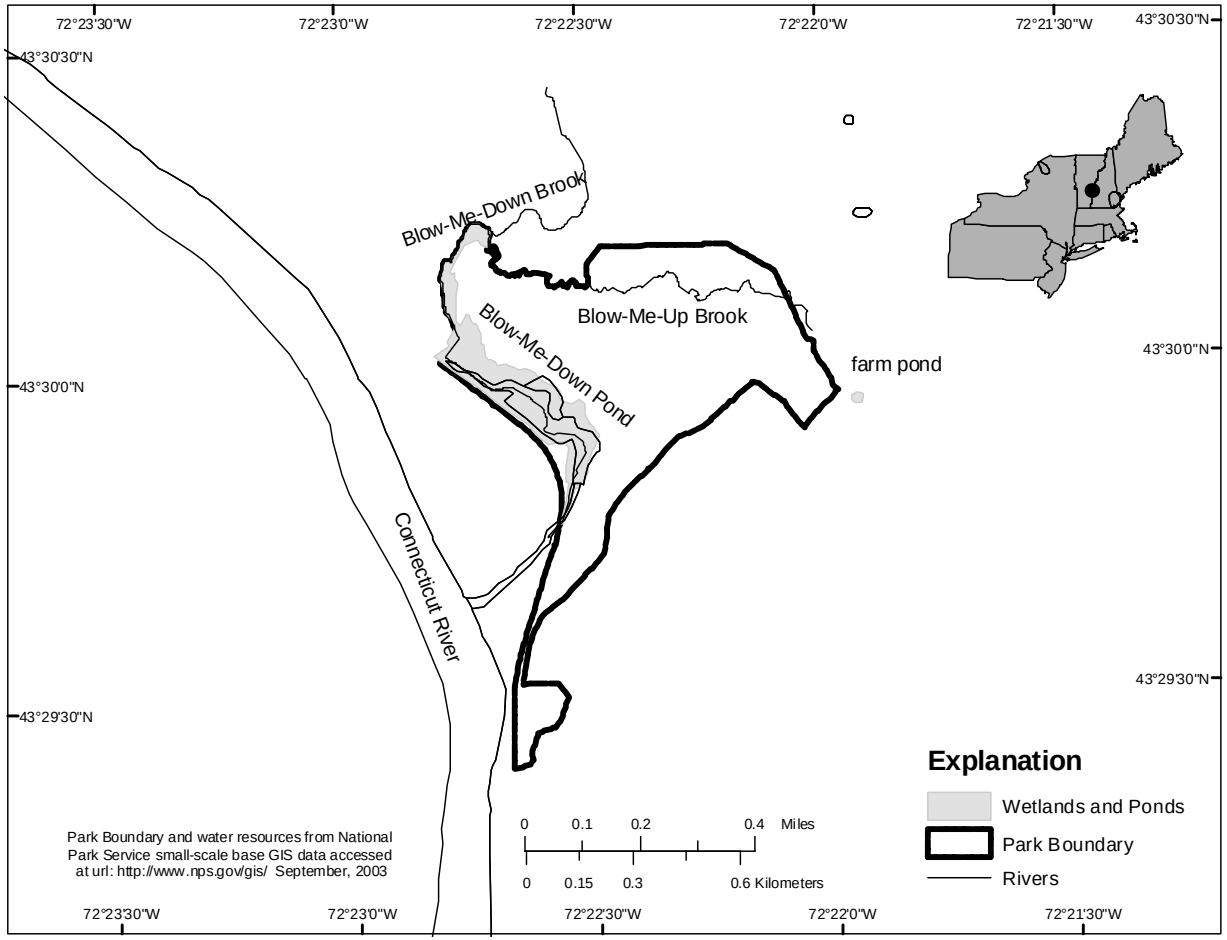


Figure 12. Freshwater resources at Saint-Gaudens National Historic Site, New Hampshire.

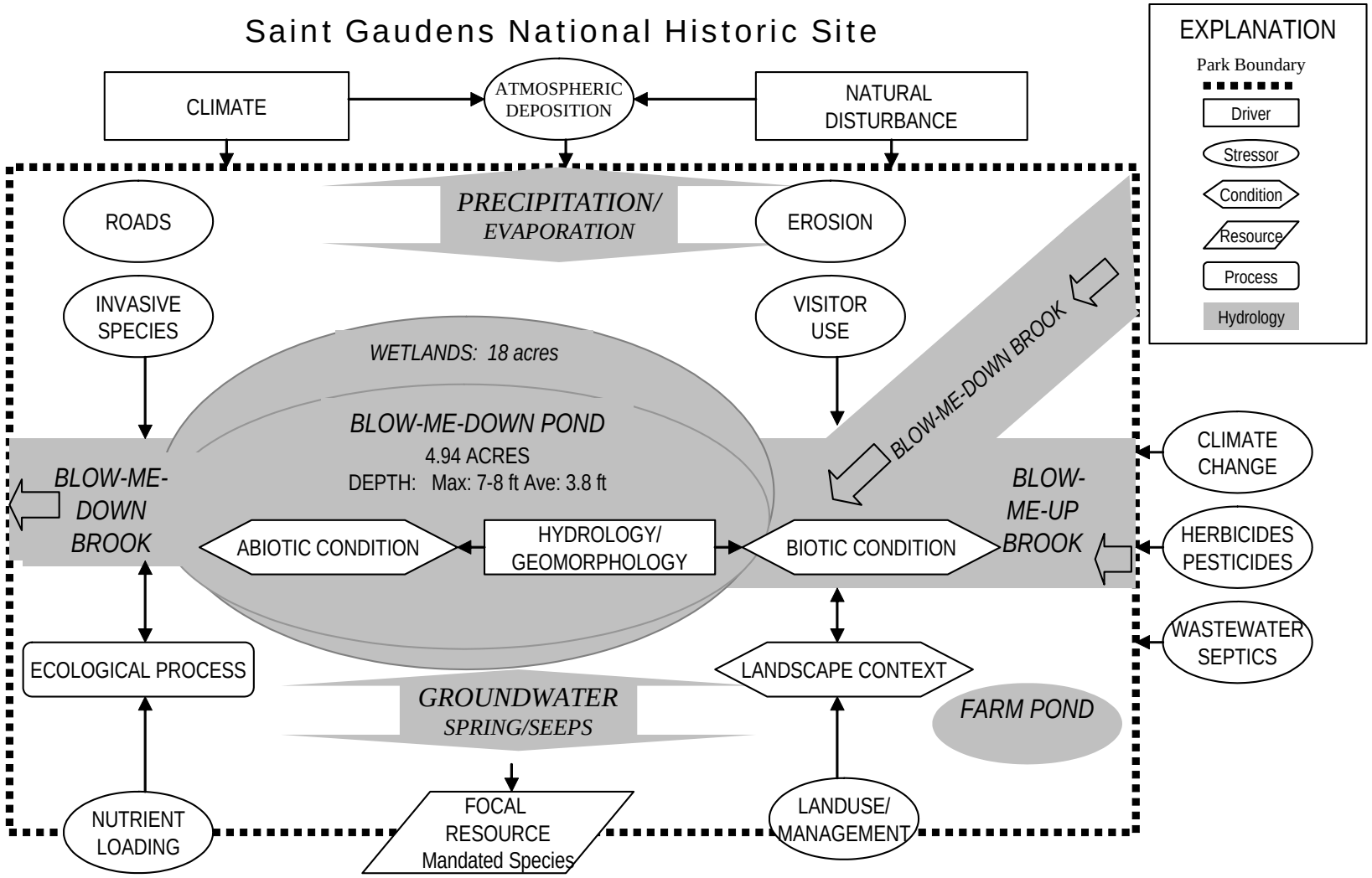


Figure 13. Conceptual model of freshwater ecosystems at Saint-Gaudens National Historical Site, New Hampshire.

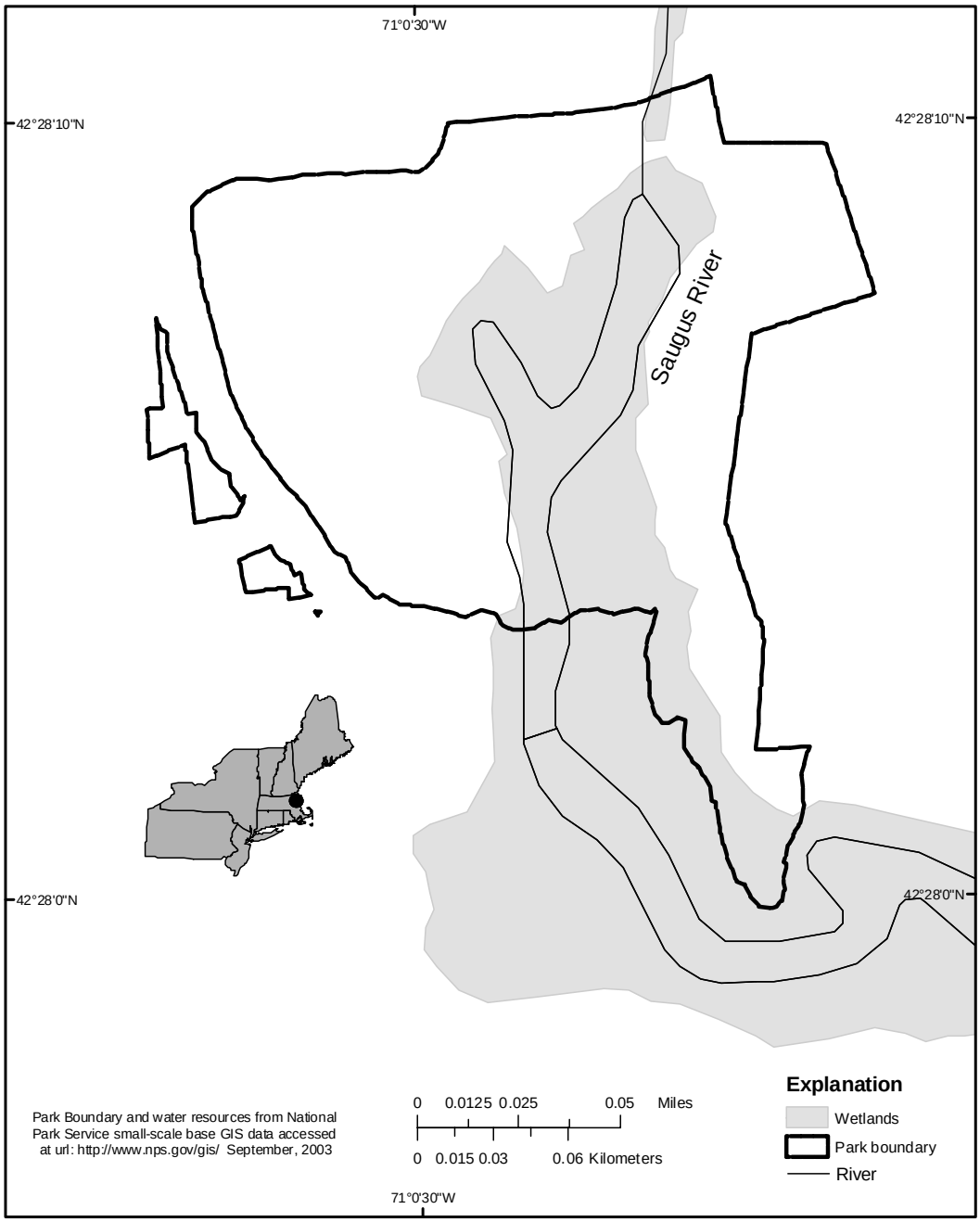


Figure 14. Freshwater resources at Saugus Iron Works National Historic Site, Massachusetts.

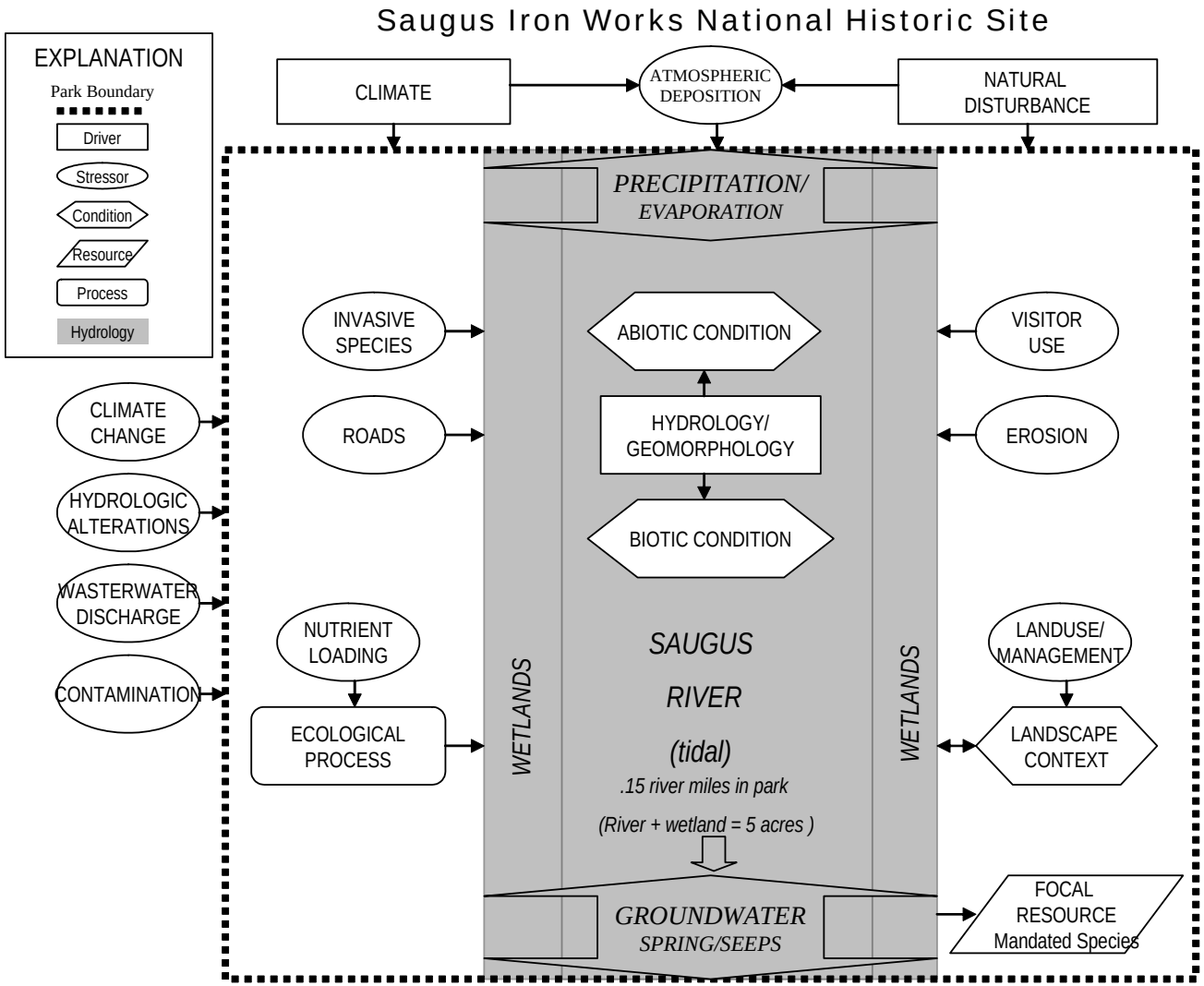


Figure 15. Conceptual model of freshwater ecosystems at Saugus Iron Works National Historic Site, Massachusetts.

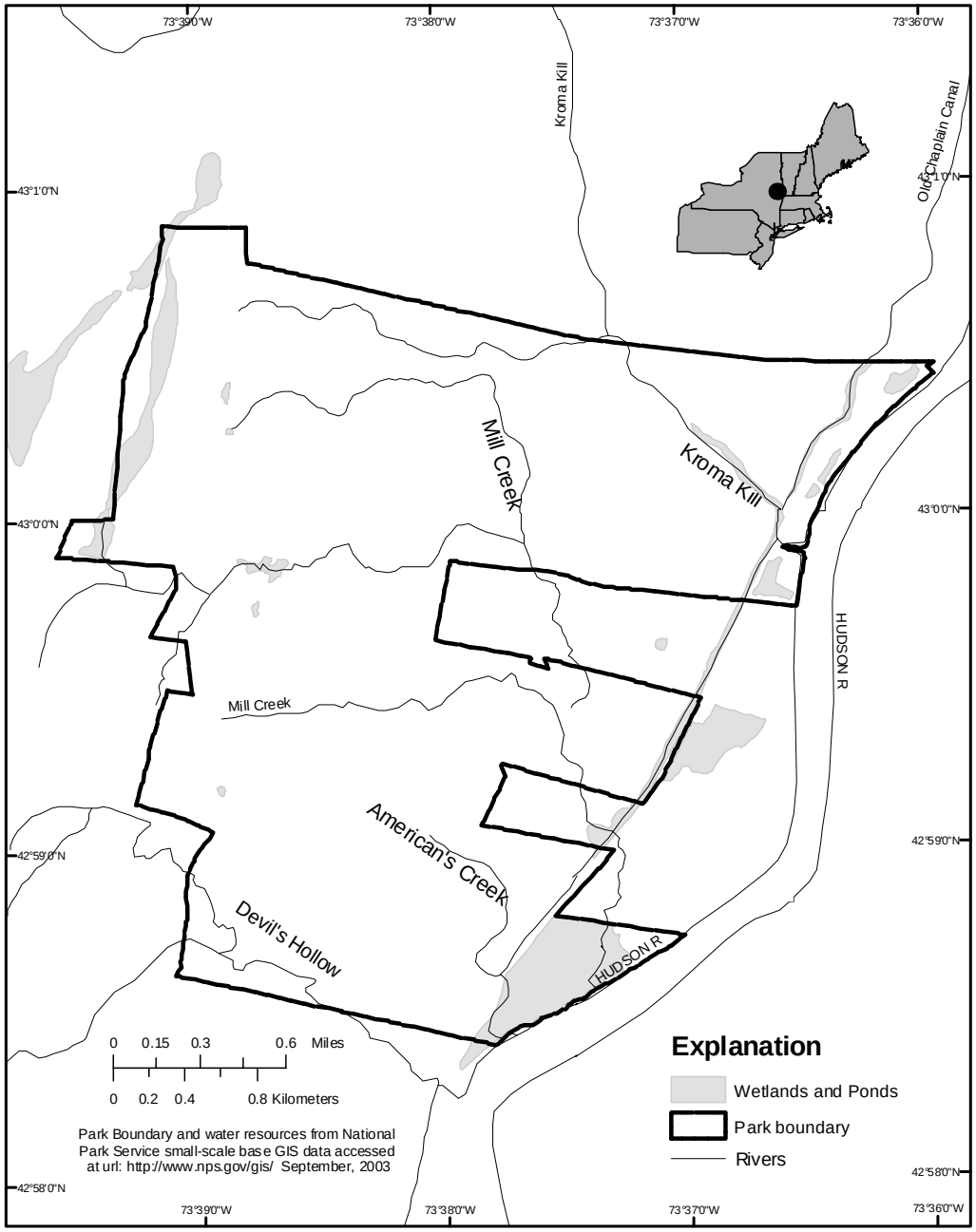


Figure 16. Freshwater resources at Saratoga National Historic Park, New York. [Note: Old Saratoga Unit not shown].

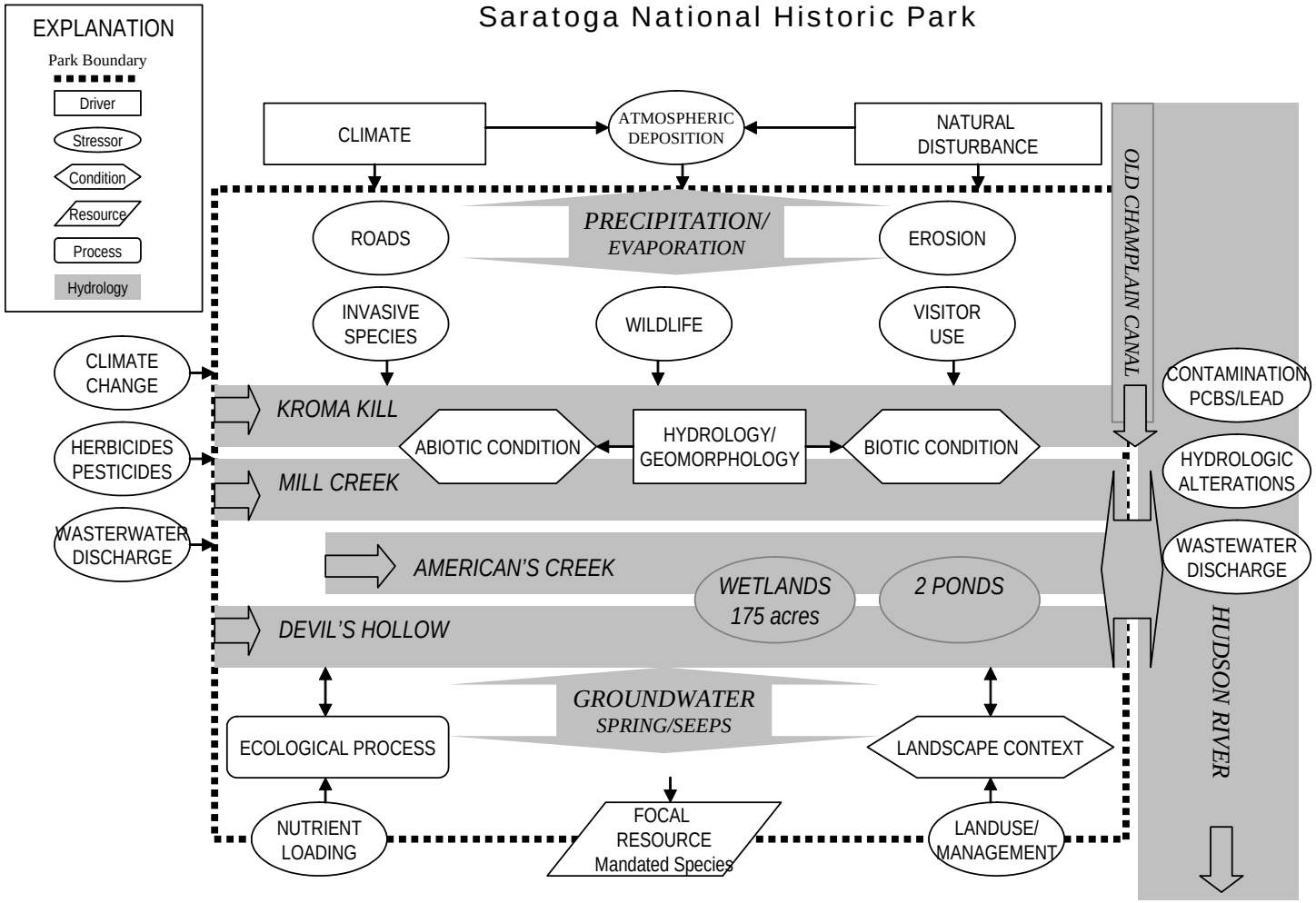


Figure 17. Conceptual model of freshwater ecosystems at Saratoga National Historic Park, New York. [Note: Old Saratoga Unit not represented].

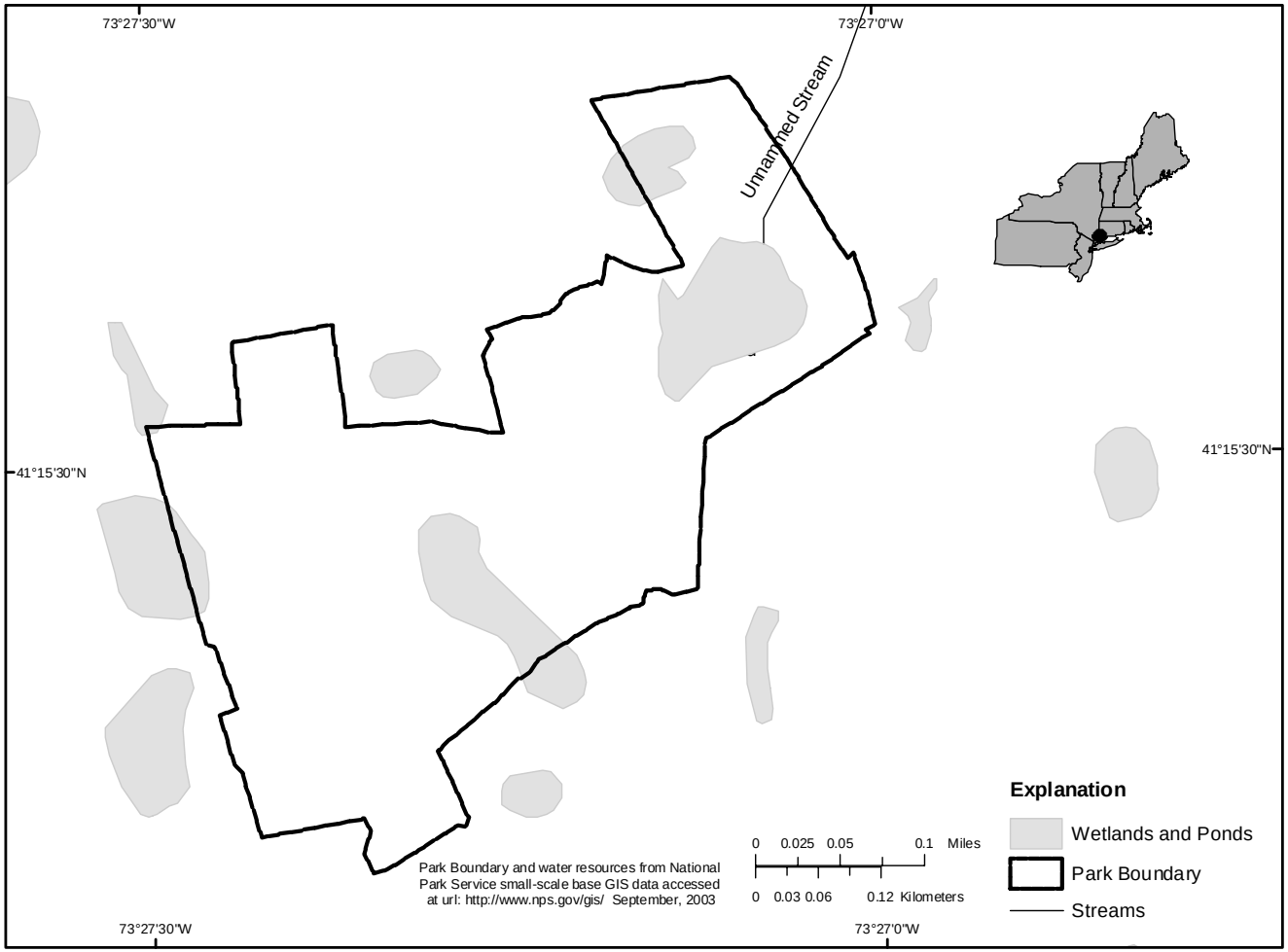


Figure 18. Freshwater resources at Weir Farm National Historic Site, Connecticut.

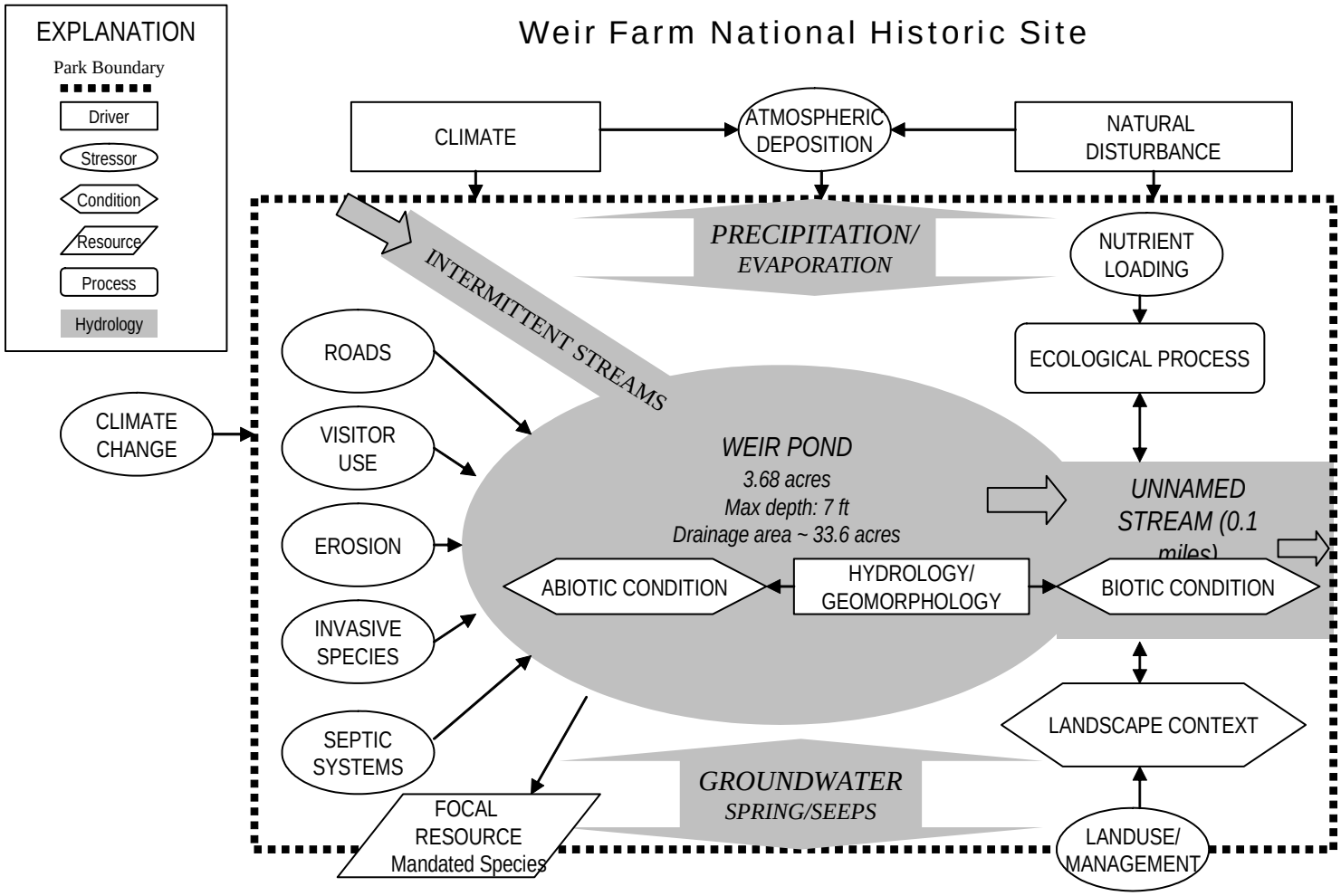


Figure 19. Conceptual model of freshwater ecosystems at Weir Farm National Historic Site, Connecticut.

Table 2. Potential natural resource threats to parks in the Northeast Temperate Network as indicated by natural resource staff [0, not a threat; 1, low threat; 2, high threat with present management concern].

STRESSORS	ACAD	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
Climate change										
Temperature change	1	1	1	1	1	1	1	1	1	1
Precipitation change	1	1	1	1	1	1	1	1	1	1
Atmospheric deposition										
Acid rain	2	2	2	2	2	2	2	2	2	2
External development										
Road runoff	2	0	1	2	2	2	2	2	2	1
Septic systems	2	0	0	2	2	2	2	2	2	1
Water withdrawals	2	0	0	2	2	2	2	2	2	0
Hydrologic alterations	1	0	0	1	0	1	0	2	2	0
Lawn chemicals	1	0	0	2	2	2	2	2	2	1
Wastewater treatment	1	0	0	2	2	2	2	2	2	0
Visitor use and park management										
Boats	1	0	0	1	0	0	0	0	1	0
Fishing	2	0	0	0	0	0	1	0	0	1
Roads/cars	2	0	2	2	2	2	2	2	2	2
Soil erosion	1	1	2	2	2	2	2	2	2	2
Forest harvest	0	0	2	0	1	0	1	0	0	0
Septic systems	1	1	1	1	1	1	1	1	1	2
Agriculture										
Nutrient loading	2	0	1	1	1	1	2	1	1	1
Irrigation	0	0	1	1	1	1	1	1	1	1
Agricultural chemicals	0	0	1	1	1	1	1	1	1	1
Livestock	0	0	1	1	1	1	1	1	2	1
Industry										
Water withdrawals	0	0	0	1	0	1	0	1	0	0
Contaminants	0	0	0	2	0	1	0	1	2	0
Invasive species										
Aquatic vegetation	2	2	2	2	2	2	2	2	2	2
Exotic fish	2	1	1	1	1	1	1	1	1	1
Wildlife										
Beaver activity	1	0	1	2	0	1	0	0	1	0

APPENDIXES

Appendix 1. USGS surface-water-discharge gaging stations and ground-water wells in Acadia National Park.

Appendix 2. USGS surface-water-discharge gaging stations and ground-water wells in all Northeast Temperate Network National Historical Parks, except Acadia.

Appendix 3. Summary of 305(b) Reports and 303(d) lists for freshwater bodies in or near Northeast Temperate Network National Parks.

Appendix 4. Freshwater body area statistics based on park Geographic Information Systems coverages and previously published information.

Appendix 1. USGS surface-water-discharge gaging stations and ground-water wells in and around Acadia National Park. [Data and site information for the above listed stations can be obtained at the following URL: http://waterdata.usgs.gov/nwis/inventory; DA, drainage area; SW, surface water; QW, water quality; GW, ground water; mi^2, square miles; Q, discharge.]

Station Name	Station Number	Latitude Longitude	Station Type	DA (mi^2)	In Park?	Data Type	Continuous/ Intermittent	Period of Record
Old Mill Brook at Old Norway Drive near Bar Harbor, Maine	01022800	44°23'55"	SW	1.55	No	Daily Q	C	4/99-9/00
		68°17'14"	QW			QW	I	2/99-9/00
Cadillac Brook near Bar Harbor, Maine	01022835	44°20'41"	SW	0.12	Yes	Daily Q	C	5/99-1/04
		68°13'02"						
Hadlock Brook nr Cedar Swamp Mtn near Northeast Harbor, Maine	01022860	44°19'54"	SW	0.18	Yes	Daily Q	C	4/99-1/04
		68°16'48"						
Old Mill Brook below Crooked Road near Bar Harbor, Maine	01022805	44°24'52"	SW	2.42	Yes	Q	I	4/99-9/00
		68°17'44"				QW	I	"
Stony Brook below Hamilton Pond near Bar Harbor, Maine	01022810	44°25'28"	SW	2.66	No	Q	I	4/99-8/00
		68°17'30"				QW	I	"
Aunt Betsey's Brook near Bar Harbor, Maine	01022815	44°24'22"	SW	0.63	No	Q	I	4/99-9/00
		68°19'10"				QW	I	"
French Hill Brook near Bar Harbor, Maine	01022817	44°24'23"	SW	0.56	No	Q	I	4/99-9/00
		68°18'44"				QW	I	"
Breakneck Brook near Bar Harbor, Maine	01022825	44°24'43"	SW	1.46	Yes	Q	I	2/99-9/00
		68°15'05"				QW	I	"
Otter Creek near Bar Harbor, Maine	01022840	44°19'58"	SW	1.35	Yes	Q	I	2/99-9/00
		68°12'26"				QW	I	"
Hunters Brook near Seal Harbor, Maine	01022845	44°18'34"	SW	1.37	Yes	Q	I	2/99-9/00
		68°13'20"				QW	I	"
Stanley Brook near Seal Harbor, Maine	01022850	44°18'20"	SW	1.36	No	Q	I	1/99-9/00
		68°14'30"				QW	I	"
Hadlock Brook at Sargent Drive at Northeast Harbor, Maine	01022865	44°18'08"	SW	0.18	No	Q	I	2/99-9/00
		68°17'58"				QW	I	"
Kitteredge Brook near Bar Harbor, Maine	01022875	44°22'46"	SW	2.84	No	Q	I	1/99-2/00
		68°19'52"				QW	I	"
Man of War Brook near Southwest Harbor, Maine	01022880	44°19'06"	SW	0.32	Yes	Q	I	1/99-9/00
		68°19'01"				QW	I	"
Marshall Brook near Southwest Harbor, Maine	01022890	44°16'29"	SW	1.97	Yes	Q	I	2/99-9/00
		68°21'06"				QW	I	"

Appendix 1. (cont.)

Station Name	Station Number	Latitude Longitude	Station Type	DA (mi^2)	In Park?	Data Type	Continuous/ Intermittent	Period of Record
Heath Brook near Tremont, Maine	01022895	44°16'40" 68°22'06"	SW	0.91	yes	Q QW	I I	2/99-9/00 "
Marshall Brook below Seal Cove Road near Southwest Harbor, Maine	441604068205701	44°16'04" 68°20'57"	SW	un-known	yes	QW	I	9/79-10/79
Marshall Brook Tributary at Seal Cove Rd nr Southwest Harbor, Maine	441702068210201	44°17'02" 68°21'02"	SW	un-known	yes	QW	I	9/79-10/79
Marshall Brook at Seal Cove Road near Southwest Harbor, Maine	441706068204701	44°17'06" 68°20'47"	SW	un-known	yes	QW	I	9/79-10/79
Marshall Brook Tributary at Mt Rd near Southwest Harbor, Maine	441734068214301	44°17'34" 68°21'43"	SW	un-known	yes	QW	I	9/79-10/79
Marshall Brook at Mt Rd near Southwest Harbor, Maine	441746068213001	44°17'46" 68°21'30"	SW	un-known	yes	QW	I	9/79-10/79
HW 137	441440068182701	44°14'40" 68°18'27"	GW	NA	yes	GW levels QW	I I	6/81-8/00 5/1985
ME-HW-173 Hio Hill near Southwest Harbor, Maine	441516068194101	44°15'16" 68°19'41"	GW	NA	yes	GW levels QW	C I	8/03-1/04 in progress
Me-HW-174 Seal Cove Road near Southwest Harbor, Maine	441650068210801	44°16'50" 68°21'08"	GW	NA	yes	GW levels QW	C I	10/03-1/04
HW 135A	44191068112101	44°19'19" 68°11'21"	GW	NA	yes	QW	I	1 day (7/27/1967)
HW 135B	442000068105501	44°20'00" 68°10'55"	GW	NA	yes	QW	I	1 day (7/27/1967)
HW 136	442102068134801	44°21'02" 68°13'48"	GW	NA	yes	QW	I	1 day (7/26/1967)
ME-HW-171 McFarland Hill near Bar Harbor, Maine	442238068154101	44°22'38" 68°15'41"	GW	NA	yes	GW levels QW	C I	8/03-1/04 in progress

Appendix 1 (cont.)

Station Name	Station Number	Latitude Longitude	Station Type	DA (mi^2)	In Park?	Data Type	Continuous/ Intermittent	Period of Record
ME-HW 170 (domestic well)	442405068165801	44°24'05" 68°16'58"	GW	NA	No	GW levels	I	1 day (12/21/1999)
ME-HW 168 (domestic well)	442408068194101	44°24'08" 68°19'41"	GW	NA	No	GW levels	I	1 day (12/21/1999
ME-HW 165 (domestic well)	442418068180701	44°24'18" 68°18'07"	GW	NA	No	GW levels	I	1 day (12/21/1999)
ME-HW 166 (domestic well)	442426068181901	44°24'26" 68°18'19"	GW	NA	No	GW levels	I	1 day (12/21/1999
ME-HW 169 (domestic well)	442436068201801	44°24'36" 68°20'18"	GW	NA	No	GW levels	I	1 day (12/21/1999
ME-HW 167 (domestic well)	442438068175201	44°24'38" 68°17'52"	GW	NA	No	GW levels	I	1 day (12/21/1999
ME-HW-172 Crooked Road near Bar Harbor, Maine	442450068175201	44°24'50" 68°17'52"	GW	NA	No	GW levels QW	C I	8/03-1/04 in progress
Northeast Creek at Rt 3 Bridge near Bar Harbor, Maine	01022820	44°25'29" 68°19'36"	Estuary	NA	No	Q QW	C C	5/31/2000-11/28/2001
Northeast Creek monitoring station 103	442507068185301	44°25'07" 68°18'53"	Estuary	NA	No	QW	C	5/31/2000-11/28/2001
Northeast Creek monitoring station 104	442509068181901	44°25'09" 68°18'19"	Estuary	NA	No	QW	C	5/31/2000-11/28/2001
Northeast Creek monitoring station 105	442516068175501	44°25'16" 68°17'56"	Estuary	NA	No	QW	C	5/31/2000-11/28/2001
Northeast Creek monitoring station 102	442517068190501	44°25'18" 68°19'05"	Estuary	NA	No	QW	C	5/31/2000-11/28/2001
Northeast Creek monitoring station 100	442530068193901	44°25'30" 68°19'40"	Estuary	NA	No	QW	I	5/31/2000-11/28/2001

Appendix 2. USGS surface-water-discharge gaging stations and ground-water wells in and around Northeast Temperate Network National Historical Parks.

[ACAD stations are in Appendix 1 only; Stations in bold text are most representative continuous-record streamflow gaging-station for the national park for which it is listed, and which is currently in operation; Data and site information for the above listed stations can be obtained at the following URL: http://waterdata.usgs.gov/nwis/inventory. DA, drainage area; SW, surface water; QW, water quality; GW, ground water; mi^2, square miles; Q, discharge; NA, not applicable/not available.]

Park	Station Name	Station Number	Latitude Longitude	DA (mi^2)	Years of Record	Data Type	In Park?	*Remarks*
MABI	**Ottauquechee River at North Hartland, Vermont**	**01151500**	**43°36'09" 72°21'17"**	**221**	**1927-2001 1930-2002 1954-1999**	**Peak Q Daily Q QW**	**No**	
	Ottauquechee River at Woodstock, Vermont	01151000	43°37'29" 72°31'14"	126	1927-1930 1928-1930	Peak Q Daily Q	No	
	VT-X8W 14	433740072305801	43°37'41" 72°30'57"	NA	1994	GW QW		
MIMA	**Concord River below Meadow Brook at Lowell, Massachusetts**	**01099500**	**42°38'12" 71°18'09"**	**400**	**1938-2001 1936-2002 1952-1994**	**Peak Q Daily Q QW**	**No**	
MORR	**Passaic River near Millington, New Jersey**	**01379000**	**40˚40'48" 74˚31'44"**	**55.4**	**1904-2002 1903-2002 1923-1998**	**Peak Q Daily Q QW**	**No**	**Real-time site**
	Passaic River near Bernardsville, New Jersey	01378690	40°44'03" 74°32'25"	8.83	1968-2001 1967-1976 1965-1979	Peak Q Daily Q QW	No	Not currently active
	Primrose Brook in Morristown National Historic Park, New Jersey	01378780	40°45'54" 74°31'47"	1.07	1997-2001	QW	Yes	
	WB Primrose Brook in Morristown National Historic Park, New Jersey	01378775	40°46'11" 74°32'10"	NA	0	QW	Yes	New station in 2003; no data yet
	EB Primrose Brook in Morristown National Historic Park, New Jersey	01378778	40°46'14" 74°31'26"	NA	0	QW	Yes	New station in 2003; no data yet

Appendix 2. (cont.)

Park	Station Name	Station Number	Latitude Longitude	DA (mi^2)	Years of Record	Data Type	In Park?	*Remarks*
ROVA	**Rondout Creek at Rosendale, New York**	**01367500**	**41˚50'35" 74˚05'11"**	**383**	**1902-2002 1901-2002 1962-1994**	**Peak Q Daily Q QW**	**No**	**Real-time site**
	Wappinger Creek near Wappingers Falls, New York	**01372500**	**41˚39'11" 73˚52'23"**	**181**	**1929-2002 1928-2002 1959-1994**	**Peak Q Daily Q QW**	**No**	**Real-time site**
	Crum Elbow Creek at Hyde Park, New York	01372040	41°47'24" 73°55'53"	17.3	1960-1976 1960-1962 1966	Peak Q Daily Q QW	No	Not currently active
	Fall Kill at Poughkeepsie, New York	01372051	41°42'36" 73°55'36"	18.8	1994-1995 1993-1995 1993-1995	Peak Q Daily Q QW	No	
	Crum Elbow Creek near Hyde Park, New York	0137203960	41°48'00" 73°54'52"	16.5	1992	QW	No	
	Hyde Park Fire & WD-Crum Elbow Creek 1843D	414729073555700	41°47'29" 73°55'57"	NA	1971; 1 day	QW		1 round of sampling
	Hyde Park Fire &WD WTP-Crum Elbow Creek 1843T	414730073555600	41°47'30" 73°55'56"	NA	1975; 1 day	QW		1 round of sampling
	Hyde Park Fire & WD WTP-Crum Elbow Creek 1843T	414730073555601	41°47'30" 73°55'56"	NA	1975; 1 day	QW		1 round of sampling
SAGA	**Sugar River at West Claremont, New Hampshire**	**01152500**	**43°23'15" 72°12'45"**	**269**	**1929-2001 1928-2002 1953-1999**	**Peak Q Daily Q QW**	**No**	
	Ottauquechee River at North Hartland, Vermont	**01151500**	**43°36'09" 72°21'17"**	**221**	**1927-2001 1930-2002 1954-1999**	**Peak Q Daily Q QW**	**No**	
	Blow-Me-Down Brook near Plainfield, New Hampshire	01151610	43°30'09" 72°22'20"	unknown	1 day	QW	No	1 round of sampling
SAIR	**Saugus River at Saugus Iron Works at Saugus, Massachusetts**	**01102345**	**42°28'10" 71°00'27"**	**20.8**	**1994-2000 1994-2002 1994-2001**	**Peak Q Daily Q QW**	**No**	

Appendix 2. (cont.)

Park	Station Name	Station Number	Latitude Longitude	DA (mi^2)	Years of Record	Data Type	In Park?	*Remarks*
SARA	**Hudson River at Stillwater, New York**	**01331095**	**42˚56'08" 73˚39'08"**	**3,773**	**1913-2002 1977-2002 1969-2002**	**Peak Q Daily Q QW**	**No**	
	Mohawk River Diversion at Crescent Dam, New York	**01357499**	**42˚48'10" 73˚42'11"**	**NA**	**1925-2002**	**Daily Q**	**No**	
	Saratoga National Park, SA-1072	430013073370401	43°01'13" 73°37'04"	224 ft	1959-1995	GW levels	Yes	
WEFA	**Norwalk River at South Wilton, Connecticut**	**01209700**	**41°09'49" 73°25'11"**	**30**	**1955-2002 1962-2002 1962-2002**	**Peak Q Daily Q QW**	**No**	

Appendix 3. Summary of 305(b) Reports and 303(d) lists for freshwater bodies in or near Northeast Temperate Network National Parks. [Parks listed in alphabetical order; waterbodies listed in **bold text** are within the park boundaries; waterbodies listed in plain text are adjacent to or near park boundaries.]

Acadia National Park (ACAD)

Waterbody	305(b) Assessment Information[1]		303(d) Information[2]		
	Unit ID	Impairments	List ID	Reason	TMDL[3]
All rivers and lakes	not available	not available	ME9985_LR	FCA Mercury	none
Long Pond	was on 303d list, but removed b/c attained QW standards		not available	not available	none
Mt Desert coastal lakes	not available	not available	not available	not available	none
Mt Desert coastal rivers	514R	attaining some, insuff. data for other uses	not available	not available	none
Tinker Brook- West Tremont	707-11	insuff. data to determine attainment	not available	not available	none

[1] http://oaspub.epa.gov/waters/state_rept.control?p_state=ME (electronic copy not submitted to USEPA as of 11/03)
[1] http://www.state.me.us/dep/blwq/docmonitoring/305bappendix.pdf
[2] http://www.wcei.org/maine/me-contents.html
[3] http://oaspub.epa.gov/waters/state_rept.control?p_state=ME
Further state information can be obtained at dave.l.courtemanch@state.me.us

Boston Harbor Islands National Recreation Area (BOHA)

Waterbody	305(b) Assessment Information[1]		303(d) Information[2]		
	Unit ID	Impairments	List ID	Reason	TMDL[3]
Ice Pond	not available	not available	MA74028	Pesticides	none

[1] http://oaspub.epa.gov/waters/w305b_report.state?p_state=MA
[2] http://www.wcei.org/massachusetts/ma-contents.html
[3] http://oaspub.epa.gov/waters/region_rept.control?p_region=MA
Further state information can be obtained at **Richard.Mcvoy@state.ma.us**

Marsh-Billings-Rockefeller National Historical Park, Vermont (MABI)

Waterbody	305(b) Assessment Information[1]		303(d) Information[2]		
	Unit ID	**Impairments**	**List ID**	**Reason**	**TMDL[3]**
All rivers and lakes	not available	not available	VT3526_LR-1998	FCA mercury	none
The Pogue Pond	not available	not available	not available	not available	none
Pogue Hole Brook	not available	not available	not available	not available	none

Appendix 3. (cont.)

[1] http://oaspub.epa.gov/waters/w305b_report.state?p_state=VT
[2] http://www.wcei.org/vermont/vt-contents.html
[3] http://oaspub.epa.gov/waters/region_rept.control?p_region=VT
Further state information can be obtained at **http://www.anr.state.vt.us/dec/waterq/Planning/Assessment.2000.pdf**

Minute Man National Historic Park, Massachusetts (MIMA)

Waterbody	305(b) Assessment Information[1]		303(d) Information[2]		
	Unit ID	**Impairments**	**List ID**	**Reason**	**TMDL[3]**
All rivers and lakes	n/a	n/a	MA4348_LR-1998	FCA mercury	none
Concord River	MA82A-07_00	metals, total toxics	MA82A-08_1998	metals, nutrients	none
			MA82A-07_1998	metals, nutrients, pathogens	
			MA82A-09_1998	nutrients, pathogens	
Elm Brook	MA83-05_00	nutrients, pathogens, turbidity	not available	not available	none
Mill Brook	MA42-10_00	not available	not available	not available	none
	MA41-07_00				

[1] http://oaspub.epa.gov/waters/w305b_report.state?p_state=MA
[2] http://www.wcei.org/massachusetts/ma-contents.html
[3] http://oaspub.epa.gov/waters/region_rept.control?p_region=MA
Further state information can be obtained at **Richard.Mcvoy@state.ma.us**

Appendix 3. (cont.)

Morristown National Historic Park, New Jersey (MORR)

Waterbody	305(b) Assessment Information[1]		303(d) Information[2]		
	Unit ID	Impairments	List ID	Reason	TMDL[3]
Primrose Brook	not available	not available	not available	not available	none
East Branch Primrose Brook	not available	not available	not available	not available	none
West Branch Primrose Brook	not available	not available	not available	not available	none
Jersey Brook	not available	not available	not available	not available	none
Great Swamp	not available	not available	not available	not available	none
Cat Swamp Pond	not available	not available	not available	not available	none
Indian Grave Brook	not available	not available	not available	not available	none
Passaic River	not available	not available	not available	not available	none
Ledell's Pond	not available	not available	not available	not available	none

[1] http://oaspub.epa.gov/waters/w305b_report.state?p_state=NJ
[2] http://www.wcei.org/newjersey/nj-contents.html
[3] http://oaspub.epa.gov/waters/state_rept.control?p_state=NJ#WBTYPE
Further state information can be obtained at **http://www.state.nj.us/dep/dsr/watershed/305b/305b.htm**

Roosevelt-Vanderbilt National Historic Site, New York (ROVA)

Waterbody	305(b) Assessment Information[1]		303(d) Information[2]		
	Unit ID	Impairments	List ID	Reason	TMDL[3]
Fall Kill Creek	not available	not available	not available	not available	none
Crum Elbow Creek	not available	not available	not available	not available	none
Meriches (Maritje) Kill	not available	not available	not available	not available	none

[1] http://oaspub.epa.gov/waters/w305b_report.state?p_state=NY
[2] http://www.wcei.org/newyork/ny-contents.html
[3] http://oaspub.epa.gov/waters/region_rept.control?p_region=NY
Further state information can be obtained at **jamyers@gw.dec.state.ny.us**

Appendix 3. (cont.)

Saint-Gaudens National Historic Site, New Hampshire (SAGA)

Waterbody	305(b) Assessment Information[1]		303(d) Information[2]		
	Unit ID	Impairments	List ID	Reason	TMDL[3]
Blow-Me-Down Brook	not available	not available	not available	not available	none
Blow-Me-Up Brook	not available	not available	not available	not available	none
Blow-Me-Down Pond	not available	not available	not available	not available	none
Farm Pond	not available	not available	not available	not available	none

[1] http://oaspub.epa.gov/waters/w305b_report.state?p_state=NH
[2] http://www.wcei.org/newhampshire/nh-contents.html
[3] http://oaspub.epa.gov/waters/state_rept.control?p_state=NH
Further state information can be obtained at **www.des.state.nh.us/wmb/wmbpubs.htm**

Saratoga National Historic Park, New York (SARA)

Waterbody	305(b) Assessment Information[1]		303(d) Information[2]		
	Unit ID	Impairments	List ID	Reason	TMDL[3]
Kroma Kill	not available	not available	not available	not available	none
Mill Creek	not available	not available	not available	not available	none
American's Creek	not available	not available	not available	not available	none
Devil's Hollow	not available	not available	not available	not available	none

[1] http://oaspub.epa.gov/waters/w305b_report.state?p_state=NY
[2] http://www.wcei.org/newyork/ny-contents.html
[3] http://oaspub.epa.gov/waters/region_rept.control?p_region=NY
Further state information can be obtained at **jamyers@gw.dec.state.ny.us**

Saugus Iron Works National Historic Site, Massachusetts (SAIR)

Waterbody	305(b) Assessment Information[1]		303(d) Information[2]		
	Unit ID	Impairments	List ID	Reason	TMDL[3]
Saugus River	MA93-14_00	ID for estuary only; impairments n/a	MA93-13_1998	Pathogens	none

[1] http://oaspub.epa.gov/waters/w305b_report.state?p_state=MA
[2] http://www.wcei.org/massachusetts/ma-contents.html
[3] http://oaspub.epa.gov/waters/region_rept.control?p_region=MA
Further state information can be obtained at **Richard.Mcvoy@state.ma.us**

Appendix 3. (cont.)

Weir Farm National Historic Site, Connecticut (WEIR)

Waterbody	305(b) Assessment Information[1]		303(d) Information[2]		
	Unit ID	Impairments	List ID	Reason	TMDL[3]
All rivers and lakes	not available	not available	CT4015_LR-1998	FCA Mercury	none
Weir Pond	not available	not available	not available	not available	none

[1] http://oaspub.epa.gov/waters/w305b_report.state?p_state=CT#assessed_waters
[2] http://www.wcei.org/connecticut/ct-contents.html
[3] http://oaspub.epa.gov/waters/state_rept.control?p_state=CT#TPOL
Further state information can be obtained at **ernest.pizzuto@po.state.ct.us**

Appendix 4. Freshwater body area statistics based on park Geographic Information System coverages and previously published information.

	Great Ponds (greater than 10 acres)		Small Ponds (less than 10 acres)		Streams		Palustrine wetlands	**Source**
	number	acres	number	acres	number	miles	acres	
Acadia National Park	14	2,370	10	50	41	(less than 2-3 miles each)	2,590	**Kahl and others, 2000 Cowardin and others, 1979**
Boston Harbor Island National Recreation Area	0	0	1	*	0	0	31	**Tiner and others, 2003**
Marsh-Billings-Rockefeller National Historical Park	1	15	0	0	1	0.9	5	**National Park Service, 2003f**
Minute Man National Historical Park	0	0	3	*	3	1.2	200	**National Park Service, 2003f**
Morristown National Historical Park	0	0	1	*	5	4.4	22	**National Park Service, 1993; National Park Service, 2003f**
Roosevelt-Vanderbilt National Historic Site	0	0	12	15	3	4.5	72	**National Park Service, 2003f**
Saint-Gaudens National Historic Site	0	0	2	5	2	1.6	18	**National Park Service, 2003f**
Saugus Iron Works National Historic Site	0	0	0	0	1	.15	5	**National Park Service, 2003f**
Saratoga National Historic Park	0	0	2	*	4	12.8	175	**National Park Service, 2003f**
Weir Farm National Historic Site	0	0	1	4	1	.06	2.5	**National Park Service, 2003f**

* Included in wetland acreage.

Appendix H: Monitoring Programs in Northeast Temperate Network Parks

History of Monitoring Programs in NETN Parks

Summary of historical, recent, and ongoing monitoring programs within Northeast Temperate Network Parks (ACAD-MORR). >5 indicates an historical program more than 5 yrs. old, <5 indicates a more recent program that has been discontinued, and + indicates an ongoing monitoring program.

Monitoring Program	ACAD			APPA			BOHA			MABI			MIMA			MORR		
	Years			Years			Years			Years			Years			Years		
	>5	<5	+	>5	<5	+	>5	<5	+	>5	<5	+	>5	<5	+	>5	<5	+
Air Quality																		
Ozone			**X**															
Visibility			**X**															
Particulates			**X**															
Deposition			**X**															
Toxics																		
Biota																		
Invertebrates			**X**															
Nuisance																		
Birds																		
Mammals																X		**X**
Vegetation			**X**															
Vertebrates																		
Fish																		
Amphibians																		
Reptiles																		
Birds			**X**															
Mammals																		
Vegetation																		
R&E Species			**X**	X		**X**											X	**X**

Appendix H: Monitoring Programs in Northeast Temperate Network Parks

Monitoring Program	ACAD			APPA			BOHA			MABI			MIMA			MORR		
	Years			Years			Years			Years			Years			Years		
	≥5	<5	+	≥5	<5	+	≥5	<5	+	≥5	<5	+	≥5	<5	+	≥5	<5	+
Communities				X		**X**										X		**X**
Non-vascular																		
Exotic Plants			**X**															
Exotic Insects			**X**															
Fire Effects			**X**															
Forest Health												**X**				X		
Geologic Resources																		
Soils																		
Land Use Change																		
Soundscapes																		
Visitor Use/Carrying Capacity			**X**						**X**									
Visual Landscape																		
Water Quality																		
Ground Water																		
Surface Water	X		**X**													X		**X**
Wetlands																		
Lake	X		**X**															
Swim Beach Bacteria	X																	
UVB	X		**X**															

Appendix H: Monitoring Programs in Northeast Temperate Network Parks

Summary of historical, recent, and ongoing monitoring programs within NETN parks (ROVA-WEFA). >5 indicates an historical program more than 5 yrs. old, <5 indicates a more recent program that has been discontinued, and + indicates an ongoing monitoring program.

Monitoring Program	ROVA			SAGA			SAIR			SARA			WEFA		
	Years			Years			Years			Years			Years		
	>5	<5	+	>5	<5	+	>5	<5	+	>5	<5	+	>5	<5	+
Air Quality															
Ozone															
Visibility															
Particulates															
Deposition															
Toxics															
Biota															
Invertebrates						X									
Nuisance															
Birds												X			
Mammals										X		X			
Vegetation						X									
Vertebrates															
Fish															
Amphibians		X	X		X										
Reptiles															
Birds		X	X									X			
Mammals															
Vegetation															
R&E Species															
Communities															
Non-vascular															
Exotic Plants						X									

Appendix H: Monitoring Programs in Northeast Temperate Network Parks

Monitoring Program	ROVA			SAGA			SAIR			SARA			WEFA		
	Years			Years			Years			Years			Years		
	>5	<5	+	>5	<5	+	>5	<5	+	>5	<5	+	>5	<5	+
Exotic Insects						X									
Fire Effects											X	X			
Forest Health						X									
Geologic Resources															
Soils															
Land Use Change															
Soundscapes															
Visitor Use/Carrying Capacity															
Visual Landscape										X		X			
Water Quality															
Ground Water															
Surface Water			X			X		X	X						
Wetlands														X	X
Lake															
Swim Beach Bacteria															
UVB															

Current Monitoring Programs in NETN Parks

Summary of current monitoring programs taking place within Northeast Temperate Network parks.

PARK	PROGRAM	DESCRIPTION
ACAD	Air Quality: Class I	**Gaseous Pollutant Monitoring**: 1)ground level ozone, 2)Sulfur Dioxide, 3)Nitrogen Oxides and volatile organic compounds; 1982-present **Meteorological Monitoring** **Visibility Monitoring:** 1)Fine particulate monitoring, 2)optical monitoring, 3)scene monitoring **Atmospheric Deposition Monitoring:** 1)Acid precipitation monitoring (NADP), 2)Mercury deposition monitoring, 3)dry deposition monitoring; 1978-present **Ultraviolet Radiation Monitoring (UV-B):** 1998-present **PRIMENet Program:** 1998-present
	Water Quality	**Lake Monitoring:** temp, dissolved oxygen, transparency, pH, specific conductance, alkalinity, color, total phosphorus, total nitrogen, chlorophyll a, lake stage, and light penetration; 1980-present B**enthic Stream Macroinvertebrate Monitoring:** benthic macroinvertebrates, habitat characterization, stream temp, pH, dissolved oxygen, specific conductance, color, and flow rate; 1997-present **Atmospheric Deposition:** National Atmospheric Deposition Program (NADP), 1980-present; and Mercury Deposition Network (MDN), 1995-present **Geographic Information System Applications**: Arc View databases and watershed atlas **Cooperators:** Maine Dept of Environmental Protection, USGS, and University of Maine at Orono.
	Invertebrates	**Macroinvertebrate** monitoring is part of the water quality program and Benthic Stream Macroinvertebrate Monitoring. Indicators are: habitat characterization, stream temp, pH, dissolved oxygen, specific conductance, color, and flow rate.
	Vegetation	1100 vascular plant species that represent a wide diversity of plant life adapted to thrive in acidic, low nutrient bogs and rocky, treeless mountain summits
	Birds	**MAPS:** Schoodic Point, habitat is evergreen woodland/mixed shrubland **Peregrine Falcons and Bald Eagles** in FY 2003 were monitored (nesting and reproduction) and data entered in an ACCESS database. Peregrine Falcons have been monitored since 1984 and Bald Eagles for several years.
	Veg R&E Species	**25** species of plants are state listed rare plants
	Exotic Plants	**Invasive Species:** one quarter of the vegetation is non-native. In FY 2003, 24 plants are listed as high management concern and a distribution and abundance survey was completed for these. Garlic Mustard, Japanese Barberry, and Purple Loosestrife top the list. Control efforts on seven new exotic invasive plant species, treating 18 acres, was initiated.
	Exotic Insects	**Integrated Pest Management:** oversees management of and control of exotic insects. Indicators include the threat, or possible threat, to native species.

Appendix H: Monitoring Programs in Northeast Temperate Network Parks

PARK	PROGRAM	DESCRIPTION
	Fire Effects	**Hazard fuels** management, fire suppression, prescribed fire, reduction of wildland/urban interface hazards, monitoring of prescribed fires and long-term forest conditions, and research into fire effects and the long-term history of wildland fire in the park.
	Visitor Use	**Carrying** capacity for carriage roads, climbing management plan, Leave No Trace and other public education, and visitor surveys.
APPA	Veg R&E Species	**Rare** and Endangered Species of plants have been identified and are being monitored through the cooperation of the state Natural Heritage Foundations.
	Veg Communities	**Vegetation** is being monitored with the cooperation of the Keeping Track protocol which helps participants use wildlife to assess habitat quality and overall forest health. This is occurring at transects on the Appalachian Trail corridor in Vermont. **The Southern** Appalachian Man and the Biosphere Foundation based Southern Appalachian Volunteer Environmental Monitoring Program is another program occurring on the AT. This program is taking place from north Georgia to southwest Virginia. Water quality, invasive exotic plants, and forest health in ten communities are being monitored.
	Water Quality	**Water** quality monitoring will be occurring through the assistance of the NPS Natural Resource Laureate Program and the Environmental Alliance for Senior Involvement. Scheduled to begin in May 2004 the goal of the program is to have a self-sustaining volunteer-based monitoring program that provides consistent, reliable water-quality information for approximately 50 to 200 key sites along the Appalachian Trail.
BOHA	Water Quality (Monitored by Ma. State Agencies)	**Environmental Health Ecosystem Indicator:** water clarity, nutrient/eutrophication status, sewage indicator bacteria, sediment profile/geochemistry, benthic infaunal community structure, blue mussel bioaccumulation, winter flounder monitoring, lobster monitoring, and eel grass **BOHA Water Quality Parameters:** surface + bottom: temperature, dissolved oxygen, salinity, turbidity, pH, Photosynthetically Active Radiation, secchi depth, transmissivity, fecal coliform bacteria, *Enterococcus* bacteria, Total Suspended Solids, Particulate Nitrogen, Total Dissolved Nitrogen, Nitrate/Nitrite, Ammonium, Total Dissolved Phosphorus, Orthophosphate, Particulate Organic Carbon, Chlorophyll *a*, Phaeophytin
	Visitor Use	**Visitor Experience and Resource Protection (VERP)**: number of people at one time, tour group size, trail encounters, trail impacts, campsite impacts, litter, graffiti, ferry service, shuttle service, amount of information, quality of information
MABI	Forest Ecosystem Dynamics	**Forest Monitoring** has been occurring since 2001 at 64 different plots with the cooperation of the University of Vermont. Indicators are: size class distribution and dominance, mortality processes and self-thinning, compositional dynamics and regeneration demography, deer browse impacts, crown condition, beech bark disease, regeneration trends, vertical structure, downed coarse woody debris, dead tree structure, understory plant assemblages, and legacy trees.
MORR	Water Quality	**Water quality** is monitored at 11 sites on a monthly basis since 1988 for: dissolved oxygen, pH, TDS, water temperature, Cl (chloride).
	Mammals	**Monitoring** deer populations and the effects on the site using deer exclosures since 1988 and monitored annually, spot light counts are done annually since 1998, tree seedling plots monitored annually since 1994, and Jack-in-the-Pulpit populations inside and out of exclosure areas since 1998.

Appendix H: Monitoring Programs in Northeast Temperate Network Parks

PARK	PROGRAM	DESCRIPTION
	Veg R&E Species	**5** plants are listed with New Jersey as threatened
	Veg Communities	**Field Mowing Program** is in place to recreate the historic scene, 15 fields are mowed totaling 122 acres. Twelve fields are mowed once every year or two to maintain the field in an advanced successional or abandoned state. Three fields are mowed two to four times each year to provide a new field appearance for historical aesthetics. **Exclosures:** Five exclosure/vegetation studies are being conducted. One set of exclosures compares the differences in type and structure of vegetation with and without deer browsing and is sampled yearly (began in 1987-88); the second set of exclosures has four plots and will compare over time the rate of range expansion of two invasive non-native species: Japanese Barberry and Japanese Wiregrass with and without browsing (1995). Additional studies include exclosures to monitor the effect of deer browsing on Jack-in the Pulpit (1997), determine the viability of reintroduction of native wildflowers (1997), and to protect native seedlings (1995).
ROVA	Water Quality	**Monthly:** Monitoring began in 1994 and measures temperature, pH, dissolved oxygen, salinity, and conductivity **Quarterly:** chloride, alkalinity, phosphate, turbidity, and nitrate
	Amphibians	**Targeted** species monitoring since 1990 (mark/release); Terrestrial Salamander Monitoring Program (USGS protocol) started in 2000. State threatened blandings turtle is at the site.
	Birds	**MAPS 1990-present:** Stanfordville, habitat is wetland/fields/forest/plantation
SAGA	Water Quality	**Water quality** is monitored at 5 stations since 1997 on a monthly basis May-November for 15-20 parameters, including: water temperature, water depth, dissolved oxygen, conductivity, pH, and turbidity. The results are reported annually. (There is one additional station just outside the park.)
	Forest Health	**US Forest Service** has been conducting the survey since 1995, checking 18 plots once every 4 years. Indicators are: species, diameter at breast height, distance, azimuth, live crown ratio, crown position, crown vigor, trunk/bole defects, crown dieback, foliage transparency, discoloration, defoliation
	Invertebrates	**Macroinvertebrate** monitoring in streams.
	Vegetation	**Vegetation monitoring** is done in conjunction with the Forest Monitoring in cooperation with the US Forest Service and is used to find exotic species and their effects on park vegetation.
	Exotic Plants	**Purple Loosestrife** is being monitored and controlled through a beetle release program in cooperation with the NH Dept of Agriculture. Other exotic plants are of management concern such as Norway Maple, multiflora rose, in addition to many others.
	Exotic Insects	**Hemlock Wooly Adelgid:** monitoring is extremely important, as early detection and subsequent mitigation may prevent significant damage to the approximately 1,100 hemlocks in the site's historic hedges. Forest health monitoring plots, established by the U.S. Forest Service, located in areas with high concentrations of hemlock will be used by park resource management staff to conduct annual examinations for the presence of hemlock woolly adelgid. **Gypsy Moth, Asian Longhorned Beetles, Emerald Ash Borer** monitoring is also occurring in the park.

PARK	PROGRAM	DESCRIPTION
SAIR	Water Quality	**Water quality:** has been measured since 1994 on a monthly basis May-October. **Water:** bacteria, pH, turbidity, dissolved oxygen **Sediment Sample:** inorganic elements, polyaromatic hydrocarbons, polychlorinated biphenyls, and organochlorine pesticides
SARA	Birds	**Sparrows** species listed by the state as "Species of Special Concern" use the fields in the park as nesting areas.
	Mammals	**Deer** population is being monitored to prevent possible ecological conflict between deer and vegetation.
	Fire Effects	**Prescribed** fire, fire suppression, hazard fuels reduction, history of fire effects in park.
	Visual Landscape	**Preservation** of historic landscape comprising the eighteenth century battlefield.
WEIR	Water Quality	**Weir Pond** has been monitored annually since 2000.

Current Aquatic Monitoring Programs at NETN Parks

Five parks currently have water-quality and (or) water-quantity monitoring programs. The parks are ACAD, MORR, ROVA, SAGA, and SAIR. BOHA benefits from a monitoring program conducted by the Massachusetts Water Resources Authority (MWRA). The monitoring programs are summarized in the Phase I scoping report. The period of data collection varies; some monitoring programs were initiated as early as the 1970s and some as recently as 1998. The parks that do have monitoring programs primarily include the measures included in the high-priority vital sign water chemistry selected for the NETN monitoring program. Data collected as a part of this program will provide historical comparisons and context for the data collected by the vital-signs program. In some cases, the NETN monitoring program will build on the program currently in place, especially where measures, sampling locations, and(or) sampling protocols are similar across programs. In other cases, however, because the monitoring programs at some of the parks are focused on specific aquatic resources or have different objectives than the vital-signs program, compatibility with the vital-signs program will vary. The remaining five parks (MABI, MIMA, SARA, WEFA, BOHA) have no known current freshwater-quality monitoring at present (2004) and will not be included in this part of the report.

Current Aquatic Monitoring Programs at NETN Parks Compared to High-Priority Vital Signs

The purpose of this section of the report is to determine the compatibility between data currently being collected (including protocols, quality assurance/quality control, and data-storage practices) and the measures associated with the high-priority vital signs selected for the NETN vital-signs monitoring program.

Direct comparisons or incorporation of the data from previous monitoring programs may be problematic for the following reasons. First, methods of analysis may have changed. For example, biological monitoring of stream macroinvertebrate communities has been conducted at four of the five parks, but the protocols or analyses are not consistent across the parks. For chemical analyses, there are different analyses used for certain constituents (e.g., pH) and so the results are not always comparable. Additionally, as chemical analytical methods advance and become more sensitive, detection limits decrease and accuracy and precision increase. As changes in methodology progress, comparability decreases. For those parameters that are consistent with the high-priority vital signs, the number of samples or the frequency of sampling may not be the same. This introduces differences in estimates of variability (standard deviations and coefficients of variation) and affects measures of central tendency such as the mean or median values. At many of the parks, data from the vital signs such as climate and water quantity, which are important for interpreting water quality data, are intermittent or unavailable. Without this contextual information, including information about vital signs such as channel morphology or lake morphometry, historical trends in water quality will be difficult to interpret. Concentrations of chemical components change with dilution, and thus depend on water quantity. Standardization of concentration data by using water quantity data to calculate annual loads and yields can not be accomplished without water-quantity data, and so year-to-year comparisons become difficult.

A matrix shows where suggested measures and current measures intersect (Table H1). The high-priority vital signs, and their mandatory and optional measures are listed down the vertical axis and the parks are listed along the top horizontal axis. In the corresponding box under each park are the components of the current monitoring programs.

Climate

None of the parks are collecting climate data. Meteorological measures such as precipitation, temperature, snowfall, snowpack conditions, and wind direction and speed are often available regionally from NOAA, National Weather Service, and the NADP. In some cases, meteorological stations run by these agencies are within or very close to park boundaries.

Stream gemorphology

Only ACAD and MORR are regularly collecting stream geomorphology data. The Rapid Bioassessment protocol conducted at MORR does not, however, include many of

the mandatory measures identified for this vital sign. The ACAD program includes many of the mandatory and optional measures. SAIR has limited stream morphology data at the USGS gage.

Lake morphometry

Several parks have had bathymetric surveys done at lakes within the parks. Most parks have estimates of surface area and mean depth of the lakes.

Water quantity

All the parks have access to local USGS stream-gaging data as part of their monitoring program. ACAD has 2 continuous-record streamflow gages within the park, and SAIR has a continuous-record streamflow gage just upstream from its northern boundary. Incidental streamflow measurements are collected at SAGA as part of the monitoring program. A USGS ground-water program at ACAD monitors water levels. None of the parks, except for SAIR, have mapped or consistently measured discharge at springs or seeps.

Water chemistry

All the parks have some type of water chemistry monitoring program. Many of the mandatory high-priority vital signs are collected as part of these programs, e.g., water temperature, pH, dissolved oxygen, and conductivity. Differences then become park specific. Mandatory measures of NETN high-priority vital signs that are currently being measured by park personnel could be incorporated into the NETN monitoring program. The only park where this might pose some difficulty is at SAIR, where water chemistry (except for temperature and specific conductance) is sampled by volunteers.

Appendix H: Monitoring Programs in Northeast Temperate Network Parks

Table H.1. Comparison of current park aquatic monitoring program components with high-priority vital signs.

[Empty boxes indicate no program components for the vital sign at a specific park; USGS, U.S. Geological Survey; NADP, National Atmospheric Deposition Program; NOAA, National Oceanic and Atmospheric Agency; NWS, National Weather Service; NPS, National Park Service; DEP, Department of Environmental Protection].

Vital Sign	Proposed measures	Measures currently collected					
		Acadia National Park	**Boston Harbor Island National Recreation Area**	**Morristown National Historical Park**	**Roosevelt-Vanderilt National Historic Site**	**Saint-Gaudens National Historic Site**	**Saugus Iron Works National Historic Site**
Climate	Optional: Air temperature and precipitation Wind speed and direction, precipitation by type, snow depth, snow water equivalent, relative humidity, and solar radiation.	NADP collects precipitation and air temperature data. NOAA and NWS collect precipitation, temperature, snowfall, snowpack conditions, wind direction and speed data.					USGS collects precipitation, air temperature, wind speed and direction data just upstream from park (station does not conform to National Weather Service standards).
Stream geomorphology	Mandatory: Stream order, drainage area, gradient Optional: Run/riffle/pool geometry, bank full cross-sectional geometry, stream sinuosity a substrate map of the stream bottom, surveys of channel geomorphologic units	Stream physical habitat data is collected at six macroinvertebrate monitoring sites by NPS. Data include channel width, depth, substrate composition, and canopy cover. Data not yet analyzed.	Not applicable	Stream habitat is evaluated with the rapid bioassessement program (Plafkin and others, 1989).			USGS has drainage area and bankfull cross-sectional geometry data just upstream from park.

Appendix H: Monitoring Programs in Northeast Temperate Network Parks

Lake morphometry	<u>Mandatory:</u> Surface area, maximum and mean depth, drainage area, lake type and origin, bathymetry, and elevation <u>Optional:</u> Flushing rate	Surface area, maximum and mean depth, lake type and flushing rates for many of Acadia's lakes including the five largest lakes from the 1982 resource management plan. Lake surface areas included in 2000 Water Resources Management Plan.	Not applicable	There is some monitoring of Cat Swamp Pond due to concern over dam integrity.	A bathymetric study of the impounded part of Fall-Kill Creek was conducted by Pandullo-Quirk Associates (1979).	Pond and wetland bathymetry mapped (Cronan and Associates, 1981) and Bureau of Reclamation survey of dams	Not applicable
Water quantity	<u>Optional:</u> Streamflow, spring seep volume ,and inventory, lake water levels, groundwater levels, groundwater inputs	Two USGS continuous-record, streamflow gaging-stations in park: (USGS stations 01022835 and 01022860). Period of record is 1999 to 2004 USGS monitors water levels and water quality at four ground-water wells on Mount Desert Island. (USGS well numbers 441516068194101, 441650068210801, 442238068154101, and 442450068175201). Three of these wells are within park boundaries. Period of record is 2003 to 2004.		Two USGS stage-gages in park (USGS station 01378775 and USGS station 01378778). Period of record is 2003 to 2004. There are several groundwater wells installed in the park-not currently in operation.		Incidental discharge measurements taken concurrently with water quality measurements by NPS. Locations of wells and seeps shown in 1992 report USGS WRIR 92-4013.	USGS continuous-record, streamflow gaging-stations on the Saugus River (USGS station 01102345) just upstream from the park. Two freshwater springs in park have been mapped and discharge measured.
Water chemistry	<u>Mandatory:</u> Water temperature, specific conductance, pH, dissolved oxygen, percent dissolved oxygen saturation, color and turbidity <u>Optional:</u> Anions, cations DOC, alkalinity, ANC, iron,	Lake monitoring by NPS in cooperation with the Maine Department of Environmental Protection in selected lakes on Mount Desert Island to monitor change due to eutrophication and atmospheric deposition. Monitoring started in the late 1970s includes secchi disk water-column transparency and surface temperature. The program continues today, with monitoring expanded to include the following: pH, Acid neutralizing capacity,	The Massachusetts Water Resources Authority has monitored wastewater and effluent components, nutrients, and water chemistry (1992-2004). Parameters (not all collected at all stations) include surface and bottom	NPS monitors the following parameters on 11 sites since 1982: temperature, pH, conductivity, and salinity; and concentrations of dissolved oxygen, chloride, total dissolved solids, and fecal coliform on a monthly basis at 11	The park initiated a water-quality monitoring program in 1994. Temperature, pH, dissolved oxygen, salinity, and conductivity are being collected at all three units on a monthly basis. Data on additional parameters, including	Water-quality parameters are measured at six permanent monitoring stations: water temperature, water depth, dissolved oxygen, conductivity, pH, and turbidity. NH_4 - ammonia, NO_3	Water- quality parameters collected monthly by the Saugus River Watershed Council include pH, dissolved oxygen, temperature, and bacteria – fecal coliform (1998-2000) and e. coli (2001-2002) Water temperature and specific conductance

	aluminum	Specific conductance, True color, Dissolved organic carbon, Dissolved inorganic carbon, Major ions, Aluminum (total dissolved), Total phosphorus, Total nitrogen, Chlorophyll a, Lake stage, Dissolved oxygen/temperature profile. Stream Monitoring: Stream temperature, pH, dissolved oxygen, specific conductance, color, and flow rate measured since 1997 on Duck Brook, Stanley Brook, Canon Brook, and Hunters Brook, and since 1998 on Lurvey Spring Brook and Heath Brook (Breen and others, 2001).	water temperature, dissolved oxygen, salinity, secchi depth, total suspended solids, and pH.	stations. Occasional samples for fecal coliforms and fecal streptococcus may be taken and forwarded to an independent laboratory for evaluation. Sites are monitored once a week during the summer and once a month the rest of the year.	concentrations of chloride, phosphate, and nitrate, and measurements of turbidity, and alkalinity, are being collected quarterly. Starting in 1998, this work has been contracted to a private laboratory.	– nitrate and phosphorus (PO_4 - orthophosphate) were measured in previous years This program will resume in 2003.	determined at USGS gage
Fish community composition in streams	Mandatory: Species composition and relative abundance		Not applicable	Fish community composition data available from surveys by US Fish and Wildlife Service for Great Swamp Refuge downstream of the park		Fish species list for park made in 1986	
Zooplankton community composition in lakes	Mandatory: Species composition and relative abundance		Not applicable				Not applicable
Trophic status	Mandatory: Algal biomass, measures of water clarity such as secchi disk, and total and dissolved phosphorus	See water chemistry, lake monitoring	Massachusetts Water Resources Authority monitors nutrients, phytoplankton composition, and productivity.	Dissolved phosphorus is monitored			

	Optional: Macrophyte distribution,(diel oxygen curve and, periphyton in streams), dissolved oxygen profiles		Parameters are photosynthetically active radiation, transmissivity, particulate nitrogen, total dissolved nitrogen, nitrate/nitrite, ammonium, total dissolved phosphorus, orthophosphate, particulate organic carbon, Chlorophyll *a*, Phaeophytin			Dissolved phosphorus is monitored
Macroinvertebrate community composition in streams	Mandatory: Taxa richness and relative abundance	Macroinvertebrates are monitored in six streams following Maine DEP protocols (Davies and Tsomides, 1997). It has been well documented, reviewed, and provides data and analyses comparable to other streams in the state. Protocols are comparable with USEPA and the USGS National Water Quality Assessment Program protocols. The resultant data are analyzed using accepted biological and taxa composition indices.	Massachusetts Water Resources Authority monitors benthic communities.	New Jersey DEP has recently initiated a Level II Rapid Bioassessment Program (Plafkin and others, 1989) throughout New Jersey including several sites along the Upper Passaic River, Indian Grave Brook, and Primrose Brook in park. New Jersey DEP conducts macroinvertebrate sampling on the West Branch of Primrose Brook.	Two macroinvertebrate studies have been conducted in the park by the Department of Environmental Conservation in Albany, New York.	The Izaak Walton League of America's Stream Quality Survey (SQS) was performed at 4 stations in the park to quantitatively evaluate the distribution and diversity of the benthic macroinvertebrates in park streams.
Landcover/land use inventories	Mandatory: landcover/ecological system map Optional: Patch size distribution, patch					

	connectivity, patch fragmentation, % impervious surface in buffer or watershed, canopy shading, buffer vegetation and width			
Atmospheric deposition	Optional: Wet deposition, dry deposition, inorganic toxics, mercury	Park Research and Intensive Monitoring of Ecosystems (PRIMENet)- cooperative program between the USEPA and the NPS. Includes mercury and nitrogen sampling in Hadlock and Cadillac Brooks from 1998 to 2000 and air-quality monitoring of ozone, wet and dry deposition, visibility, meteorology, and UV-B monitoring. NADP sites in park include collection of wet precipitation chemistry, ozone, particulates, sulfer dioxide and mercury wet deposition. University of Maine collects fog chemistry data		
Contamination	Optional: Air toxic concentrations,	See atmospheric deposition	Massachusetts Water Resources Authority monitors toxic contaminants,	The wetland is contaminated with polyaromatic hydrocarbons and

	MTBE, chloroforms, trichloroethylene, contaminant spills, toxic boat point, sediment contaminants, metals, bioaccumulation in indicator species		pathogens, and fish and shellfish pathology.			arsenic. The slag pile has arsenic levels above the Imminent Hazard threshold, (Goff-Chem, 1996). The USGS & Massachusetts DEP, are sampling sediments in the Saugus River for heavy metals. One site is just downstream from SAIR.
Invasive exotic species	Mandatory: Presence/ absence Optional: Abundance	Multiple level surveys conducted for aquatic invasive species				Proposed restoration of historic site includes removal of invasive plants.
Septic systems/ Wastewater Discharge	Mandatory: the number of septic systems Optional: Nearby permits Waste water discharges	An estimate of number of houses in rural Bar Harbor was made from 1998 digital orthophotographs and field checks in 2001 (Glenn Guntenspergen, USGS, written commun., 2001). Bar Harbor Water Company tracks municipal water use	Massachusetts Water Resources Authority monitors wastewater and effluent components and sewage indicator bacteria, including fecal coliform bacteria and *Enterococcus spp.*	See water quality	Fecal coliform levels were assessed three times in 2002 at four stations	

Fish community composition

None of the parks are monitoring fish community composition in streams as part of their environmental monitoring programs.

Zooplankton community composition in lakes

None of the parks are monitoring zooplankton community composition in streams as part of their environmental monitor programs

Water quality – trophic status

Nutrient chemistry data and water clarity are collected as part of water chemistry monitoring at ACAD, ROVA, and SAGA. These programs are very close to the mandatory measures for this vital sign.

Macroinvertebrate community composition in streams

All the parks except SAIR have some form of invertebrate community composition monitoring for streams. The protocols vary among the parks so there is a lack of consistency. Modification of the existing protocols to a common methodology will provide consistency for the mandatory measures.

Land use/land cover inventory

None of the parks currently have a land-use/land-cover program, but these data should be available for all the parks as state or national GIS layers.

Atmospheric deposition

Only ACAD has an atmospheric deposition component in the current program as part of National Networks such as NADP and PRIMENet.

Contamination inventory

As part of the atmospheric deposition research at ACAD, mercury and nitrogen are monitored. States provide consumption advisories for fish, but none of the parks has an active contaminants sampling program. SAIR has had sediment sampling for contaminants associated with several research projects.

Invasive exotic species

All the parks have lists of potential invaders, but monitoring is not performed on a standardized schedule.

Septic systems/wastewater discharge

This information is generally tracked by municipalities where available. In some cases it must be estimated from water use.

Protocols, Quality control, and Data Storage at NETN Parks

Each of the parks with a water quality monitoring program has components of the program that correspond to one or more vital signs; however the design of each of the programs however differs due to the objectives associated with it. Documented protocols, quality assurance/quality control, and data storage of the current monitoring programs are presented where available (table H2) in order to understand some of these differences.

Appendix H: Monitoring Programs in Northeast Temperate Network Parks

Most of the monitoring programs do not have sufficiently documented protocols, quality-assurance/quality-control procedures, or data storage. Although each park has limited internal documents that provide some of this information, few published reports are available. For the data at these parks to be incorporated into the vital-signs programs and analyses, protocols will need to be standardized and documented, quality-assurance/quality-control procedures will need to be adopted and(or) documented, and data-storage practices will need to be updated. The exception is at Acadia where many of these protocols and documentation are already in place. The environmental monitoring and research program at Acadia has written protocols, written quality control specifications, a database, and an annual reports program to publish the data and analyses. As such, very little modification to the current Acadia aquatic environmental monitoring program will be required to include all the necessary vital signs.

Table H2. Standardized protocols, quality control, and data storage at the four parks with current environmental monitoring programs.

Park	Protocols	Quality Assurance/Quality Control Procedures	Data Storage
ACAD	Gawley, 1996, Acadia National Park lake monitoring: field and laboratory methods.: Acadia National Park Natural Resources Report 96-01 Kahl, and Manski, 1997, Developing long-term monitoring protocols for freshwater resources at Acadia National Park: Interim report from a workshop, January 9-10, 1997.	Gawley, W. G. 1996, Acadia National Park lake monitoring: field and laboratory methods: Acadia National Park Natural Resources Report 96-01	Internal database, Annual report series, Year end reports for lake, water, and macroinvertebrates.
MORR	J. Runde, 2004, Draft Report: Synthesis, analysis, and interpretation of water resources at Morristown National Historical Park Technical Report NPS/NRWRD/NRTR-xx/xx Morristown National Historical Park Standard Operating Procedure SOP Number: 601 Subject: Water Quality Testing Effective Date: October 1992 Revision Dates: April 2001	J. Runde, 2004, Draft Report: Synthesis, analysis, and interpretation of water resources at Morristown National Historical Park Technical Report NPS/NRWRD/NRTR-xx/xx Morristown National Historical Park Standard Operating Procedure SOP Number: 601 Subject: Water Quality Testing Effective Date: October 1992 Revision Dates: April 2001	Results of water quality inventory studies in the park have been reported by Mele and Mele (1983), and Trama and Galloway (1988). Storet Excel spreadsheet
SAGA	Zubricki, B., 1995, Water resources monitoring plan, Saint-Gaudens National Historical Site Izaak Walton League of America, 1994, Save our streams, volunteer trainers handbook.	Instrumentation calibrated and checked for accuracy	Annual interpretive reports Water quality data in Storet
SAIR			Data collected by Saugus River Watershed Council Hard copy only

Appendix H: Monitoring Programs in Northeast Temperate Network Parks

Appendix I: Monitoring programs adjacent to Northeast Temperate Network Parks

The Northeast Temperate Network established a task agreement with the State University of New York at Syracuse to search for data ("data-mine") on existing monitoring programs in the vicinity of the Network's 11-parks. The intent of the project was to increase our awareness of existing monitoring activities around each park unit and to identify potential partnerships that may benefit the network prior to implementation of the NETN Vital Signs monitoring program. By synthesizing, reviewing, and summarizing the existing monitoring programs around NETN parks we hope to avoid redundancy in program development. The information identified through this project will provide the network with a foundation for future scoping workshops, protocol development, and integration of NPS monitoring with other ongoing programs. This project was accomplished through literature review, web-based queries, contacts with NPS resource mangers, and interviews/solicitations with regional professionals involved in monitoring natural resources.

Information gathered through this effort resides in an MS-Access database developed by the NETN data manager. The database is designed to allow future users to quickly add new programs, review and edit already entered programs, and generate reports that list programs associated with each park.

The listings identified on the following pages represent a 'working' collection of the programs that the Northeast Temperate Network knows to exist. While we have made a concerted effort to ensure that our data-mining activities have been thorough and complete, we also recognize that there are more programs to discover. Accordingly, this list should not be viewed as a definitive listing of all programs that are near our parks. Some parks present greater challenges than others. For example, the Appalachian Trail passes through multiple states, geographic regions, ecological units, as well as other categorizing features and the number of potential monitoring programs that may be operating in the vicinity of the Appalachian Trail in one or more of these units is potentially staggering. Consequently, any listing of programs that are in close proximity to the Appalachian Trail, or any other park, only represents that portion of all programs that are better known and easily discoverable.

Acadia National Park

Center for Sponsored Coastal Ocean Research

ECOHAB Ecology and Oceanography of Harmful Algal Blooms

Gulf of Maine

Project Objective(s): goal of the ECOHAB program is to develop reliable models to forecast bloom development, persistence, and toxicity.
This research will foster rapid response by monitoring agencies and health departments to safeguard public health, local economies, and fisheries.
Further, identification of bloom-favorable conditions may permit management of specific environmental factors to reduce bloom impacts.

Project Measures: Algae

Web Link(s): http://www.cop.noaa.gov/Fact_Sheets/ECOHAB.html

U.S. Global Ocean Ecosystem Dynamics (GLOBEC)

GLOBEC Georges Bank

Project Objective(s): Distribution and Status of High Priority Species.
The proximate goal of the Georges Bank program is to understand the population dynamics of key species on the Bank - cod, haddock, and two species of zooplankton.
goal is to be able to predict changes in the distribution and abundance of these species as a result of changes in their physical and biotic environment as well as to anticipate how their populations might respond to climate variability and change.

Project Measures: water quality; fish distribution and abundance

Web Link(s): http://www.cop.noaa.gov/Fact_Sheets/GLOBECNWA.html

Gulf of Maine Council on the Marine Environment

Environmental Quality Monitoring Committee

Gulfwatch

Project Objective(s): Water Quality Data
assess the types and concentration of contaminants in coastal waters of the Gulf of Maine.

Project Measures: Molluscan contamination; water quality; chemical contaminants

Web Link(s): http://www.gulfofmaine.org/
http://www.gulfofmaine.org/council/committees/eqmc/gulfwatch/default.asp

Gulf of Maine Ocean Observing System

Gulf of Maine Ocean Observing System

Project Objective(s): Routine observing of ocean waters designed to bring hourly oceanographic data from the Gulf of Maine to all those who need it.

Project Measures: Weather; Wind; Wave height; Salinity; Visibility; Temperature

Web Link(s): http://www.gomoos.org/

Institute for Bird Populations

Monitoring Avian Productivity and Survivorship

Avian Inventory Program

Project Objective(s): indices of adult population size and post-fledging productivity from data on the numbers and proportions of young and adult birds captured.
estimates of adult population size, adult survival rates, proportions of residents, and recruitment into the adult population from mark-recapture data on adult birds.

Project Measures: avian distribution and abundance

Web Link(s): http://www.birdpop.org
http://www.birdpop.org/avianinv.htm
http://www.birdpop.org/maps.htm

Maine Audubon

Important Bird Areas (IBA)

Project Objective(s): identify and prioritize the most important areas for bird conservation in the state of Maine.
assist as needed in planning for the conservation and management of these bird-rich areas.

Project Measures: avian distribution and abundance; breeding; threatened & endangered
Habitat usage

Web Link(s): http://www.maineaudubon.org/conservation/iba/index.html

Least Tern and Piping Plover

Project Objective(s): For more than 20 years, we have worked to conserve state endangered least terns and piping plovers, two small birds that nest on Maine's beaches.
We use wire exclosures to keep predators away from plover nests and stake-and-twine to keep people and dogs away from nesting areas of both plovers and terns and night patrols at largest least tern colony.

Project Measures: shorebird nesting activity

Web Link(s): http://www.maineaudubon.org/
http://www.maineaudubon.org/conserve/overview.shtml

Loons and Lakes

Project Objective(s): Determine the population status of loons in Maine.
Efforts to allow municipalities the flexibility to develop watercraft restrictions on lakes within their jurisdictions, and to spread the work on the potentially lethal dangers posed to loons of fishing with lead sinkers and jigs.

Project Measures: waterfowl reproductive success

Web Link(s): http://www.maineaudubon.org
http://www.maineaudubon.org/conserve/overview.shtml

Maine Amphibian Monitoring Project

Project Objective(s): determining preliminary population trends for many of Maine's frogs and toads.

Project Measures: Amphibian distrbution and abundance | breeding | Amphibian egg mass count
Frog populations | Frog calls | Habitat usage

Web Link(s): http://www.maineaudubon.org/

Maine Owl Monitoring Program

Owl Survey and Monitoring

Project Objective(s): To learn more about the fluctuations in owl populations in our state and ultimately to ensure that each species remains an integral part of our ecosystem.
The Maine Cooperative Owl Surveys in 2002 and 2003 allowed us to analyze a large amount of data that helped us identify the best times to survey for owls.

Project Measures: avian distribution and abundance | Habitat usage

Web Link(s): http://www.maineaudubon.org/conserve/citsci/owl.shtml
http://www.maineaudubon.org

Maine Audubon

Project Puffin

Project Objective(s): The National Audubon Society started Project Puffin in 1973 in an effort to learn how to restore puffins to historic nesting islands in the Gulf of Maine.
Between 1973 and 1986, 954 young puffins were transplanted from Great Island, Newfoundland to Eastern Egg Rock and 914 of these successfully fledged. Transplanted puffins began returning to Eastern Egg Rock in June of 1977.
In 1981, four pairs nested beneath boulders at the edge of the island (Eastern Egg Rock) and the colony has since increased to 37 pairs in 2001.
In 1984, National Audubon Society and the Canadian Wildlife Service began a similar puffin restoration project at Seal Island National Wildlife Refuge in outer Penobscot Bay.
Seven pairs returned to nest in 1992 and the colony has rapidly increased to 145 pairs by 2001.

Project Measures: avian distribution and abundance | Habitat usage | shorebird nesting activity

Web Link(s): http://www.audubon.org/bird/puffin/what.html
http://www.maineaudubon.org/

Vernal Pools

Project Objective(s): Vernal pools are small, usually ephemeral wetlands that are essential breeding sites for 4 of Maine's species: wood frogs, spotted and blue-spotted salamanders, and fairy shrimp.
inventory and study vernal pools in southern, central, and northern Maine.

Project Measures: Wetland community composition and distribution | breeding

Web Link(s): http://www.maineaudubon.org/
http://www.maineaudubon.org/conserve/overview.shtml

Maine Department of Conservation

Maine Natural Areas Program

Aquatic Vegetation Surveys of Selected Maine Lakes

Project Objective(s): If particularly outstanding examples of vegetation communities are identified, that information could be used to identify lakes and watersheds most in need of protection through mechanisms such as the Land for Maine's Future Board.
This project will help establish important baseline data on the structure and composition of near shore aquatic plant communities in selected Maine lakes.
the work will serve as a pilot project which will guide conservation groups, interested citizens, and others in developing strategies to monitor the vegetation of the state's lakes.

Project Measures: aquatic plant community composition | water quality | shoreline disturbance

Web Link(s): http://www.state.me.us/doc/nrimc/mnap/programs/aquatics.html
http://www.maine.gov/dep/blwq/docmonitoring/lake/index.htm
http://mainevolunteerlakemonitors.org/index2.htm

Furbish Lousewort

Project Objective(s): Distribution and Status of High Priority Species.

Project Measures: rare plant distribution and abundance

Web Link(s): http://www.state.me.us/doc/nrimc/mnap/programs/oldflmonitr.htm
http://www.state.me.us/doc/nrimc/mnap/programs/programs.html

Management of Invasive Non-native Plants in Maine

Project Objective(s): assess and track the most invasive plant species in Maine.
educate landowners, land managers, nursery groups, and the general public about native alternatives to non-native plants for use in gardening, landscaping, and restoration work.
generating educational materials on the ecology and management of at least five of the most invasive non-native plants in Maine.

Project Measures: disease/pest conditions

Web Link(s): http://www.state.me.us/doc/nrimc/mnap/programs/invasives.html
http://www.state.me.us/doc/nrimc/mnap/home.htm

Maine Department of Conservation

Maine Natural Areas Program

Natural Communities

Project Objective(s): Distribution and Status of High Priority Species.
Maine Natural Areas Program has been trying to improve the quality and quantity of data on natural community occurrences in Maine.

Project Measures: rare plant distribution and abundance; Rare community distribution and composition

Web Link(s): http://www.state.me.us/doc/nrimc/mnap/fieldforms/formsexp.html
http://www.state.me.us/doc/nrimc/mnap/home.htm

Natural Heritage Program

Vegetation Mapping of Acadia NF Internal

Project Objective(s): Vegetation Mapping.

Project Measures: Land use

Web Link(s): http://www.state.me.us/doc/nrimc/mnap/home.htm

Maine Department of Environmental Protection

Maine River and Streams

Stream Team Program

Project Objective(s): A stream team is a group of who people who have banded together to promote stewardship of their local stream.

Project Measures: water quality

Web Link(s): http://www.state.me.us/dep/blwq/docstream/team/streamteam.htm

Surface Water Ambient Toxic Monitoring Program

Project Objective(s): comprehensively monitor the lakes, rivers & streams, marine & estuarine waters of the State on an ongoing basis.
Incorporate testing for suspected toxic contamination in biological tissue & sediment, may include testing of the water column & must include biomonitoring & the monitoring of the health of individual organisms that may serve as indicators of toxic contamination.
collect data sufficient to support assesment of the risks to human & ecological health posed by the direct and indirect discharge of toxic contaminants.

Project Measures: Tissue contaminant load; Sediment contaminant composition; Water column contaminant composition; mercury monitoring; Molluscan contamination

Web Link(s): http://www.state.me.us/dep/blwq/docmonitoring/swat/2001swatexsum.pdf
http://www.maine.gov/dep/blwq/docmonitoring/swat/index.htm

Maine Department of Inland Fisheries and Wildlife

Birds

Maine Colonial Waterbird Inventory: 19 species

Project Objective(s): These birds are extremely vulnerable to human disturbance during the spring and early summer nesting season; close monitoring of nesting colonies is warranted.

Project Measures: waterfowl reproductive success

Web Link(s): http://www.state.me.us/ifw/wildlife/wildlife.htm
http://www.state.me.us/ifw/wildlife/03report/birds.htm
http://www.state.me.us/ifw/wildlife/03report/birdgroup.htm

Maine Department of Inland Fisheries and Wildlife

Birds

Marshbird Surveys

Project Objective(s): Several species of wetland-associated birds are found in Maineby broadcasting tape recordings of their vocalizations, the presence of many of these species in a marsh can be confirmed.
In 2002, we completed the second and final year of our fieldworkto evaluate the distribution and relative abundance of 10 wetland bird species in the Boundary Plateau and St. John Upland regions of northwestern Maine.
least bittern, yellow rail, and common moorhen are currently listed as special concern in Maine. Additional information about these species would help clarify their status, and may lead to habitat management strategies to aid in their conservation.

Project Measures: avian distribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/wildlife.htm
http://www.state.me.us/ifw/wildlife/03report/birds.htm
http://www.state.me.us/ifw/wildlife/03report/birdgroup.htm

Migratory Shorebird Surveys

Project Objective(s): In May 2001:1) Maintain or enhance vital shorebird staging and wintering habitats in Maine; and 2) Maintain or enhance nesting, feeding, and roosting habitats to support viable breeding shorebird populations in Maine.
To determine seasonal movements and site fidelity a combined effort to develop techniques to capture and band purple sandpipers on Maine's offshore ledges began in April 2002, cont. in Dec 2002-May 2003.

Project Measures: avian distribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/wildlife.htm
http://www.state.me.us/ifw/wildlife/03report/birds.htm
http://www.state.me.us/ifw/wildlife/03report/birdgroup.htm

Ruffed Grouse

Project Objective(s): Despite its importance as a quality game bird in Maine, little management and research effort is devoted to this species because of limited dollars and personnel time.

Project Measures: game animal distribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/birds.htm
http://www.state.me.us/ifw/wildlife/03report/upbird.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Rusty Blackbird

Project Objective(s): We surveyed 188 sites among 84 townships during the two field seasons. Despite this amount of effort, we detected this species at only 18 of the 188 sites during summers of 2001 and 2002.
Evidence of successful breeding was limited as most observations were of individuals, but we observed multiple birds at 6 of 18 occupied sites as well as a fledged brood at one site.
Results of our surveys will form a base from which the first steps toward a monitoring program could be taken.

Project Measures: avian distribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/wildlife.htm
http://www.state.me.us/ifw/wildlife/03report/birds.htm
http://www.state.me.us/ifw/wildlife/03report/birdgroup.htm

Maine Department of Inland Fisheries and Wildlife

Birds

Sharp-tailed Sparrows

Project Objective(s): The sharp-tailed sparrows, Nelson's and saltmarsh sharp-tailed sparrows, are restricted to coastal marshes for every aspect of their life cycle.
In 2001, we completed field work on the ecology of sharp-tailed sparrows at Scarborough Marsh Wildlife Management Area.
Specific analyses in the past year have included developing a standardized method for monitoring these species.
Field work on these species has been limited with more work anticipated in 2003 to further evaluate the degree of exposure of these species to mercury.

Project Measures: avian distribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/wildlife.htm
http://www.state.me.us/ifw/wildlife/03report/birds.htm
http://www.state.me.us/ifw/wildlife/03report/birdgroup.htm

Turkey

Project Objective(s): the Department's goal is to have a viable wild turkey population wherever suitable wild turkey habitat exists.

Project Measures: game animal distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/birds.htm
http://www.state.me.us/ifw/wildlife/03report/upbird.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Waterfowl

Project Objective(s): Habitat protection and enhancement efforts are another form of management that the Department is using to increase waterfowl breeding populations.
Waterfowl are now being managed to increase certain breeding populations.

Project Measures: waterfowl reproductive success

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/birds.htm
http://www.state.me.us/ifw/wildlife/03report/waterfowl.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Black Tern

Project Objective(s): Distribution and Status of High Priority Species.

Project Measures: avian distribution and abundance; shorebird nesting activity

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm

Ecoregional Survey

Project Objective(s): identifies known locations of all natural features and wildlife habitats.

Project Measures: Habitat classification/profiling; Mapping; rare vertebrate distribution and abundance; rare invert distribution; rare plant distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/wildlife.htm

Endangered and Threatened Species

Butterflies

Project Objective(s): Distribution and Status of High Priority Species

Project Measures: lepidopteran distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Maine Department of Inland Fisheries and Wildlife

Endangered and Threatened Species

Dragonflies

Project Objective(s): Distribution and Status of High Priority Species

Project Measures: odonate distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://mdds.umf.maine.edu/~odonata/.
http://www.state.me.us/ifw/wildlife/wildlife.htm

Freshwater Mussels

Project Objective(s): document the occurrences of the State's freshwater mussels; learn about their life histories, habitat requirements, and conservation needs; and conserve habitat for Maine's rarer species.
In 2002, MDIFW continued collaboration on a research project to advance the understanding and conservation of Maine's two rarest freshwater mussel species _ the yellow lampmussel and tidewater mucket.
From 1992-97, MDIFW conducted a statewide survey to determine the status, abundance, and distribution of the State's freshwater mussels.

Project Measures: molluscan distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Maine Amphibian and Reptile Atlasing Project

Project Objective(s): Distribution and Status of High Priority Species.
From 1986-1990 over 250 volunteers from around the state contributed approximately 1,200 records of observations of amphibians and reptiles.
MDIFW continues to maintain a statewide database for amphibians and reptiles.

Project Measures: herptile distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Partners in Amphibian and Reptile Conservation

Project Objective(s): MDIFW participates in PARC meetings designed to improve communication on efforts to conserve threatened herptile species in the Northeast, and to identify new projects of regional priority for implementation.

PARC's mission is to forge partnerships among diverse public and private organizations in an effort to stem recent declines of amphibian and reptile (herptile) populations worldwide.

Project Measures: Amphibian distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/wildlife.htm
http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.parcplace.org/

Vernal Pools

Project Objective(s): Water Body Location and Classification
learn about why some vernal pools receive greater wildlife use than others.
wildlife use and characteristics of vernal pools in three southern Maine townships: Biddeford; Kennebunkport; and, North Berwick.

Project Measures: Amphibians | aquatic plant community composition | Frog populations | waterfowl reproductive success

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Maine Department of Inland Fisheries and Wildlife

Endangered and Threatened Species Study

Amphibian Monitoring

Project Objective(s): determining preliminary population trends for many of Maine's frogs and toads.

Project Measures: Frog populations | Frog calls

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Bald Eagle

Project Objective(s): Habitat "safety net" to maintain species recovery including at least 50 nesting areas under conservation ownership or appropriate easements.
At least 100 additional areas under conservation ownership, appropriate easements, or cooperative agreements with private landowners.

Project Measures: avian distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Blandings and Spotted Turtles

Project Objective(s): More than 80 turtles were marked or radio-tagged to gather information on nesting and hibernation sites, movements, and the types of wetlands used.
Most significantly, her work demonstrated the importance of small pocket swamps and vernal pools as productive foraging and breeding habitats, with individual turtles often requiring multiple wetlands within a single activity area.
MDIFW is committed to working with landowners and towns to help conserve remaining large blocks of habitat needed to sustain viable populations of these rare turtles.

Project Measures: chelonian population viability

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm
http://www.state.me.us/ifw/wildlife/03report/et.htm

Golden Eagle

Project Objective(s): MDIFW will work cooperatively with landowners to maintain suitable habitat at the few eyries once used by goldens.

Project Measures: avian distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Grasshopper Sparrows

Project Objective(s): Distribution and Status of High Priority Species.

Project Measures: avian distribution and abundance

Web Link(s):

Peregrine Falcon

Project Objective(s): A total of 144 young peregrines produced in captive-breeding programs were successfully released at 8 different locations in Maine during 1984-1997.
1989 - 2001, but numbers of nesting peregrines did not change appreciably: 5 - 8 eyries were inhabited each year.
in 2002. The statewide breeding population doubled in a single year. Peregrines inhabited 15 eyries, and 26 young peregrines fledged from ten of those eyries.
Diligence by land managers has been crucial to maintaining eyries favored by peregrines.

Project Measures: avian distribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Maine Department of Inland Fisheries and Wildlife

Endangered and Threatened Species Study

Wood Turtles

Project Objective(s): About 40 radio-tagged turtles were tracked and the nests located, and documented their movements and habitat use.
summer temperature influences hatching success of wood turtles - a critical factor influencing population viability at the northern edge of the specie's range.
Now studying the conservation genetics of wood turtles.
at the state level, several of Maine's major watersheds host unique wood turtle populations that have been isolated from one another over hundreds or thousands of years.

Project Measures: Reptile distribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Mammals

Black Bears

Project Objective(s): Distribution and Status of High Priority Species.
The Department's goal, chosen with public input, is to maintain the bear population at its current level.

Project Measures: game animal distribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/mamm.htm
http://www.state.me.us/ifw/wildlife/03report/bbear.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Coyote/Wolf

Project Objective(s): a genetic study to clarify whether Maine's coyotes are true coyotes or coyote/wolf hybrids, and to determine whether our coyotes can be distinguished from eastern Canadian wolves.
Information from this research will help our Department better understand how to approach enforcement issues concerning the incidental killing of wolves by trappers or snarers, and may give insight into the behavior of our coyotes.
this research will be an essential step in determining whether it is feasible or desirable to recover wolves in Maine and the rest of the Northeast.

Project Measures: game animal distribution and genetic markers
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/furbear.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Marten

Project Objective(s): Distribution and Status of High Priority Species.

Project Measures: game animal dstribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/furbear.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Moose

Project Objective(s): Distribution and Status of the species.

Project Measures: game animal distribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/wildlife.htm
http://www.state.me.us/ifw/wildlife/03report/mamm.htm
http://www.state.me.us/ifw/wildlife/03report/moose.htm

Maine Department of Inland Fisheries and Wildlife

Mammals

New England Cottontail

Project Objective(s): A cooperative Master's project between MDIFW and Dr. John Litvaitis, University of New Hampshire, was started in the Fall of 1999.
(1) determine the current distribution of New England cottontails in Maine using snowtrack, fecal pellet, and live trapping surveys.
(2) characterize the attributes of sites occupied by New England cottontails in Maine.
(3) develop a monitoring protocol capable of detecting status changes of New England cottontails in Maine.
Having a clear set of management goals for New England cottontail is critical at this time, since the species is on the verge of being listed as either a Threatened or Endangered species by the U.S. Fish and Wildlife Service.

Project Measures: Mammalian distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/wildlife.htm
http://www.state.me.us/ifw/wildlife/03report/mamm.htm
http://www.state.me.us/ifw/wildlife/03report/furbear.htm

Whitetail Deer

Project Objective(s): we have set population objectives of 15 or 20 deer/mi2 for each central and southern Maine WMD.
In northern and eastern Maine, the road to a more abundant deer population must involve increasing and restoring some of the deer wintering habitat that was lost during the past 3 decades.

Project Measures: game animal dstribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/deer.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Partners in Flight

Grassland Birds & Monitoring/Atlasing

Project Objective(s): Distribution and Status of High Priority Species.
Grassland Bird Focus Group: 1: inventory all the significant populations of grassland birds in Maine with Upland Sandpipers and Vesper Sparrows as primary targets.
Grassland Bird Focus Group: 2:to ensure that Conservation Reserve Program lands are maintained in early successional cover and thus continue to provide habitat for grassland birds.
Monitoring/Atlasing: to improve monitoring for species that are inadequately surveyed by the North American Breeding Bird Survey.

Project Measures: avian distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/pif/index.htm
http://www.state.me.us/ifw/wildlife/pif/focus/index.htm

Penobscot Meadow Vole

Project Objective(s): Distribution and Status of High Priority Species

Project Measures: Mammalian distribution and abundance

Web Link(s):

Roseate Tern

Project Objective(s): Distribution and Status of High Priority Species.

Project Measures: shorebird nesting activity

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm

Tomah Mayfly

Project Objective(s): Distribution and Status of High Priority Species.

Project Measures: invertebrate range and distribution

Web Link(s):

Maine Department of Inland Fisheries and Wildlife

Wildlife Division

Canada Lynx

Project Objective(s): Distribution and Status of High Priority Species.

Project Measures: Mammalian distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/furbear.htm - Sliverskip
http://www.state.me.us/ifw/wildlife/03report/wildlifeplanning.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Wood Cock

Project Objective(s): Distribution and Status of High Priority Species.
Project Measures: game animal distribution and abundance
Web Link(s):

Maine Department of Marine Resources

Finfish Aquaculture Monitoring Program

Project Objective(s): The diver survey is intended to provide an overall assessment of environmental conditions under and adjacent to finfish operations and to determine if additional monitoring, compliance, or enforcement actions are needed.

Benthic infauna monitoring is used to determine attainment of Maine's marine and estuarine life (infauna) and habitat suitability according to 38 M.R.S.A., Article 4-A, Water Classification Program narrative standards.

The objective of monitoring dissolved oxygen is to determine attainment of Maine's marine dissolved oxygen standards (M.R.S.A. 38, Article 4-A, section 465-B).

Project Measures: water quality Dissolved Oxygen marine and estuarine life
bottom conditions
Web Link(s): http://www.state.me.us/dmr/aquaculture/famp01.htm

Maine Phytoplankton Monitoring

Project Objective(s): For the success of Maine's shellfish resources, there needs to be an active monitoring program that can pick out and observe toxic phytoplankton.

Alexandrium spp., Dinophysis spp.,Prorocentrum spp., or Pseudonitzschia spp. May "bloom" in a given area when conditions are right, and an active monitoring project may be extremely effective in promoting shellfish safety.

Project Measures: Phytoplankton density
Web Link(s): http://www.ume.maine.edu/ssteward/phyto.htm

Maine Shore Stewards

Shellfish Sanitation Program

Project Objective(s): Volunteers collect water samples in shellfish growing areas for analysis of fecal coliform at state laboratories. The data is used by the DMR to decide whether shellfish areas have water quality acceptable for harvesting.
Project Measures: Fecal coliform
Web Link(s): http://www.ume.maine.edu/ssteward/dmr.htm

Maine Forest Service

Forest Health Monitoring

Pine Shoot Beetle/Hemlock Woolly Adelgid

Project Objective(s): protect the forest, shade and ornamental tree resources of the state from significant insect and disease damage.

to provide pest management and damage prevention for homeowners, municipalities, and forest land owners and managers.

Project Measures: disease/pest conditions
Web Link(s): http://www.state.me.us/doc/mfs/psb.htm
http://www.state.me.us/doc/mfs/idmhome.htm
http://www.state.me.us/doc/mfs/idmhwa.htm

Maine Sea Grant

Maine Phytoplankton Monitoring

Paralytic Shellfish Poisoning Monitoring Program

Project Objective(s): Thirty trained citizen volunteers monitor thirty-seven sites from Kittery to Calais weekly and report on the phytoplankton cells that they find.

The volunteers also alerted the DMR to the presence of Alexandrium, which, to date, has resulted in two regions being tested for toxicity levels and subsequently closed to shellfish harvesting in 2001.

Project Measures: Algal Blooms ("Red Tide") Alexandrium Phytoplankton
Web Link(s): http://www.seagrant.umaine.edu/Extension/Ecosystem%20Health/shore%20stewards/phyto/HAB.htm

Maine State Planning Office

Maine Shore Stewards

Coastal Swim BEACH Monitoring

Project Objective(s): Community based groups will take water samples at coastal swim beaches for bacteria, an indicator of recreational water-borne illnesses.

Project Measures: Bacteria; water quality

Web Link(s):
http://www.state.me.us/dep/blwq/docbeach/coastalswimbeach.htm
http://www.state.me.us/dep/blwq/docbeach/coastalfactsheet.pdf
http://www.state.me.us/dep/blwq/beach.htm
http://www.ume.maine.edu/ssteward/programs.htm

Maine Tribal Community / U.S. Environmental Protection Agency

Penobscot Air Program

Project Objective(s): control pollutant emissions from automobiles, factories, and other sources.

Project Measures: Carbon monoxide; nitrogen dioxide; Ozone; Lead; particulate matter; sulfur dioxide

Web Link(s):
http://www.penobscotnation.org/DNR/Air%20news/overview.htm
http://www.penobscotnation.org/DNR/air_index.htm
http://www.penobscotnation.org/DNR/DNR1.htm

Marine Environmental Research Institute

Toxic Chemicals in Gulf of Maine Seals

Project Objective(s): Water Quality Data

Project Measures: Tissue contaminant load

Web Link(s): http://www.meriresearch.org/research/index.html

National Atmospheric Deposition Program

Atmospheric Integrated Research Monitoring Network (AIRMoN)

AIRMonN-Wet & AIRMoN-Dry

Project Objective(s): Determining the effectiveness of emission controls mandated by the Clean Air Act.
Evaluating the potential impacts of new sources of emissions on protected areas such as Class I Wilderness Areas.
Identifying source/receptor relationships in atmospheric models.
AIRMoN was designed to provide data with a greater temporal resolution.

Project Measures: Precipitation composition; nitrogen; Ozone; sulfur dioxide; gaseous nitric acid

Web Link(s): http://nadp.sws.uiuc.edu/airmon/

Mercury Depostion Network (MDN)

Project Objective(s): The objective of the MDN is to develop a national database of weekly concentrations of total mercury in precipitation and the seasonal and annual flux of total mercury in wet deposition.
The data will be used to develop information on spatial and seasonal trends in mercury deposited to surface waters, forested watersheds, and other sensitive receptors.

Project Measures: mercury monitoring; Precipitation composition; methylmercury

Web Link(s): http://nadp.sws.uiuc.edu/mdn/

National Oceanic and Atmospheric Administration

Marine Monitoring Programs in the Gulf of Maine

MARMAP

Project Objective(s): 1)Assess the seasonal, interannual, and decadal variability in the planktonic and oceanographic components of the Northeast Shelf Ecosystem.
2) characterize changes in these variables as an indication of broad-scale ecological and environmental changes.
3) develop appropriate indices of the changing states of the marine ecosystem.

Project Measures: Phytoplankton; Zooplankton abundance and compostion; Water column temperature; Surface salinity; Meteorological conditions

Web Link(s):
http://www.stat.psu.edu/~gpp/marmap_system_partnership.htm
http://gulfofmaine.org/library/pdf/mon_inventory.pdf
http://gulfofmaine.org/library/monitoring_inventory.html

National Estuarine Research Reserve System

Biological

Project Objective(s): Biological monitoring is used for detecting the health of aquatic environments and assessing the relative severity of the pollution impacts.

Project Measures: Chlorophyll a; Submerged aquatic vegetation; Emergent vegetation

Web Link(s): http://nerrs.noaa.gov/Monitoring/Biological.html

System-wide Monitoring Program

Project Objective(s): tracks short-term variability and long-term changes in estuarine waters to understand how human activities and natural events can change ecosystems.

The reserve system currently measures physical and chemical water quality indicators, nutrients and the impacts of weather on estuaries.

Project Measures: Land use; water quality (physical and chemical indicators)

Web Link(s): http://nerrs.noaa.gov/Monitoring/

Water Quality

Project Objective(s): Indicators of habitat quality for numerous estuarine species and to determine health criteria and human uses.

Project Measures: Water Temperature; Water Depth; Salinity; pH; Dissolved Oxygen; Turbidity

Web Link(s): http://nerrs.noaa.gov/Monitoring/Water.html

National Status and Trends Program

Mussel Watch

Project Objective(s): This project is designed to monitor the status of and temporal changes in metal and organic contaminants in Great Lakes, estuarine and coastal waters using bivalve molluscs as sentinel organisms.

Project Measures: Crustacean contaminat loads; PAH; PCB; Pesticide; Trace Elements; Reproductive development; disease/pest conditions; Size frequency

Web Link(s): http://vertigo.hsrl.rutgers.edu/NST.html
http://nsandt.noaa.gov/

National Benthic Surveillance Project

Project Objective(s): To determine the current status of and to detect any long-term trends in the environmental quality of the nearshore waters of the United States.

The primary objective was to determine concentrations of more than 70 organic and inorganic contaminants in the liver and bile of bottom dwelling fishes and associated surficial sediment from coastal and estuarine waters.

Project Measures: Bile and liver contamination loads; PAH; PCB; Butyltins; DDT and metabolites; Chlorinated pesticides

Web Link(s): http://nsandt.noaa.gov/

Penobscot Nation Dept of Natural Resources

Forest Management

Forest Management Plan

Project Objective(s): Preserve and protect water quality on the trust lands; Preserve and enhance the long-term productivity of the forest resource.

Provide for the protection of the forest resource from insects, disease, fire, trespass and invasive species. Identify and protect significant natural resources located on the trust lands; including but not limited to fisheries and important wildlife habitat such as deer wintering areas, habitat for threatened and endangered species and vernal pools.

Identify and protect significant cultural and archaeological resources on the trust lands; Where appropriate, emphasis the management of the forest to maintain and improve the populations of moose and white-tailed deer.

Project Measures: water quality; archaeological resources; disease/pest conditions; Habitat usage; Land use

Web Link(s): http://www.penobscotnation.org/DNR/forest_management_goals.htm
http://www.penobscotnation.org/DNR/DNR1.htm
http://www.penobscotnation.org/DNR/forestry.htm

Penobscot Water Quality Program

National Fish Tissue Study

Project Objective(s): The statistical design of the 4 year study will allow us to develop national estimates of the mean concentrations of 268 chemicals in fish tissue from lakes and reservoirs of the lower 48 States. study results will define national background levels for the 265 chemicals in fish, to provide a baseline to track progress of pollution control activities, and to identify areas where contaminant levels are high enough to warrant further investigation.

Project Measures: Fish tissue contaminant composition

Web Link(s): http://www.penobscotnation.org/DNR/PINWQP.htm
http://www.penobscotnation.org/DNR/DNR1.htm
http://www.epa.gov/waterscience/fishstudy/

Sea Grant

Paralytic Shellfish Poisoning Monitoring Program

Project Objective(s): A national plan has been prepared to guide research and monitoring programs on all aspects of the harmful algal bloom (HAB) problem, from toxin detection to resource management to bloom ecology.

Project Measures: Algal Blooms ("Red Tide") Alexandrium

Web Link(s): http://www.seagrantnews.org/news/whoi.html

The Lobster Conservancy

Junior Lobster Monitoring Program

Project Objective(s): Census intertidal lobster nursery sites. Harboring “baby” lobsters under rocks, these nursery sites are accessible once a month during the lowest low tides; and are extremely valuable as indicators of lobster fishery health.

Project Measures: Crustacean distribution and abundance

Web Link(s): http://www.lobsters.org/research/research.html
http://www.lobsters.org/volunt/volunteer.html

U.S. Army Corps of Engineers

Disposal Area Monitoring System (DAMOS)

New England District

Project Objective(s): Manage and monitor offshore dredged material disposal sites from Long Island Sound to Maine.

Project Measures: Sediment contaminant composition

Web Link(s): http://www.nae.usace.army.mil/environm/damos/splash_page.htm

U.S. Fish and Wildlife Service

Gulf of Maine Coastal Program

Atlantic Salmon Watersheds, Maine: Habitat Identi

Project Objective(s): Mapping spawning and nursery habitat, developing watershed land cover information, providing assistance to watershed coalitions by identifying potential threats to salmon survival, providing technical assistance to partners.
restoring natural river channels, and developing on-the-ground parnerships to protect salmon habitat.

Project Measures: fish distribution and abundance Habitat classification/profiling

Web Link(s): http://gulfofmaine.fws.gov/salmon.html
http://gulfofmaine.fws.gov/documents/salmon.pdf

Casco Bay Habitat Identification & Protection

Project Objective(s): identified and mapped important habitat for 9 groups of species, including waterbirds, seabirds, wading birds, fish, eelgrass, cordgrass, marine worms, shellfish and endangered/threatened species.

Project Measures: Habitat usage fish distribution and abundance waterfowl reproductive success
Salt marsh plant community composition

Web Link(s): http://gulfofmaine.fws.gov/cascobay.html

Coastal Nesting Islands

Project Objective(s): Identified approximately 300 nationally significant nesting islands and is working in partnerships to promote habitat protection and restoration.

Project Measures: avian distribution and abundance waterfowl reproductive success

Web Link(s): http://gulfofmaine.fws.gov/mcni.html

Gulf of Maine Rivers Ecosystem Team

Project Objective(s): Conserve, manage and restore fish, wildlife and plant resources and their habitats within the watershed and identifies fish and wildlife resource priorities in the watershed and implements collective actions to address those priorities.

Project Measures: Habitat usage; waterfowl reproductive success; fish distribution and abundance; threatened & endangered

Web Link(s): http://gulfofmaine.fws.gov/ecoteam/ecoteam.html

Gulf of Maine Watershed Habitat Analysis

Project Objective(s): Identified, mapped, and ranked important fish and wildlife habitat for priority species throughout the Gulf of Maine watershed.

Project Measures: Habitat usage; fish distribution and abundance; waterfowl reproductive success

Web Link(s): http://gulfofmaine.fws.gov/gomanalysis/gomanalysis.html
http://gulfofmaine.fws.gov/gomanalysis/documents/gomanalysis.pdf

Habitat Restoration in Maine

Project Objective(s): Working in voluntary partnerships with all interested stakeholders, to restore rivers, nesting islands, coastal marshes and grasslands for migratory fish, birds, endangered species.

Project Measures: Wetland community composition and distribution; Grassland community compostion and distribution; Habitat usage; Salt marsh plant community composition

Web Link(s): http://gulfofmaine.fws.gov/restore1.html

U.S. Forest Service

Forest Health Monitoring

Forest Inventory and Analysis

Project Objective(s): The Forest Inventory and Analysis Program tracks 3 Criteria and 67 Indicators. Criteria are: 1)Conservation of Biological Diversity; 2) Maintenance of Productive Capacity of Forest Ecosystems; 3)Maintenance of Forest Ecosystem Health & Vitality.

Collect and disseminate information about the forests of the Northeastern United States relating to forest distribution, forest condition, ownership patterns, timber utilization, and forest mensuration techniques.

Develop and apply scientific knowledge and technology in support of the inventory and analysis project.

Project Measures: Soil characteristics; Tree condition; Lichens; Air quality

Web Link(s): http://www.fs.fed.us/projects/
http://fia.fs.fed.us/rpa.htm
http://www.fs.fed.us/ne/fia/
http://www.fs.fed.us/research/sustain/

University of Maine Cooperative Extension

Maine Shore Stewards

BEACH PROFILING PROJECT

Project Objective(s): Trained volunteers are currently making topographic profiles of 10 important barrier systems in southern Maine. In addition, moored wave/current meters offshore are collecting data.

it is possible to determine how individual beaches respond to a variety of meteorological changes depending on their level of development and the volume of sand contained in, or available to each beach.

Project Measures: changes in topography of marine barrier systems

Web Link(s): http://www.geology.um.maine.edu/beach/
http://www.ume.maine.edu/ssteward/programs.htm

Clean Water/Partners in Monitoring

Project Objective(s): study the health of estuarine water by monitoring for dissolved oxygen, temperature, pH, salinity, and fecal coliform bacteria.

As a result of successful monitoring efforts in Maine, thousands of acres of clam flats have been opened.

Project Measures: Fecal coliform; Temperature; Dissolved Oxygen; pH; Salinity

Web Link(s): http://www.ume.maine.edu/ssteward/cwpim.htm

University of Southern Maine

Casco Bay Estuary Project

Casco Bay Air Monitoring Report

Project Objective(s): The current role of atmopsheric deposition, as it relates to nitrogen, mercury and fine partulcate matter pollution in Casco Bay.
If atmospheric deposition (both wet and dry) provides significant sources of nitrogen and mercury pollution to Casco Bay.
The relative potential contribution of atmospheric deposition to the total pollution measured in the sediments.

Project Measures:

toxins stored in lobster adipose tissue	Crustacean contaminat loads	Sediment contaminant composition
PAH	Hydrocarbon pollution	nitrogen
mercury monitoring		

Web Link(s): http://www.cascobay.usm.maine.edu/
http://www.cascobay.usm.maine.edu/toxics.html - Air%20Deposition

University of Southern Maine

Casco Bay Estuary Project

Habitat Protection and Restoration

Project Objective(s): The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.
Results are being used to catalyze voluntary habitat protection efforts in the region.

Project Measures:

Mapping	aquatic plant community composition	Wetland community composition and distribution
rivers		

Web Link(s): http://www.cascobay.usm.maine.edu/
http://gulfofmaine.fws.gov/cascobay.html
http://www.cascobay.usm.maine.edu/Habfact.pdf

Wildlife Areas/Protected Lands Mapping

Project Objective(s): Habitat identification was based on species occurrences and also was projected from environmental parameters favorable to those species, such as suitable vegetation, water depth, or presence of food resources.
This information is being used in an analysis of threats to important habitats from development activities, performed in cooperation with the Casco Bay Estuary Project.

Project Measures: Habitat classification/profiling Mapping

Web Link(s): http://www.cascobay.usm.maine.edu/
http://gulfofmaine.org/library/casco/casco.htm

Vermont Institute of Natural Science

Mountain Bird Watch

Mountain Bird Watch

Project Objective(s): Mountain Bird watch is a long-term monitoring program for songbirds that breed in high-elevation forests of the Northeast. Skilled volunteers conduct annual surveys along 1-km routes that are located on mountains in New York, Vermont, New Hampshire, and Maine. Primary emphasis is placed on Bicknell's Thrush, the region's only endemic bird species, and a montane fir specialist that is vulnerable to ongoing and projected habitat loss. Other focal species include Blackpoll Warbler, Swainson's Thrush, White-throated Sparrow, and Winter Wren. In 2002, Mountain Birdwatchers gathered observations from 142 locations, with point count surveys completed on 118 routes.

Project Measures: avian distribution and abundance

Web Link(s): http://www.vinsweb.org/cbd/mtn_birdwatch.html

Wells National Estuarine Research Reserve

NERR

Marsh-dominated estuarine ecosystems Gulf ME

Project Objective(s): the influence of land use and hydrologic change on estuarine health.
the relative contributions of sea-level rise and human activity to coastal habitat degradation (marshes, beaches, estuaries).
the role of marsh-dominated estuaries in supporting Gulf of Maine migratory and marine fisheries.

Project Measures:

Hydrology	Erosion	Salt marsh plant community composition
Salt marsh fish community composition	Salt marsh invertebrate community composition	Lyme disease ecology and epidemiology

Web Link(s): http://inlet.geol.sc.edu/WEL/index.html

Appalachian National Scenic Trail

Appalachian Mountain Club

Mountain Watch

Mountain Watch

Project Objective(s): During the first phase of Mountain Watch, data collection will focus on several air quality measurements, including visibility degradation and hiker exposure to ground-level ozone pollution that gets transported to the mountain ecosystems of the Northeast. Because alpine ecosystems are some of the most sensitive to global climate change, they cannot "migrate" to cooler climates. Participants will also contribute to databases on when alpine plants flower, trees break bud in the spring and the onset of fall foliage. Weather measurements will also be taken to correlate with longer-term climatic records to correlate with the timing of the annual cycles of plants – plant phenology.

Project Measures: Air quality; Weather; vegetative & flower bud development

Web Link(s):

Appalachian Trail Conference

Corridor Monitoring

Project Objective(s): Corridor monitoring involves the regular, systematic gathering of information about the A.T. corridor for the specific purpose of protecting A.T. lands from encroachment.

Project Measures: Boundary Encroachment

Web Link(s): http://www.appalachiantrail.org/protect/steward/corridor.html

Environmental Monitoring

Project Objective(s): The Environmental Monitoring program involves gather information regarding air and water quality, wildlife habitat, and forest health and the changes that occur over time.

Project Measures: Air quality

Web Link(s): http://www.appalachiantrail.org/protect/steward/enviro.html

Baxter State Park

Monitoring Bicknell's Thrush

Project Objective(s): Monitor birds at high elevation sites and their distribution in the park.

Project Measures: avian distribution and abundance

Web Link(s): http://www.baxterstateparkauthority.com/sciforest/index.html
http://www.state.me.us/ifw/wildlife/pif/news/min97101.htm - Sliverskip

Connecticut Audubon

Important Bird Areas (IBA)

Project Objective(s): Sites that are important to endangered or threatened species, species of high conservation priority that contain rare habitat.

Project Measures: avian distribution and abundance

Web Link(s): http://greenwich.center.audubon.org/
http://greenwich.center.audubon.org/research.html

Connecticut Department of Environmental Protection

Environmental and Geographic Information Center

Connecticut Butterfly Atlas

Project Objective(s): Collect data, in the form of vouchers and field forms, over one or more of five field seasons from 1995 through 1999. Vouchers are either specimens or photographs, and provide the information needed to produce a map of each species' distribution.

Project Measures: lepidopteron distribution and abundance; Invertebrate distribution and status

Web Link(s): http://george.peabody.yale.edu/cbap/
http://dep.state.ct.us/cgnhs/nddb/Nddb2.htm

Connecticut Department of Environmental Protection

Environmental and Geographic Information Center

Rare Animal Species

Project Objective(s): To conserve, protect, restore and enhance any endangered or threatened species and their essential

Project Measures: rare vertebrate distribution and abundance; rare invertebrate distribution and abundance

Web Link(s): http://dep.state.ct.us/cgnhs/nddb/nddb2.htm; http://dep.state.ct.us/cgnhs/index.htm

Rare Plant Species

Project Objective(s): Conserve, protect, restore and enhance any endangered or threatened species and their essential habitat.

Project Measures: rare plant distribution and abundance

Web Link(s): http://dep.state.ct.us/cgnhs/nddb/nddb2.htm; http://dep.state.ct.us/cgnhs/index.htm

Whip-poor-Will and Nighthawk Survey

Project Objective(s): Survey these species to determine whether or not the birds are undergoing a decline in their populations. Both species have been listed as a state species of special concern since 1991.

Project Measures: avian distribution and abundance; breeding

Web Link(s): http://dep.state.ct.us/cgnhs/nddb/volun.htm; http://dep.state.ct.us/cgnhs/nddb/nddb2.htm; http://dep.state.ct.us/cgnhs/index.htm

Institute for Bird Populations

Monitoring Avian Productivity and Survivorship

Avian Inventory Program

Project Objective(s): indices of adult population size and post-fledging productivity from data on the numbers and proportions of young and adult birds captured.
estimates of adult population size, adult survival rates, proportions of residents, and recruitment into the adult population from mark-recapture data on adult birds.

Project Measures: avian distribution and abundance

Web Link(s): http://www.birdpop.org; http://www.birdpop.org/avianinv.htm; http://www.birdpop.org/maps.htm

Long Term Ecological Research Network

Hubbard Brook

Project Objective(s): Core Research Questions : (i) Dynamic patterns and control of primary production, over time, and in relation to natural and induced stresses or disturbances; (ii) Dynamics of selected populations of seed plants, saprophytic organisms, invertebrates, fish, birds and mammals in relation to time as well as natural and induced stresses or disturbances; (iii) Patterns and control of organic accumulation (biomass) in surface layers and substrate (or sediment) in relation to time or natural and Induced stresses or disturbances; (iv) Patterns of inorganic contributions (atmospheric or hydrologic) and movement through soils, groundwater, streams and lakes in relation to time and natural or induced stresses or disturbances; (v) Patterns and frequency of apparent site interventions (disturbances) over space and time (drought, fire, windthrow, insects or other perturbations) that may be a product of, or induce, long-term trends.

Project Measures: Climate; Weather; Hydrology; Forest community composition and distribution; Habitat classification/profiling; Natural communities; Water chemistry

Web Link(s): www.hubbardbrook.org

Maine Audubon

Important Bird Areas (IBA)

Project Objective(s): identify and prioritize the most important areas for bird conservation in the state of Maine.
assist as needed in planning for the conservation and management of these bird-rich areas.

Project Measures: avian distribution and abundance; breeding; threatened & endangered; Habitat usage

Web Link(s): http://www.maineaudubon.org/conservation/iba/index.html

Loons and Lakes

Project Objective(s): Determine the population status of loons in Maine.
Efforts to allow municipalities the flexibility to develop watercraft restrictions on lakes within their jurisdictions, and to spread the work on the potentially lethal dangers posed to loons of fishing with lead sinkers and jigs.

Project Measures: waterfowl reproductive success

Web Link(s): http://www.maineaudubon.org
http://www.maineaudubon.org/conserve/overview.shtml

Maine Amphibian Monitoring Project

Project Objective(s): determining preliminary population trends for many of Maine's frogs and toads.

Project Measures: Amphibian distribution and abundance | breeding | Amphibian egg mass count
Frog populations | Frog calls | Habitat usage

Web Link(s): http://www.maineaudubon.org/

Maine Owl Monitoring Program

Owl Survey and Monitoring

Project Objective(s): To learn more about the fluctuations in owl populations in our state and ultimately to ensure that each species remains an integral part of our ecosystem.
The Maine Cooperative Owl Surveys in 2002 and 2003 allowed us to analyze a large amount of data that helped us identify the best times to survey for owls.

Project Measures: avian distribution and abundance | Habitat usage

Web Link(s): http://www.maineaudubon.org/conserve/citsci/owl.shtml
http://www.maineaudubon.org

Vernal Pools

Project Objective(s): Vernal pools are small, usually ephemeral wetlands that are essential breeding sites for 4 of Maine's species: wood frogs, spotted and blue-spotted salamanders, and fairy shrimp.
inventory and study vernal pools in southern, central, and northern Maine.

Project Measures: Wetland community composition and distribution | breeding

Web Link(s): http://www.maineaudubon.org/
http://www.maineaudubon.org/conserve/overview.shtml

Maine Department of Conservation

Maine Natural Areas Program

Aquatic Vegetation Surveys of Selected Maine Lakes

Project Objective(s): If particularly outstanding examples of vegetation communities are identified, that information could be used to identify lakes and watersheds most in need of protection through mechanisms such as the Land for Maine's Future Board.
This project will help establish important baseline data on the structure and composition of near shore aquatic plant communities in selected Maine lakes.
the work will serve as a pilot project which will guide conservation groups, interested citizens, and others in developing strategies to monitor the vegetation of the state's lakes.

Project Measures: aquatic plant community composition | water quality | shoreline disturbance

Web Link(s): http://www.state.me.us/doc/nrimc/mnap/programs/aquatics.html
http://www.maine.gov/dep/blwq/docmonitoring/lake/index.htm
http://mainevolunteerlakemonitors.org/index2.htm

Management of Invasive Non-native Plants in Maine

Project Objective(s): assess and track the most invasive plant species in Maine.
educate landowners, land managers, nursery groups, and the general public about native alternatives to non-native plants for use in gardening, landscaping, and restoration work.
generating educational materials on the ecology and management of at least five of the most invasive non-native plants in Maine.

Project Measures: disease/pest conditions

Web Link(s): http://www.state.me.us/doc/nrimc/mnap/programs/invasives.html
http://www.state.me.us/doc/nrimc/mnap/home.htm

Natural Communities

Project Objective(s): Distribution and Status of High Priority Species.
Maine Natural Areas Program has been trying to improve the quality and quantity of data on natural community occurrences in Maine.

Project Measures: rare plant distribution and abundance | Rare community distribution and composition

Web Link(s): http://www.state.me.us/doc/nrimc/mnap/fieldforms/formsexp.html
http://www.state.me.us/doc/nrimc/mnap/home.htm

Small-whorled Pogonia

Project Objective(s): Distribution and Status of High Priority Species.

Project Measures: rare plant distribution and abundance

Web Link(s): http://www.state.me.us/doc/nrimc/mnap/programs/programs.html

Maine Department of Environmental Protection

Maine River and Streams

Stream Team Program

Project Objective(s): A stream team is a group of who people who have banded together to promote stewardship of their local stream.

Project Measures: water quality

Web Link(s): http://www.state.me.us/dep/blwq/docstream/team/streamteam.htm

Maine Department of Environmental Protection

Surface Water Ambient Toxic Monitoring Program

Project Objective(s): comprehensively monitor the lakes, rivers & streams, marine & estuarine waters of the State on an ongoing basis.

Incorporate testing for suspected toxic contamination in biological tissue & sediment, may include testing of the water column & must include biomonitoring & the monitoring of the health of individual organisms that may serve as indicators of toxic contamination.

collect data sufficient to support assessment of the risks to human & ecological health posed by the direct and indirect discharge of toxic contaminants.

Project Measures:

Tissue contaminant load	Sediment contaminant composition	Water column contaminant composition
mercury monitoring	Molluscan contamination	

Web Link(s): http://www.state.me.us/dep/blwq/docmonitoring/swat/2001swatexsum.pdf
http://www.maine.gov/dep/blwq/docmonitoring/swat/index.htm

Maine Department of Inland Fisheries and Wildlife

Birds

Marshbird Surveys

Project Objective(s): Several species of wetland-associated birds are found in Maine by broadcasting tape recordings of their vocalizations, the presence of many of these species in a marsh can be confirmed.

In 2002, we completed the second and final year of our fieldwork to evaluate the distribution and relative abundance of 10 wetland bird species in the Boundary Plateau and St. John Upland regions of northwestern Maine.

least bittern, yellow rail, and common moorhen are currently listed as special concern in Maine. Additional information about these species would help clarify their status, and may lead to habitat management strategies to aid in their conservation.

Project Measures: avian distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/wildlife.htm
http://www.state.me.us/ifw/wildlife/03report/birds.htm
http://www.state.me.us/ifw/wildlife/03report/birdgroup.htm

Ruffed Grouse

Project Objective(s): Despite its importance as a quality game bird in Maine, little management and research effort is devoted to this species because of limited dollars and personnel time.

Project Measures: game animal distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/birds.htm
http://www.state.me.us/ifw/wildlife/03report/upbird.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Rusty Blackbird

Project Objective(s): We surveyed 188 sites among 84 townships during the two field seasons. Despite this amount of effort, we detected this species at only 18 of the 188 sites during summers of 2001 and 2002.

Evidence of successful breeding was limited as most observations were of individuals, but we observed multiple birds at 6 of 18 occupied sites as well as a fledged brood at one site.

Results of our surveys will form a base from which the first steps toward a monitoring program could be taken.

Project Measures: avian distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/wildlife.htm
http://www.state.me.us/ifw/wildlife/03report/birds.htm
http://www.state.me.us/ifw/wildlife/03report/birdgroup.htm

Maine Department of Inland Fisheries and Wildlife

Birds

Sharp-tailed Sparrows

Project Objective(s): The sharp-tailed sparrows, Nelson's and saltmarsh sharp-tailed sparrows, are restricted to coastal marshes for every aspect of their life cycle.
In 2001, we completed field work on the ecology of sharp-tailed sparrows at Scarborough Marsh Wildlife Management Area.
Specific analyses in the past year have included developing a standardized method for monitoring these species.
Field work on these species has been limited with more work anticipated in 2003 to further evaluate the degree of exposure of these species to mercury.

Project Measures: avian distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/wildlife.htm
http://www.state.me.us/ifw/wildlife/03report/birds.htm
http://www.state.me.us/ifw/wildlife/03report/birdgroup.htm

Turkey

Project Objective(s): the Department's goal is to have a viable wild turkey population wherever suitable wild turkey habitat exists.

Project Measures: game animal distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/birds.htm
http://www.state.me.us/ifw/wildlife/03report/upbird.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Waterfowl

Project Objective(s): Habitat protection and enhancement efforts are another form of management that the Department is using to increase waterfowl breeding populations.
Waterfowl are now being managed to increase certain breeding populations.

Project Measures: waterfowl reproductive success

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/birds.htm
http://www.state.me.us/ifw/wildlife/03report/waterfowl.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Ecoregional Survey

Project Objective(s): identifies known locations of all natural features and wildlife habitats.

Project Measures: Habitat classification/profiling; Mapping; rare vertebrate distribution and abundance; rare invert distribution; rare plant distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/wildlife.htm

Endangered and Threatened Species

Butterflies

Project Objective(s): Distribution and Status of High Priority Species

Project Measures: lepidopteran distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Maine Department of Inland Fisheries and Wildlife

Endangered and Threatened Species

Clayton's Copper

Project Objective(s): Five survey plots were surveyed throughout the peak of the copper's flight season in order to begin estimating population size and monitoring trends at Dwinal Pond.
A habitat characterization system was developed and used to document the butterfly's habitat preferences and distribution within the flowage.
What is learned about monitoring Clayton's copper populations and managing habitat at Dwinal Pond will then be applied to benefit other sites and potentially improve the butterfly's status.

Project Measures: lepidopteran distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Dragonflies

Project Objective(s): Distribution and Status of High Priority Species

Project Measures: odonate distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://mdds.umf.maine.edu/~odonata/.
http://www.state.me.us/ifw/wildlife/wildlife.htm

Freshwater Mussels

Project Objective(s): document the occurrences of the State's freshwater mussels; learn about their life histories, habitat requirements, and conservation needs; and conserve habitat for Maine's rarer species.
In 2002, MDIFW continued collaboration on a research project to advance the understanding and conservation of Maine's two rarest freshwater mussel species _ the yellow lampmussel and tidewater mucket.
From 1992-97, MDIFW conducted a statewide survey to determine the status, abundance, and distribution of the State's freshwater mussels.

Project Measures: molluscan distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Maine Amphibian and Reptile Atlasing Project

Project Objective(s): Distribution and Status of High Priority Species.
From 1986-1990 over 250 volunteers from around the state contributed approximately 1,200 records of observations of amphibians and reptiles.
MDIFW continues to maintain a statewide database for amphibians and reptiles.

Project Measures: herptile distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Partners in Amphibian and Reptile Conservation

Project Objective(s): MDIFW participates in PARC meetings designed to improve communication on efforts to conserve threatened herptile species in the Northeast, and to identify new projects of regional priority for implementation.

PARC's mission is to forge partnerships among diverse public and private organizations in an effort to stem recent declines of amphibian and reptile (herptile) populations worldwide.

Project Measures: Amphibian distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/wildlife.htm
http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.parcplace.org/

Maine Department of Inland Fisheries and Wildlife

Endangered and Threatened Species

Vernal Pools

Project Objective(s): Water Body Location and Classification
learn about why some vernal pools receive greater wildlife use than others.
wildlife use and characteristics of vernal pools in three southern Maine townships: Biddeford; Kennebunkport; and, North Berwick.

Project Measures: Amphibians | aquatic plant community composition | Frog populations | waterfowl reproductive success

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Endangered and Threatened Species Study

Amphibian Monitoring

Project Objective(s): determining preliminary population trends for many of Maine's frogs and toads.

Project Measures: Frog populations | Frog calls

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Bald Eagle

Project Objective(s): Habitat "safety net" to maintain species recovery including at least 50 nesting areas under conservation ownership or appropriate easements.
At least 100 additional areas under conservation ownership, appropriate easements, or cooperative agreements with private landowners.

Project Measures: avian distribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Blandings and Spotted Turtles

Project Objective(s): More than 80 turtles were marked or radio-tagged to gather information on nesting and hibernation sites, movements, and the types of wetlands used.
Most significantly, her work demonstrated the importance of small pocket swamps and vernal pools as productive foraging and breeding habitats, with individual turtles often requiring multiple wetlands within a single activity area.
MDIFW is committed to working with landowners and towns to help conserve remaining large blocks of habitat needed to sustain viable populations of these rare turtles.

Project Measures: chelonian population viability

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm
http://www.state.me.us/ifw/wildlife/03report/et.htm

Golden Eagle

Project Objective(s): MDIFW will work cooperatively with landowners to maintain suitable habitat at the few eyries once used by goldens.

Project Measures: avian distribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Grasshopper Sparrows

Project Objective(s): Distribution and Status of High Priority Species.

Project Measures: avian distribution and
abundance

Web Link(s):

Maine Department of Inland Fisheries and Wildlife

Endangered and Threatened Species Study

Peregrine Falcon

Project Objective(s): A total of 144 young peregrines produced in captive-breeding programs were successfully released at 8 different locations in Maine during 1984-1997.
1989 - 2001, but numbers of nesting peregrines did not change appreciably: 5 - 8 eyries were inhabited each year.
in 2002. The statewide breeding population doubled in a single year. Peregrines inhabited 15 eyries, and 26 young peregrines fledged from ten of those eyries.
Diligence by land managers has been crucial to maintaining eyries favored by peregrines.

Project Measures: avian distribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Wood Turtles

Project Objective(s): About 40 radio-tagged turtles were tracked and the nests located, and documented their movements and habitat use.
summer temperature influences hatching success of wood turtles - a critical factor influencing population viability at the northern edge of the specie's range.
Now studying the conservation genetics of wood turtles.
at the state level, several of Maine's major watersheds host unique wood turtle populations that have been isolated from one another over hundreds or thousands of years.

Project Measures: Reptile distribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/etss.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Mammals

Black Bears

Project Objective(s): Distribution and Status of High Priority Species.
The Department's goal, chosen with public input, is to maintain the bear population at its current level.

Project Measures: game animal distribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/mamm.htm
http://www.state.me.us/ifw/wildlife/03report/bbear.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Coyote/Wolf

Project Objective(s): a genetic study to clarify whether Maine's coyotes are true coyotes or coyote/wolf hybrids, and to determine whether our coyotes can be distinguished from eastern Canadian wolves.
Information from this research will help our Department better understand how to approach enforcement issues concerning the incidental killing of wolves by trappers or snares, and may give insight into the behavior of our coyotes.
this research will be an essential step in determining whether it is feasible or desirable to recover wolves in Maine and the rest of the Northeast.

Project Measures: game animal distribution and genetic markers
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/furbear.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Marten

Project Objective(s): Distribution and Status of High Priority Species.

Project Measures: game animal distribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/furbear.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Maine Department of Inland Fisheries and Wildlife

Mammals

Moose

Project Objective(s): Distribution and Status of the species.

Project Measures: game animal distribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/wildlife.htm
http://www.state.me.us/ifw/wildlife/03report/mamm.htm
http://www.state.me.us/ifw/wildlife/03report/moose.htm

New England Cottontail

Project Objective(s): A cooperative Master's project between MDIFW and Dr. John Litvaitis, University of New Hampshire, was started in the Fall of 1999.
(1) determine the current distribution of New England cottontails in Maine using snowtrack, fecal pellet, and live trapping surveys.
(2) characterize the attributes of sites occupied by New England cottontails in Maine.
(3) develop a monitoring protocol capable of detecting status changes of New England cottontails in Maine.
Having a clear set of management goals for New England cottontail is critical at this time, since the species is on the verge of being listed as either a Threatened or Endangered species by the U.S. Fish and Wildlife Service.

Project Measures: Mammalian distribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/wildlife.htm
http://www.state.me.us/ifw/wildlife/03report/mamm.htm
http://www.state.me.us/ifw/wildlife/03report/furbear.htm

Whitetail Deer

Project Objective(s): we have set population objectives of 15 or 20 deer/mi2 for each central and southern Maine WMD.
In northern and eastern Maine, the road to a more abundant deer population must involve increasing and restoring some of the deer wintering habitat that was lost during the past 3 decades.

Project Measures: game animal distribution and
abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/deer.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Partners in Flight

Grassland Birds & Monitoring/Atlasing

Project Objective(s): Distribution and Status of High Priority Species.
Grassland Bird Focus Group: 1: inventory all the significant populations of grassland birds in Maine with Upland Sandpipers and Vesper Sparrows as primary targets.
Grassland Bird Focus Group: 2:to ensure that Conservation Reserve Program lands are maintained in early successional cover and thus continue to provide habitat for grassland birds.
Monitoring/Atlasing: to improve monitoring for species that are inadequately surveyed by the North American Breeding Bird Survey.

Project Measures: avian distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/pif/index.htm
http://www.state.me.us/ifw/wildlife/pif/focus/index.htm

Penobscot Meadow Vole

Project Objective(s): Distribution and Status of High Priority Species

Project Measures: Mammalian distribution and abundance

Web Link(s):

Tomah Mayfly

Project Objective(s): Distribution and Status of High Priority Species.

Project Measures: invertebrate range and distribution

Web Link(s):

Maine Department of Inland Fisheries and Wildlife

Wildlife Division

Canada Lynx

Project Objective(s): Distribution and Status of High Priority Species.

Project Measures: Mammalian distribution and abundance

Web Link(s): http://www.state.me.us/ifw/wildlife/03report/furbear.htm - Sliverskip
http://www.state.me.us/ifw/wildlife/03report/wildlifeplanning.htm
http://www.state.me.us/ifw/wildlife/wildlife.htm

Wood Cock

Project Objective(s): Distribution and Status of High Priority Species.

Project Measures: game animal distribution and abundance

Web Link(s):

Maine Forest Service

Forest Health Monitoring

Pine Shoot Beetle/Hemlock Woolly Adelgid

Project Objective(s): protect the forest, shade and ornamental tree resources of the state from significant insect and disease damage.
to provide pest management and damage prevention for homeowners, municipalities, and forest land owners and managers.

Project Measures: disease/pest conditions

Web Link(s): http://www.state.me.us/doc/mfs/psb.htm
http://www.state.me.us/doc/mfs/idmhome.htm
http://www.state.me.us/doc/mfs/idmhwa.htm

Maine Tribal Community / U.S. Environmental Protection Agency

Penobscot Air Program

Project Objective(s): control pollutant emissions from automobiles, factories, and other sources.

Project Measures:

Carbon monoxide	nitrogen dioxide	Ozone
Lead	particulate matter	sulfur dioxide

Web Link(s): http://www.penobscotnation.org/DNR/Air%20news/overview.htm
http://www.penobscotnation.org/DNR/air_index.htm
http://www.penobscotnation.org/DNR/DNR1.htm

Maryland Department of Natural Resources

Endangered and Threatened Species Study

Bald Eagles

Project Objective(s): Distribution and Status of High Priority Species.
Project Measures: avian distribution and abundance
Web Link(s): http://www.dnr.state.md.us/wildlife/rimon.html

Natural Heritage & Endangered Species Program

Piping Plover Nest

Project Objective(s): Distribution and Status of High Priority Species.
Project Measures: avian distribution and abundance
Web Link(s): http://www.dnr.state.md.us/wildlife/rimon.html

Maryland Department of Natural Resources

Natural Heritage Program

Ancient xeric sand dunes

Project Objective(s): Geology.
Project Measures: Rare community distribution and composition
Web Link(s): http://www.dnr.state.md.us/wildlife/rimon.html

Bog Turtle

Project Objective(s): Distribution and Status of High Priority Species.
Project Measures: chelonian population viability
Web Link(s): http://www.dnr.state.md.us/wildlife/rimon.html

Butterflies

Project Objective(s): Distribution and Status of High Priority Species.
Project Measures: lepidopteran reproductive success
Web Link(s): http://www.dnr.state.md.us/wildlife/rimon.html

Colonial Waterbirds

Project Objective(s): Distribution and Status of High Priority Species.
Project Measures: avian distribution and abundance
Web Link(s): http://www.dnr.state.md.us/wildlife/rimon.html

Delmarva Fox Squirrel

Project Objective(s): Distribution and Status of High Priority Species.
Project Measures: Mammalian distribution and abundance
Web Link(s): http://www.dnr.state.md.us/naturalresource/fall2002/squirrel.html
http://www.dnr.state.md.us/wildlife/rimon.html

Dragonflies

Project Objective(s): Distribution and Status of High Priority Species.
Project Measures: rare invert distribution
Web Link(s): http://www.dnr.state.md.us/wildlife/rimon.html

Freshwater Fish: Rare Animal Species

Project Objective(s): Distribution and Status of High Priority Species.
Project Measures: fish distribution and abundance
Web Link(s): http://www.dnr.state.md.us/wildlife/rimon.html

Freshwater Mussels

Project Objective(s): Distribution and Status of High Priority Species.
Project Measures: molluscan distribution and abundance
Web Link(s): http://www.dnr.state.md.us/wildlife/dwm.html
http://www.dnr.state.md.us/wildlife/rimon.html

Ground Water Fauna

Project Objective(s): Water Body Location and Classification.
Project Measures: Algae
Web Link(s): http://www.dnr.state.md.us/wildlife/rimon.html

Limestone glades and woodlands

Project Objective(s): Soils.
Project Measures: Rare community distribution and composition
Web Link(s): http://www.dnr.state.md.us/wildlife/rimon.html

Maryland Department of Natural Resources

Natural Heritage Program

Mixed-mesophytic forests
Project Objective(s): Vegetation Mapping.
Project Measures: Rare community distribution and composition
Web Link(s): http://www.dnr.state.md.us/wildlife/rimon.html

Nanticoke River watershed communities
Project Objective(s): Water Body Location and Classification.
Project Measures: Rare community distribution and composition
Web Link(s): http://www.dnr.state.md.us/wildlife/rimon.html

Potomac drainage floodplain forests
Project Objective(s): Distribution and Status of High Priority Species.
Project Measures: Habitat classification/profiling
Web Link(s): http://www.dnr.state.md.us/wildlife/rimon.html

Rare Plant Species
Project Objective(s): Distribution and Status of High Priority Species.
Project Measures: rare plant distribution and abundance
Web Link(s): http://www.dnr.state.md.us/wildlife/rimon.html

Reptile and Amphibian Surveys
Project Objective(s): Distribution and Status of High Priority Species.
Project Measures: herptile distribution and abundance
Web Link(s): http://www.dnr.state.md.us/wildlife/rimon.html

Sandstone glades
Project Objective(s): Soils.
Project Measures: Rare community distribution and composition
Web Link(s): http://www.dnr.state.md.us/wildlife/mcc.html
http://www.dnr.state.md.us/wildlife/rimon.html

Shale barren habitats
Project Objective(s): Soils.
Project Measures: Rare community distribution and composition
Web Link(s): http://www.dnr.state.md.us/wildlife/rimon.html

Small Mammal Survey and Monitoring
Project Objective(s): Distribution and Status of High Priority Species.
Project Measures: Mammalian distribution and abundance
Web Link(s): http://www.dnr.state.md.us/wildlife/rimon.html

Massachusetts Audubon

Important Bird Areas (IBA)

Project Objective(s): To identify, nominate, and designate key sites that contribute to the preservation of significant bird populations or communities.
To provide information that will help land managers evaluate areas for habitat management and/or land acquisition.
To activate public and private participation in bird conservation efforts.
To provide public education and community outreach opportunities.
Project Measures: avian distribution and abundance Habitat usage threatened & endangered breeding
Web Link(s): http://www.massaudubon.org/index.php
http://www.massaudubon.org/Birds_&_Beyond/IBAs/index.php

Massachusetts Department of Environmental Protection

Air Program Planning Unit

Addressing Air Toxics in Massachusetts

Project Objective(s): In order to protect the health of Massachusetts' residents and preserve our environment; aims to reduce the emissions and ambient air impact of a number of toxic air pollutants likely to be used by business, industry, and individuals in the state.

TURA (Massachusetts Toxic Use Reduction Act)focusing on pollution prevention as a way to comply with regulatory standards while increasing the economic competitiveness of Massachusetts industry.

Ozone Reduction is the reduction of volatile organic compound (VOCs) emissions from a variety of sources, including industry and mobile sources.

Project Measures:

polycyclic aromatic hydrocarbons	Chromium	benzene
toluene	xylenes	perchloroethylene
methylene chloride	Cadmium	mercury monitoring

Web Link(s): http://www.state.ma.us/dep/bwp/daqc/files/airtox.htm

Wetlands Conservancy Program

Project Objective(s): The DEP is mapping the state's wetlands using aerial photography and photointerpretation to delineate wetland boundaries which is used to document the extent and type of the state's wetlands.

Project Measures: Wetland community composition and distribution

Web Link(s): http://www.state.ma.us/dep/brp/
http://www.state.ma.us/dep/brp/ww/rpwwhome.htm
http://www.state.ma.us/dep/brp/ww/files/wcpbroch.pdf

Massachusetts Division of Fisheries and Wildlife

Natural Heritage & Endangered Species Program

Natural Communities

Project Objective(s): The Massachusetts Natural Heritage Program actively inventories and tracks the distribution and status of uncommon and exemplary natural communities across the state.

Conservation priority should be given to: natural communities with limited distribution across ecoregions within the state, those with restricted global distribution, and those common types for which the best documented examples occur in Massachusetts.

Project Measures: Rare community distribution and composition

Web Link(s): http://www.state.ma.us/dfwele/dfw/nhesp/nhcommun.htm
http://www.state.ma.us/dfwele/dfw/nhesp/nhesp.htm

Rare Animal Species

Project Objective(s): The Program's highest priority is protecting the approximately 190 species of vertebrate and invertebrate animals that are officially listed as endangered, threatened or of special concern in Massachusetts.

Project Measures:

rare vertebrate distribution and abundance	rare invertebrate distribution and abundance

Web Link(s): http://www.state.ma.us/dfwele/dfw/nhesp/nhspecies.htm
http://www.state.ma.us/dfwele/dfw/nhesp/nhesp.htm

Massachusetts Division of Fisheries and Wildlife

Natural Heritage & Endangered Species Program

Rare Plant Species

Project Objective(s): The Program's highest priority is protecting the approximately 258 species of native plants that are officially listed as Endangered, Threatened or of Special Concern in Massachusetts.

Project Measures:

rare plant distribution and abundance	Habitat usage

Web Link(s): http://www.state.ma.us/dfwele/dfw/nhesp/nhspecies.htm
http://www.state.ma.us/dfwele/dfw/nhesp/nhesp.htm

Vernal Pools

Project Objective(s): The NHESP serves the important role of officially "certifying" vernal pools that are documented by citizens. Finding vernal pools is the first step for protection.

Project Measures:

Rare community distribution and composition	Habitat usage	Wetland community composition and distribution

Web Link(s): http://www.state.ma.us/dfwele/dfw/nhesp/nhvernal.htm
http://www.state.ma.us/dfwele/dfw/nhesp/nhesp.htm

National Atmospheric Deposition Program

Atmospheric Integrated Research Monitoring Network (AIRMoN)

AIRMonN-Wet & AIRMoN-Dry

Project Objective(s): Determining the effectiveness of emission controls mandated by the Clean Air Act.
Evaluating the potential impacts of new sources of emissions on protected areas such as Class I Wilderness Areas.
Identifying source/receptor relationships in atmospheric models.
AIRMoN was designed to provide data with a greater temporal resolution.

Project Measures: Precipitation composition; nitrogen; Ozone; sulfur dioxide; gaseous nitric acid

Web Link(s): http://nadp.sws.uiuc.edu/airmon/

Mercury Depostion Network (MDN)

Project Objective(s): The objective of the MDN is to develop a national database of weekly concentrations of total mercury in precipitation and the seasonal and annual flux of total mercury in wet deposition.
The data will be used to develop information on spatial and seasonal trends in mercury deposited to surface waters, forested watersheds, and other sensitive receptors.

Project Measures: mercury monitoring; Precipitation composition; methylmercury

Web Link(s): http://nadp.sws.uiuc.edu/mdn/

New Hampshire Audubon

Backyard Bird Survey

Backyard Winter Bird Survey

Project Objective(s): Backyard Winter Bird Survey participants report any bird species visiting their yard and/or feeders in New Hampshire on the second weekend of February. Originally begun as a "Cardinal-Tufted Titmouse Census," it was expanded in 1987 to gather information on the distribution and abundance of many winter species in New Hampshire.

Project Measures: avian distribution and abundance

Web Link(s): http://www.nhaudubon.org

New Hampshire Division of Forests and Lands

Natural Heritage Bureau

Natural Communities

Project Objective(s): The NH Natural Heritage Bureau tracks "exemplary" natural community occurrences.
To qualify as exemplary, a natural community in a given place must be of a rare type, such as a pitch pine/scrub oak barrens, or must be an exceptional occurrence of a common type, such as an old growth spruce/fir forest.

Project Measures: Commuinity composition; Wetland community composition and distribution; Forest community composition and distribution; Grassland community composition and distribution

Web Link(s): http://www.nhdfl.org/formgt/nhiweb/

Rare Animal Species

Project Objective(s): The NH Natural Heritage Bureau tracks rare animal species.

Project Measures: rare vertebrate distribution and abundance; rare invert distribution

Web Link(s): http://www.nhdfl.org/formgt/nhiweb/

Rare Plant Species

Project Objective(s): The NH Natural Heritage Bureau tracks the state's rarest and most imperiled plant species.

Project Measures: rare plant distribution and abundance

Web Link(s): http://www.nhdfl.org/formgt/nhiweb/

New Hampshire Fish and Game Department

Moose Research

Moose Research in North Country

Project Objective(s): To track the movements and habitat use as well as population dynamics, mortality and habitat needs.
Information collected on the study moose will enable Fish and Game biologists to more effectively manage the state's overall moose population.

Project Measures: Habitat usage; Mammalian distribution and abundance

Web Link(s): http://www.wildlife.state.nh.us/Newsroom/News_2003/News_2003_Q3/Moose_Research_090403.htm
http://www.wildlife.state.nh.us/

New Jersey Audubon

Important Bird and Birding Area Program (IBBA)

Project Objective(s): Identify both areas that are essential habitats for sustaining native avian populations (Important Bird Areas), and areas that are exceptional for birdwatching (Important Birding Areas).

Project Measures: breeding; Habitat usage

Web Link(s): http://www.njaudubon.org/Conservation/IBBA/OurIBBA.html
http://www.njaudubon.org/

New Jersey Department of Environmental Protection

Natural Heritage Program

Rare Plants and Animals

Project Objective(s): Identifies the state's most significant natural areas through a comprehensive inventory of rare plant and animal species and representative natural communities.

Project Measures: rare plant distribution and abundance; rare invertebrate distribution and abundance; rare vertebrate distribution and abundance

Web Link(s): http://www.natureserve.org/nhp/us/nj/

New York State Department of Environmental Conservation

Natural Heritage Program

Ecological Communities

Project Objective(s): An ecological community is a variable assemblage of interacting plant and animal populations that share a common environment; in NY a classification has been developed to help assess and protect the biological diversity of the state.

Project Measures: Community composition

Web Link(s): http://www.dec.state.ny.us/website/dfwmr/heritage/
http://www.dec.state.ny.us/website/dfwmr/heritage/ecology.htm

New York Natural Heritage Program

Herp Atlas

Project Objective(s): Herp Atlas was a ten year survey that was designed to document the geographic distribution of New York State's herpetofauna.

Project Measures: herptile distribution and abundance

Web Link(s): http://www.dec.state.ny.us/website/dfwmr/wildlife/herp/

Rare Animal Species

Project Objective(s): Actively surveys rare animal species of all vertebrate groups and selected rare species from the invertebrate groups.

Project Measures: rare vertebrate distribution and abundance; rare invertebrate distribution and abundance

Web Link(s): http://www.dec.state.ny.us/website/dfwmr/heritage/animallist.pdf
http://www.dec.state.ny.us/website/dfwmr/heritage/
http://www.dec.state.ny.us/website/dfwmr/heritage/animals.htm

Rare Plant Species

Project Objective(s): The New York Natural Heritage Program keeps track of the status of the state's rare flowering plants, conifers, ferns and fern allies, and mosses.

Project Measures: rare plant distribution and abundance

Web Link(s): http://www.dec.state.ny.us/website/dfwmr/heritage/plants.htm
http://www.dec.state.ny.us/website/dfwmr/heritage/index.htm

New York State Museum

Inventory of Sterling Forest (1998 to 2000)

Project Objective(s): Scientists from the New York State Museum have conducted faunal and floral inventories of the recently acquired Sterling Forest State Park. Lists of species were generated for amphibians, reptiles, fish, crayfish, mammals, insects (butterflies, moths, dragonflies, and damselflies), and plants.

Project Measures: Species diversity

Web Link(s): http://www.nysm.nysed.gov/bri/research/steward.html - Sterling

Wildlife Science and Conservation Initiative

Albany Pine Bush Carnivore Research Project

Project Objective(s): Establish the distribution and relative abundance of carnivores in the PB reserve.
Evaluate the health of carnivore populations in terms of population size, disease, genetic diversity, and animal dispersal between reserve fragments.
Estimate the diet of different carnivore species through fecal analysis.
Change in relative abundance and diversity of prey communities (e.g., rodents and smaller carnivores).
Related change in seed predation or dispersal by rodents.
Related change in browsing and grazing intensity by deer and rabbits.
Change in nest predation rates for birds.

Project Measures: Mammalian distribution and abundance

Web Link(s): http://www.nysm.nysed.gov/WildSci/pinebush.html

Penobscot Nation Dept of Natural Resources

Forest Management

Forest Management Plan

Project Objective(s): Preserve and protect water quality on the trust lands; Preserve and enhance the long-term productivity of the forest resource.
Provide for the protection of the forest resource from insects, disease, fire, trespass and invasive species.
Identify and protect significant natural resources located on the trust lands; including but not limited to fisheries and important wildlife habitat such as deer wintering areas, habitat for threatened and endangered species and vernal pools.
Identify and protect significant cultural and archaeological resources on the trust lands; Where appropriate, emphasis the management of the forest to maintain and improve the populations of moose and white-tailed deer.

Project Measures: water quality; archaeological resources; disease/pest conditions; Habitat usage; Land use

Web Link(s): http://www.penobscotnation.org/DNR/forest_management_goals.htm
http://www.penobscotnation.org/DNR/DNR1.htm
http://www.penobscotnation.org/DNR/forestry.htm

Penobscot Water Quality Program

National Fish Tissue Study

Project Objective(s): The statistical design of the 4 year study will allow us to develop national estimates of the mean concentrations of 268 chemicals in fish tissue from lakes and reservoirs of the lower 48 States.
study results will define national background levels for the 265 chemicals in fish, to provide a baseline to track progress of pollution control activities, and to identify areas where contaminant levels are high enough to warrant further investigation.

Project Measures: Fish tissue contaminant composition

Web Link(s): http://www.penobscotnation.org/DNR/PINWQP.htm
http://www.penobscotnation.org/DNR/DNR1.htm
http://www.epa.gov/waterscience/fishstudy/

Southern Appalachian Man and the Biosphere

Southern Appalachian Man and the Biosphere

Project Objective(s): The Southern Appalachian Man and the Biosphere (SAMAB) Program is a public/private partnership that focuses its attention on the Southern Appalachian Biosphere Reserve. The program encourages the utilization of ecosystem and adaptive management principles. SAMAB's vision is to foster a harmonious relationship between people and the Southern Appalachian environment. Its mission is to promote the environmental health and stewardship of natural, economic, and cultural resources in the Southern Appalachians. It encourages community-based solutions to critical regional issues through cooperation among partners, information gathering and sharing, integrated assessments, and demonstration projects.

Project Measures: Air quality; Ecosystem Health; Invasive species

Web Link(s):

U.S. Fish and Wildlife Service

Gulf of Maine Coastal Program

Atlantic Salmon Watersheds, Maine: Habitat Identi

Project Objective(s): Mapping spawning and nursery habitat, developing watershed land cover information, providing assistance to watershed coalitions by identifying potential threats to salmon survival, providing technical assistance to partners.

restoring natural river channels, and developing on-the-ground partnerships to protect salmon habitat.

Project Measures: fish distribution and abundance; Habitat classification/profiling

Web Link(s): http://gulfofmaine.fws.gov/salmon.html
http://gulfofmaine.fws.gov/documents/salmon.pdf

U.S. Fish and Wildlife Service

Gulf of Maine Coastal Program

Gulf of Maine Watershed Habitat Analysis

Project Objective(s): Identified, mapped, and ranked important fish and wildlife habitat for priority species throughout the Gulf of Maine watershed.

Project Measures: Habitat usage; fish distribution and abundance; waterfowl reproductive success

Web Link(s): http://gulfofmaine.fws.gov/gomanalysis/gomanalysis.html
http://gulfofmaine.fws.gov/gomanalysis/documents/gomanalysis.pdf

U.S. Forest Service

Air Resources Program

Project Objective(s): The Mission of the Air Resource Program is to protect and/or enhance air quality on the National Forest. As we work to implement this mission we in effect, provide for cleaner air and healthier forests in all of southern Vermont. To achieve this mission we: Monitor the effects of air quality on components of the forest ecosystem. Monitoring is done in cooperation with several state and federal agencies, and educational institutions; Evaluate the impacts of proposed new major emissions sources on Lye Brook Wilderness, our Class I Air Quality Area; Evaluate the effects of Forest Service management activities on air quality; Share our monitoring information and expertise with the public.

Project Measures: Air quality

Web Link(s): http://www.fs.fed.us/r9/gmfl/resource_management/air/air.htm

Forest Health Monitoring

Forest Inventory and Analysis

Project Objective(s): The Forest Inventory and Analysis Program tracks 3 Criteria and 67 Indicators. Criteria are: 1)Conservation of Biological Diversity; 2) Maintenance of Productive Capacity of Forest Ecosystems; 3)Maintenance of Forest Ecosystem Health & Vitality.

Collect and disseminate information about the forests of the Northeastern United States relating to forest distribution, forest condition, ownership patterns, timber utilization, and forest mensuration techniques.

Develop and apply scientific knowledge and technology in support of the inventory and analysis project.

Project Measures: Soil characteristics; Tree condition; Lichens; Air quality

Web Link(s): http://www.fs.fed.us/projects/
http://fia.fs.fed.us/rpa.htm
http://www.fs.fed.us/ne/fia/
http://www.fs.fed.us/research/sustain/

U.S. Geologic Survey

North American Breeding Bird Survey

North American Breeding Bird Survey

Project Objective(s): To monitor the status and trends of North American bird populations.

Project Measures: avian distribution and abundance

Web Link(s): http://www.mp2-pwrc.usgs.gov/bbs/

Southeastern Amphibian Research and Monitoring Initiative

Great Smoky Mountains NP I&M Project

Project Objective(s): Provide a geographically-referenced inventory of the amphibian resources of the Great Smoky Mountains National Park.

Provide indices of abundance of Park amphibian species, referenced to locations and habitat types. Develop and transfer to the Great Smoky Mountains National Park and National Park Service a series of protocols suitable for long-term monitoring of amphibian populations in the Smokies and other Appalachian Parks.

As possible, evaluate current distributions and abundance of amphibian species in the Park with literature reports of past investigations.

Project Measures: Amphibians

Web Link(s): http://cars.er.usgs.gov/Amphibians_and_Reptiles/Herp_Program_Goals/herp_program_goals.html

University of Maine Cooperative Extension

Maine Shore Stewards

Clean Water/Partners in Monitoring

Project Objective(s): study the health of estuarine water by monitoring for dissolved oxygen, temperature, pH, salinity, and fecal coliform bacteria.

As a result of successful monitoring efforts in Maine, thousands of acres of clam flats have been opened.

Project Measures:

Fecal coliform	Temperature	Dissolved Oxygen
pH	Salinity	

Web Link(s): http://www.ume.maine.edu/ssteward/cwpim.htm

Vermont Department of Environmental Conservation

Air Pollution Control Division

Ambient Air Toxics Monitoring in Vermont

Project Objective(s): The Vermont Air Pollution Control Division (APCD) has been monitoring a battery of toxics in the ambient air at several locations in the state since 1993.

The toxics monitored include volatile organic compounds (VOCs), carbonyls, metals and semi-volatiles.

Project Measures:

toxic elements	Carbon monoxide	Ozone
Nitrogen Oxides	particulate matter	sulfur dioxide

Web Link(s): http://www.anr.state.vt.us:8500/public/dec/air/Planning/htm/AirToxMonitoring.htm

Water Quality Division

Biomonitoring and Aquatic Studies Section (BASS)

Project Objective(s): To conduct environmental monitoring of aquatic resources, with an emphasis on the assessment of biological integrity.

BASS also conducts special studies in areas of special concern such as acid rain, malformed frogs, aquatic nuisance control and seasonal pools.

Project Measures:

Macroinvertebrates	Water chemistry	Habitat usage

Web Link(s): http://dep.state.ct.us/air2/toxics/monitiat.htm

Vermont Department of Fish and Wildlife

Nongame and Natural Heritage Program

Natural Communities

Project Objective(s): To protect natural communities which are an assemblage of plants and animals that are found recurring across a specific landscape under similar environmental conditions where natural processes, rather than human disturbances, prevail.

Project Measures: Rare community distribution and composition

Web Link(s): http://www.anr.state.vt.us/fw/fwhome/nnhp/index.html
http://www.vtfishandwildlife.com/
http://www.vtfishandwildlife.com/wildlife_nongame.cfm

Rare Animal Species

Project Objective(s): We are actively tracking rare species with the following state ranks: SH, S1,S2 (breeding records only for birds). We are also interested in information on uncommon species S3.

Project Measures:

rare vertebrate distribution and abundance	rare invertebrate distribution and abundance

Web Link(s): http://www.anr.state.vt.us/fw/fwhome/nnhp/index.html
http://www.vtfishandwildlife.com/
http://www.vtfishandwildlife.com/wildlife_nongame.cfm

Rare Plant Species

Project Objective(s): We are actively tracking rare species with the following state ranks (SH, S1, S2). However, we are also interested in information on uncommon species (S3).

Project Measures: rare plant distribution and abundance

Web Link(s): http://www.anr.state.vt.us/fw/fwhome/nnhp/Intro%20to%20Plant%20R,T,E%202000.htm
http://www.vtfishandwildlife.com/
http://www.vtfishandwildlife.com/wildlife_nongame.cfm

Vermont Institute of Natural Science

Mountain Bird Watch

Mountain Bird Watch

Project Objective(s): Mountain Birdwatch is a long-term monitoring program for songbirds that breed in high-elevation forests of the Northeast. Skilled volunteers conduct annual surveys along 1-km routes that are located on mountains in New York, Vermont, New Hampshire, and Maine. Primary emphasis is placed on Bicknell's Thrush, the region's only endemic bird species, and a montane fir specialist that is vulnerable to ongoing and projected habitat loss. Other focal species include Blackpoll Warbler, Swainson's Thrush, White-throated Sparrow, and Winter Wren. In 2002, Mountain Birdwatchers gathered observations from 142 locations, with point count surveys completed on 118 routes.

Project Measures: avian distribution and abundance

Web Link(s): http://www.vinsweb.org/cbd/mtn_birdwatch.html

Vermont Butterfly Survey

Project Objective(s): The Vermont Butterfly Survey is a five-year census to document the relative abundance and distribution of butterflies across Vermont.
To learn which butterfly species exist in Vermont.
Allow Vermonters to contribute to a greater understanding of the nature of their state.

Project Measures: lepidopteron distribution and abundance

Web Link(s): http://www.uvm.edu/~vbap/index.html

Vermont Monitoring Cooperative

Amphibian Survey and Monitoring

Salamanders and Frogs on Mount Mansfield and The L

Project Objective(s): The purpose of this study is to establish baseline population data that can be compared to future surveys and be compared to data collected in the following years to look for trends or changes in population numbers and species over time.

Project Measures: Amphibian distribution and abundance; Community composition

Web Link(s): http://vmc.snr.uvm.edu/summary/general001.htm

Basic Meteorological Monitoring

Project Objective(s): The continuous monitoring of a variety of meteorological variables.
The information collected at this site can be used in conjunction with biological or physical information gathered in other projects at or near the site.

Project Measures: Temperature; Wind direction; Wind speed; Relative humidity; Barometric pressure; Precipitation

Web Link(s): http://vmc.snr.uvm.edu/summary/general006.htm

Bicknell's Thrush: Population Demographics and Ecology

Project Objective(s): To monitor population densities and determine the breeding ecology of Bicknell's Thrush, to assess the conservation status of this bird regionally, and to determine the effects of ski area development on the forest bird community.

Project Measures: avian distribution and abundance

Web Link(s): http://vmc.snr.uvm.edu/summary/general049.htm

Forest Bird Monitoring

Project Objective(s): To determine long-term bird population changes in protected, non-fragmented habitats.
Results will help provide insights into how forest fragmentation in unprotected areas may affect the relative abundance of forest-breeding songbirds.

Project Measures: avian distribution and abundance; breeding; Habitat usage; Habitat classification/profiling

Web Link(s): http://vmc.snr.uvm.edu/bird.html
http://vmc.snr.uvm.edu/summary/general013.htm

Vermont Monitoring Cooperative

Landscape Fall Color and Leaf Drop Monitoring

Project Objective(s): To develop a visual rating system for monitoring fall color and leaf drop on a landscape scale on Mount Mansfield.

Project Measures: Fall foliage color quality; Fall foliage color composition

Web Link(s): http://vmc.snr.uvm.edu/summary/general031.htm
http://vmc.snr.uvm.edu/summary.asp?tab=1

Pine Mountain Biodiversity Project

Project Objective(s): The variety of plants and animals, their genetic variability, their interrelationships, and the biological and physical systems, communities and landscapes in which they exist.

Project Measures: Species diversity; Natural communities; Geology; Water resources; Climate

Web Link(s): http://vmc.snr.uvm.edu/summary/generalpineMT.htm

Virginia Department of Conservation and Recreation

Natural Heritage Program

Invasive Plants

Project Objective(s): VA has identified 115 invasive alien plant species that threaten or potentially threaten natural areas, parks, and other protected lands in Virginia.

Project Measures: disease/pest conditions

Web Link(s): http://www.dcr.state.va.us/dnh/invinfo.htm

Natural Communities

Project Objective(s): An ecological community is an assemblage of co-existing, interacting species, considered together with the physical environment and associated processes, that usually recurs on the landscape.

This present treatment is restricted to NATURAL COMMUNITIES, those which have experienced only minimal human alteration or have recovered from anthropogenic disturbance under mostly natural regimes of species interaction and disturbance.

Provide a comprehensive classification of Natural Communities in VA and construct a broad framework for understanding and defining such communities at several hierarchical levels.

Project Measures: Rare community distribution and composition; vegetation; Wetland community composition and distribution

Web Link(s): http://www.dcr.state.va.us/dnh/community_list.pdf

Rare Animal Species

Project Objective(s): Species that use discrete habitat patches or can directly benefit from habitat protection.

Project Measures: rare vertebrate distribution and abundance; rare invertebrate distribution and abundance

Web Link(s): http://www.dcr.state.va.us/dnh/
http://www.dcr.state.va.us/dnh/anlist03.pdf

Rare Plant Species

Project Objective(s): Identify Natural Heritage Resources which are in need of conservation attention while creating an efficient means of evaluating the impacts of economic growth.

Focus the inventory on the Natural Heritage Resources most likely to be lost without conservation action in the near future.

Project Measures: rare plant distribution and abundance; Vascular plants; Non-Vascular plants

Web Link(s): http://www.dcr.state.va.us/dnh/plantlist03.pdf

Boston Harbor Island, a National Park Area

Center for Sponsored Coastal Ocean Research

ECOHAB Ecology and Oceanography of Harmful Algal Blooms

Gulf of Maine

Project Objective(s): goal of the ECOHAB program is to develop reliable models to forecast bloom development, persistence, and toxicity.

This research will foster rapid response by monitoring agencies and health departments to safeguard public health, local economies, and fisheries.

Further, identification of bloom-favorable conditions may permit management of specific environmental factors to reduce bloom impacts.

Project Measures: Algae

Web Link(s): http://www.cop.noaa.gov/Fact_Sheets/ECOHAB.html

U.S. Global Ocean Ecosystem Dynamics (GLOBEC)

GLOBEC Georges Bank

Project Objective(s): Distribution and Status of High Priority Species.

The proximate goal of the Georges Bank program is to understand the population dynamics of key species on the Bank - cod, haddock, and two species of zooplankton.

goal is to be able to predict changes in the distribution and abundance of these species as a result of changes in their physical and biotic environment as well as to anticipate how their populations might respond to climate variability and change.

Project Measures: water quality; fish distribution and abundance

Web Link(s): http://www.cop.noaa.gov/Fact_Sheets/GLOBECNWA.html

Institute for Bird Populations

Monitoring Avian Productivity and Survivorship

Avian Inventory Program

Project Objective(s): indices of adult population size and post-fledging productivity from data on the numbers and proportions of young and adult birds captured.

estimates of adult population size, adult survival rates, proportions of residents, and recruitment into the adult population from mark-recapture data on adult birds.

Project Measures: avian distribution and abundance

Web Link(s): http://www.birdpop.org
http://www.birdpop.org/avianinv.htm
http://www.birdpop.org/maps.htm

Massachusetts Audubon

Important Bird Areas (IBA)

Project Objective(s): To identify, nominate, and designate key sites that contribute to the preservation of significant bird populations or communities.

To provide information that will help land managers evaluate areas for habitat management and/or land acquisition.

To activate public and private participation in bird conservation efforts.

To provide public education and community outreach opportunities.

Project Measures: avian distribution and abundance; Habitat usage; threatened & endangered breeding

Web Link(s): http://www.massaudubon.org/index.php
http://www.massaudubon.org/Birds_&_Beyond/IBAs/index.php

Massachusetts Department of Environmental Protection

Air Program Planning Unit

Addressing Air Toxics in Massachusetts

Project Objective(s): In order to protect the health of Massachusetts' residents and preserve our environment; aims to reduce the emissions and ambient air impact of a number of toxic air pollutants likely to be used by business, industry, and individuals in the state.
TURA (Massachusetts Toxic Use Reduction Act)focusing on pollution prevention as a way to comply with regulatory standards while increasing the economic competitiveness of Massachusetts industry.
Ozone Reduction is the reduction of volatile organic compound (VOCs) emissions from a variety of sources, including industry and mobile sources.

Project Measures:

polycyclic aromatic hydrocarbons	Chromium	benzene
toluene	xylenes	perchloroethylene
methylene chloride	Cadmium	mercury monitoring

Web Link(s): http://www.state.ma.us/dep/bwp/daqc/files/airtox.htm

Wetlands Conservancy Program

Project Objective(s): The DEP is mapping the state's wetlands using aerial photography and photointerpretation to delineate wetland boundaries which is used to document the extent and type of the state's wetlands.

Project Measures: Wetland community composition and distribution

Web Link(s): http://www.state.ma.us/dep/brp/
http://www.state.ma.us/dep/brp/ww/rpwwhome.htm
http://www.state.ma.us/dep/brp/ww/files/wcpbroch.pdf

Eelgrass Mapping

Project Objective(s): Massachusetts has completely mapped its Eelgrass beds along the coast and is distributing these to conservation commissions: Eelgrass beds are good indicators of water quality.

Project Measures: Herbaceous plants; Mapping

Web Link(s): http://www.state.ma.us/dep/brp/ww/files/wcpbroch.pdf

Massachusetts Division of Fisheries and Wildlife

Natural Heritage & Endangered Species Program

Natural Communities

Project Objective(s): The Massachusetts Natural Heritage Program actively inventories and tracks the distribution and status of uncommon and exemplary natural communities across the state.
Conservation priority should be given to: natural communities with limited distribution across ecoregions within the state, those with restricted global distribution, and those common types for which the best documented examples occur in Massachusetts.

Project Measures: Rare community distribution and composition

Web Link(s): http://www.state.ma.us/dfwele/dfw/nhesp/nhcommun.htm
http://www.state.ma.us/dfwele/dfw/nhesp/nhesp.htm

Rare Animal Species

Project Objective(s): The Program's highest priority is protecting the approximately 190 species of vertebrate and invertebrate animals that are officially listed as endangered, threatened or of special concern in Massachusetts.

Project Measures:

rare vertebrate distribution and abundance	rare invertebrate distribution and abundance

Web Link(s): http://www.state.ma.us/dfwele/dfw/nhesp/nhspecies.htm
http://www.state.ma.us/dfwele/dfw/nhesp/nhesp.htm

Rare Plant Species

Project Objective(s): The Program's highest priority is protecting the approximately 258 species of native plants that are officially listed as Endangered, Threatened or of Special Concern in Massachusetts.

Project Measures: rare plant distribution and abundance; Habitat usage

Web Link(s): http://www.state.ma.us/dfwele/dfw/nhesp/nhspecies.htm
http://www.state.ma.us/dfwele/dfw/nhesp/nhesp.htm

Massachusetts Division of Fisheries and Wildlife

Natural Heritage & Endangered Species Program

Vernal Pools

Project Objective(s): The NHESP serves the important role of officially "certifying" vernal pools that are documented by citizens. Finding vernal pools is the first step for protection.

Project Measures:

Rare community distribution and composition	Habitat usage	Wetland community composition and distribution

Web Link(s): http://www.state.ma.us/dfwele/dfw/nhesp/nhvernal.htm
http://www.state.ma.us/dfwele/dfw/nhesp/nhesp.htm

Massachusetts Office of Coastal Zone Management

Coastal 2000 - Comprehensive Marine Monitoring Program

Project Objective(s): Surface sediments from 90 randomly selected stations will be sampled through the summer of 2001 for a variety of contaminants of environmental concern, both inorganic and organic.
Water column samples will be taken at each site to provide a "snapshot" of hydrographic variables, nutrients, pigments, and suspended matter at the time of sampling.
Fish trawls will also be conducted to assess the composition of fish communities, and any pathology or parasites found.

Project Measures:

Sediment contaminant composition	Water column contaminant composition	PCB
PAH	Pesticide	Temperature
Salinity	Nutrients	Pigments
Suspended solids	disease/pest conditions	Community composition

Web Link(s): http://www.state.ma.us/czm/coastal2k.htm

Coastal Nonpoint Pollution Control Plan

Gulf Watch

Project Objective(s): Through the Coastal Nonpoint Pollution Control Plan, mechanisms are established to reduce the impacts of nonpoint source pollution on the aquatic resources and habitats of Massachusetts coastal watersheds.
The plan details enforceable measures for implementing best management practices designed to reduce nonpoint source (NPS) pollutant loading to ground and surface waters of the coastal environment.

Project Measures:

Molluscan contamination	organic contaminants	metal contaminants
water quality		

Web Link(s): http://www.state.ma.us/czm/gulf_watch.htm
http://www.state.ma.us/czm/npsprog.htm
http://www.state.ma.us/czm/inventory.htm - Data%20Table%20Description

Massachusetts Historic Shoreline Change Project

Project Objective(s): Coastal shorelines change constantly in response to wind, waves, tides, sea level fluctuation, seasonal and climatic variation, human alteration, and other factors that influence the movement of sand and material within a shoreline system.
The loss (erosion) and gain (accretion) of coastal land is a visible result of the way shorelines are reshaped in the face of these dynamic conditions.
CZM completed a statistical analysis from the mid-1800s to 1978 for Massachusetts' ocean-facing coastline and produced 76 maps showing several historic shorelines to demonstrate long-term shoreline change.
CZM recently completed an update of the Shoreline Change Project produce a 1994 shoreline, add it to the previous project, and update the statistics and calculate erosion rates.

Project Measures:

Erosion	changes in topography of marine barrier systems

Web Link(s): http://www.state.ma.us/czm/shorelinechangeproject.htm

Wetland Ecology and Assessment

Project Objective(s): To develop and evaluate techniques for assessing the ecological integrity of coastal wetlands in order to.
Inventory of wetland sites in specific areas; Report on wetland condition;
Identify degraded wetland sites; Evaluate restoration potential; Monitor restoration response.
To transfer techniques to interested parties, with an emphasis on training and assisting volunteers.
To convey the assessment methods and results to coastal wetland decision-makers.

Project Measures: Land use; water quality

Web Link(s): http://www.state.ma.us/czm/wastart.htm

Massachusetts Office of Coastal Zone Management

Wetland Ecology and Assessment

Cape Cod Salt Marsh Assessment Project

Project Objective(s): examined salt marsh indicators; these sites had varying types and intensities of human land use or disturbance.
second investigation: comparison of indicators from three pairs of salt marshes–each pair having a marsh area with restricted tidal hydrology and a corresponding area with normal tidal hydrology.

Project Measures: Habitat classification/profiling; Land use; water quality

Web Link(s): http://www.state.ma.us/czm/wetlandassesscape.htm
http://www.state.ma.us/czm/wastart.htm

North Shore Wetland Assessment Project

Project Objective(s): There is a continued need to establish long-term datasets for wetland reference sites.
It is also important to see if the Wetland Assessment Method can be transferred to other applications, such as the investigation of tidal hydrological restrictions of salt marsh wetlands.

Project Measures:

Land use	Invertebrate distribution and status	water quality
vegetation		

Web Link(s): http://www.state.ma.us/czm/wetlandassessnorth.htm

Waquoit Bay Wetlans Assessment Project

Project Objective(s): Goal was to develop, test, and refine a transferable approach for wetlands evaluation to determine the effects of adjacent land uses and nonpoint sources (NPS) of pollution on the condition of these aquatic resources.

Project Measures:	Land use	water quality	vegetation

Web Link(s): http://www.state.ma.us/czm/wetlandassesswaquoit.htm
http://www.state.ma.us/czm/wastart.htm

Massachusetts Water Resources Authority

Boston Harbor Project

Project Objective(s): Water Quality Data.

Project Measures:	Bacteria	Suspended solids	Water clairty
	Dissolved Oxygen	Nutrients	Algae

Web Link(s): http://www.mwra.state.ma.us/harbor/html/wklyintr.htm
http://www.mass.gov/portal/index.jsp?pageID=mg2constituent&L=2&L0=Home&L1=State%20Government&sid=massgov2

National Atmospheric Deposition Program

Mercury Depostion Network (MDN)

Project Objective(s): The objective of the MDN is to develop a national database of weekly concentrations of total mercury in precipitation and the seasonal and annual flux of total mercury in wet deposition.
The data will be used to develop information on spatial and seasonal trends in mercury deposited to surface waters, forested watersheds, and other sensitive receptors.

Project Measures:	mercury monitoring	Precipitation composition	methylmercury

Web Link(s): http://nadp.sws.uiuc.edu/mdn/

National Oceanic and Atmospheric Administration

Marine Monitoring Programs in the Gulf of Maine

MARMAP

Project Objective(s): 1)Assess the seasonal, interannual, and decadal variability in the planktonic and oceanographic components of the Northeast Shelf Ecosystem.
2) characterize changes in these variables as an indication of broad-scale ecological and environmental changes.
3) develop appropriate indices of the changing states of the marine ecosystem.

Project Measures:	Phytoplankton	Zooplankton abundance and composition	Water column temperature
	Surface salinity	Meteorological conditions	

Web Link(s): http://www.stat.psu.edu/~gpp/marmap_system_partnership.htm
http://gulfofmaine.org/library/pdf/mon_inventory.pdf
http://gulfofmaine.org/library/monitoring_inventory.html

National Estuarine Research Reserve System

Biological

Project Objective(s): Biological monitoring is used for detecting the health of aquatic environments and assessing the relative severity of the pollution impacts.

Project Measures:	Chlorophyll a	Submerged aquatic vegetation	Emergent vegetation

Web Link(s): http://nerrs.noaa.gov/Monitoring/Biological.html

Water Quality

Project Objective(s): Indicators of habitat quality for numerous estuarine species and to determine health criteria and human uses.

Project Measures:	Water Temperature	Water Depth	Salinity
	pH	Dissolved Oxygen	Turbidity

Web Link(s): http://nerrs.noaa.gov/Monitoring/Water.html

National Status and Trends Program

Mussel Watch

Project Objective(s): This project is designed to monitor the status of and temporal changes in metal and organic contaminants in Great Lakes, estuarine and coastal waters using bivalve molluscs as sentinel organisms.

Project Measures:	Crustacean contaminant loads	PAH	PCB
	Pesticide	Trace Elements	Reproductive development
	disease/pest conditions	Size frequency	

Web Link(s): http://vertigo.hsrl.rutgers.edu/NST.html
http://nsandt.noaa.gov/

National Benthic Surveillance Project

Project Objective(s): To determine the current status of and to detect any long-term trends in the environmental quality of the nearshore waters of the United States.
The primary objective was to determine concentrations of more than 70 organic and inorganic contaminants in the liver and bile of bottom dwelling fishes and associated surficial sediment from coastal and estuarine waters.

Project Measures: Bile and liver contamination loads; PAH; PCB; Butyltins; DDT and metabolites; Chlorinated pesticides

Web Link(s): http://nsandt.noaa.gov/

Sea Grant

Paralytic Shellfish Poisoning Monitoring Program

Project Objective(s): A national plan has been prepared to guide research and monitoring programs on all aspects of the harmful algal bloom (HAB) problem, from toxin detection to resource management to bloom ecology.

Project Measures: Algal Blooms ("Red Tide"); Alexandrium

Web Link(s): http://www.seagrantnews.org/news/whoi.html

U.S. Army Corps of Engineers

Disposal Area Monitoring System (DAMOS)

New England District

Project Objective(s): Manage and monitor offshore dredged material disposal sites from Long Island Sound to Maine.

Project Measures: Sediment contaminant composition

Web Link(s): http://www.nae.usace.army.mil/environm/damos/splash_page.htm

U.S. Fish and Wildlife Service

Gulf of Maine Coastal Program

Gulf of Maine Watershed Habitat Analysis

Project Objective(s): Identified, mapped, and ranked important fish and wildlife habitat for priority species throughout the Gulf of Maine watershed.

Project Measures: Habitat usage; fish distribution and abundance; waterfowl reproductive success

Web Link(s): http://gulfofmaine.fws.gov/gomanalysis/gomanalysis.html
http://gulfofmaine.fws.gov/gomanalysis/documents/gomanalysis.pdf

U.S. Forest Service

Forest Health Monitoring

Forest Inventory and Analysis

Project Objective(s): The Forest Inventory and Analysis Program tracks 3 Criteria and 67 Indicators. Criteria are: 1)Conservation of Biological Diversity; 2) Maintenance of Productive Capacity of Forest Ecosystems; 3)Maintenance of Forest Ecosystem Health & Vitality.
Collect and disseminate information about the forests of the Northeastern United States relating to forest distribution, forest condition, ownership patterns, timber utilization, and forest mensuration techniques.
Develop and apply scientific knowledge and technology in support of the inventory and analysis project.

Project Measures: Soil characteristics; Tree condition; Lichens; Air quality

Web Link(s): http://www.fs.fed.us/projects/
http://fia.fs.fed.us/rpa.htm
http://www.fs.fed.us/ne/fia/
http://www.fs.fed.us/research/sustain/

U.S. Geologic Survey

North American Breeding Bird Survey

North American Breeding Bird Survey

Project Objective(s): To monitor the status and trends of North American bird populations.

Project Measures: avian distribution and abundance

Web Link(s): http://www.mp2-pwrc.usgs.gov/bbs/

Marsh-Billings-Rockefeller National Historic Park

Institute for Bird Populations

Monitoring Avian Productivity and Survivorship

Avian Inventory Program

Project Objective(s): indices of adult population size and post-fledging productivity from data on the numbers and proportions of young and adult birds captured.
estimates of adult population size, adult survival rates, proportions of residents, and recruitment into the adult population from mark-recapture data on adult birds.

Project Measures: avian distribution and abundance

Web Link(s): http://www.birdpop.org
http://www.birdpop.org/avianinv.htm
http://www.birdpop.org/maps.htm

Long Term Ecological Research Network

Hubbard Brook

Project Objective(s): Core Research Questions : (i) Dynamic patterns and control of primary production, over time, and in relation to natural and induced stresses or disturbances; (ii) Dynamics of selected populations of seed plants, saprophytic organisms, invertebrates, fish, birds and mammals in relation to time as well as natural and induced stresses or disturbances; (iii) Patterns and control of organic accumulation (biomass) in surface layers and substrate (or sediment) in relation to time or natural and Induced stresses or disturbances; (iv) Patterns of inorganic contributions (atmospheric or hydrologic) and movement through soils, groundwater, streams and lakes in relation to time and natural or induced stresses or disturbances; (v) Patterns and frequency of apparent site interventions (disturbances) over space and time (drought, fire, windthrow, insects or other perturbations) that may be a product of, or induce, long-term trends.

Project Measures:

Climate	Weather	Hydrology
Forest community composition and distribution	Habitat classification/profiling	Natural communities
Water chemistry		

Web Link(s): www.hubbardbrook.org

National Atmospheric Deposition Program

Atmospheric Integrated Research Monitoring Network (AIRMoN)

AIRMonN-Wet & AIRMoN-Dry

Project Objective(s): Determining the effectiveness of emission controls mandated by the Clean Air Act.
Evaluating the potential impacts of new sources of emissions on protected areas such as Class I Wilderness Areas.
Identifying source/receptor relationships in atmospheric models.
AIRMoN was designed to provide data with a greater temporal resolution.

Project Measures:

Precipitation composition	nitrogen	Ozone
sulfur dioxide	gaseous nitric acid	

Web Link(s): http://nadp.sws.uiuc.edu/airmon/

U.S. Forest Service

Air Resources Program

Project Objective(s): The Mission of the Air Resource Program is to protect and/or enhance air quality on the National Forest. As we work to implement this mission we in effect, provide for cleaner air and healthier forests in all of southern Vermont. To achieve this mission we: Monitor the effects of air quality on components of the forest ecosystem. Monitoring is done in cooperation with several state and federal agencies, and educational institutions; Evaluate the impacts of proposed new major emissions sources on Lye Brook Wilderness, our Class I Air Quality Area; Evaluate the effects of Forest Service management activities on air quality; Share our monitoring information and expertise with the public.

Project Measures: Air quality

Web Link(s): http://www.fs.fed.us/r9/gmfl/resource_management/air/air.htm

U.S. Forest Service

Forest Health Monitoring

Forest Inventory and Analysis

Project Objective(s): The Forest Inventory and Analysis Program tracks 3 Criteria and 67 Indicators. Criteria are: 1)Conservation of Biological Diversity; 2) Maintenance of Productive Capacity of Forest Ecosystems; 3)Maintenance of Forest Ecosystem Health & Vitality.

Collect and disseminate information about the forests of the Northeastern United States relating to forest distribution, forest condition, ownership patterns, timber utilization, and forest mensuration techniques.

Develop and apply scientific knowledge and technology in support of the inventory and analysis project.

Project Measures:

Soil characteristics	Tree condition	Lichens
Air quality		

Web Link(s):
http://www.fs.fed.us/projects/
http://fia.fs.fed.us/rpa.htm
http://www.fs.fed.us/ne/fia/
http://www.fs.fed.us/research/sustain/

U.S. Geologic Survey

North American Breeding Bird Survey

North American Breeding Bird Survey

Project Objective(s): To monitor the status and trends of North American bird populations.

Project Measures: avian distribution and abundance

Web Link(s): http://www.mp2-pwrc.usgs.gov/bbs/

Vermont Audubon

Important Bird Areas (IBA)

Project Objective(s): Currently working on Phase II of the program which focuses on completing the Vermont IBA Technical Report along with supporting and developing monitoring projects at Vermont's IBAs.

Sites important to: endangered or threatened species, species of high conservation priority, that contain rare or unique habitat, where significant numbers of birds concentrate for breeding, during migration, or in winter, & long-term research/monitoring.

Project Measures:

Habitat usage	breeding	avian distribution and abundance

Web Link(s):
http://vt.audubon.org/iba.html
http://vt.audubon.org/IBACrit.html

Vermont Department of Environmental Conservation

Air Pollution Control Division

Ambient Air Toxics Monitoring in Vermont

Project Objective(s): The Vermont Air Pollution Control Division (APCD) has been monitoring a battery of toxics in the ambient air at several locations in the state since 1993.

The toxics monitored include volatile organic compounds (VOCs), carbonyls, metals and semi-volatiles.

Project Measures:

toxic elements	Carbon monoxide	Ozone
Nitrogen Oxides	particulate matter	sulfur dioxide

Web Link(s): http://www.anr.state.vt.us:8500/public/dec/air/Planning/htm/AirToxMonitoring.htm

Water Quality Division

Biomonitoring and Aquatic Studies Section (BASS)

Project Objective(s): To conduct environmental monitoring of aquatic resources, with an emphasis on the assessment of biological integrity.

BASS also conducts special studies in areas of special concern such as acid rain, malformed frogs, aquatic nuisance control and seasonal pools.

Project Measures:

Macroinvertebrates	Water chemistry	Habitat usage

Web Link(s): http://dep.state.ct.us/air2/toxics/monitiat.htm

Vermont Department of Fish and Wildlife

Nongame and Natural Heritage Program

Natural Communities

Project Objective(s): To protect natural communities which are an assemblage of plants and animals that are found recurring across a specific landscape under similar environmental conditions where natural processes, rather than human disturbances, prevail.

Project Measures: Rare community distribution and composition

Web Link(s):
http://www.anr.state.vt.us/fw/fwhome/nnhp/index.html
http://www.vtfishandwildlife.com/
http://www.vtfishandwildlife.com/wildlife_nongame.cfm

Rare Animal Species

Project Objective(s): We are actively tracking rare species with the following state ranks: SH, S1,S2 (breeding records only for birds). We are also interested in information on uncommon species S3.

Project Measures: rare vertebrate distribution and abundance; rare invertebrate distribution and abundance

Web Link(s): http://www.anr.state.vt.us/fw/fwhome/nnhp/index.html
http://www.vtfishandwildlife.com/
http://www.vtfishandwildlife.com/wildlife_nongame.cfm

Rare Plant Species

Project Objective(s): We are actively tracking rare species with the following state ranks (SH, S1, S2). However, we are also interested in information on uncommon species (S3).

Project Measures: rare plant distribution and abundance

Web Link(s): http://www.anr.state.vt.us/fw/fwhome/nnhp/Intro%20to%20Plant%20R,T,E%202000.htm
http://www.vtfishandwildlife.com/
http://www.vtfishandwildlife.com/wildlife_nongame.cfm

Vermont Institute of Natural Science

Mountain Bird Watch

Mountain Bird Watch

Project Objective(s): Mountain Birdwatch is a long-term monitoring program for songbirds that breed in high-elevation forests of the Northeast. Skilled volunteers conduct annual surveys along 1-km routes that are located on mountains in New York, Vermont, New Hampshire, and Maine. Primary emphasis is placed on Bicknell's Thrush, the region's only endemic bird species, and a montane fir specialist that is vulnerable to ongoing and projected habitat loss. Other focal species include Blackpoll Warbler, Swainson's Thrush, White-throated Sparrow, and Winter Wren. In 2002, Mountain Birdwatchers gathered observations from 142 locations, with point count surveys completed on 118 routes.

Project Measures: avian distribution and abundance

Web Link(s): http://www.vinsweb.org/cbd/mtn_birdwatch.html

Vermont Butterfly Survey

Project Objective(s): The Vermont Butterfly Survey is a five-year census to document the relative abundance and distribution of butterflies across Vermont.
To learn which butterfly species exist in Vermont.
Allow Vermonters to contribute to a greater understanding of the nature of their state.

Project Measures: lepidopteran distribution and abundance

Web Link(s): http://www.uvm.edu/~vbap/index.html

Vermont Monitoring Cooperative

Amphibian Survey and Monitoring

Salamanders and Frogs on Mount Mansfield and The L

Project Objective(s): The purpose of this study is to establish baseline population data that can be compared to future surveys and be compared to data collected in the following years to look for trends or changes in population numbers and species over time.

Project Measures: Amphibian distribution and abundance; Community composition

Web Link(s): http://vmc.snr.uvm.edu/summary/general001.htm

Basic Meteorological Monitoring

Project Objective(s): The continuous monitoring of a variety of meteorological variables.
The information collected at this site can be used in conjunction with biological or physical information gathered in other projects at or near the site.

Project Measures: Temperature; Wind direction; Wind speed; Relative humidity; Barometric pressure; Precipitation

Web Link(s): http://vmc.snr.uvm.edu/summary/general006.htm

Bicknell's Thrush: Population Demographics and Ecology

Project Objective(s): To monitor population densities and determine the breeding ecology of Bicknell's Thrush, to assess the conservation status of this bird regionally, and to determine the effects of ski area development on the forest bird community.

Project Measures: avian distribution and abundance

Web Link(s): http://vmc.snr.uvm.edu/summary/general049.htm

Biological and Chemical Survey of Selected Surface Waters in Lye Brook Wilderness Area

Project Objective(s): To establish baseline chemical and biological characteristics that could be compared to future monitoring data for evidence of change and its potential relationship to air quality data for the region.

Project Measures:

Water chemistry	Sediment contaminant composition	Macroinvertebrates
fish distribution and abundance	Contaminant load of freshwater fishes	

Web Link(s):
http://vmc.snr.uvm.edu/summary/general012.htm
http://vmc.snr.uvm.edu/subproj.asp?ID=89
http://vmc.snr.uvm.edu/subproj.asp?ID=72
http://vmc.snr.uvm.edu/subproj.asp?ID=73
http://vmc.snr.uvm.edu/subproj.asp?ID=75
http://vmc.snr.uvm.edu/subproj.asp?ID=74

Cloudwater chemistry on Mount Mansfield

Project Objective(s): Sample cloud/fog water at timberline: three sets of paired funnels simultaneously collected cloud throughfall under the red spruce-balsam fir canopy.

Project Measures:

Precipitation composition	pH	Conductivity
mercury monitoring	Calcium	Potassium
Magnesium	Sodium	Chloride
Sulfate	Nitrate	

Web Link(s):
http://vmc.snr.uvm.edu/subproj.asp?ID=67
http://vmc.snr.uvm.edu/summary/general071.htm

Evaluating Crown Canopy Changes In Vermont

Ice-Damaged Forests by Image Analysis

Project Objective(s): This research project uses image analysis to evaluate crown canopy changes as a consequence of the 1998 ice storm.

Project Measures: forest canopy closure

Web Link(s):
http://vmc.snr.uvm.edu/summary/general084.htm

Vermont Monitoring Cooperative

Forest Bird Monitoring

Project Objective(s): To determine long-term bird population changes in protected, non-fragmented habitats. Results will help provide insights into how forest fragmentation in unprotected areas may affect the relative abundance of forest-breeding songbirds.

Project Measures:

avian distribution and abundance	breeding	Habitat usage
Habitat classification/profiling		

Web Link(s):
http://vmc.snr.uvm.edu/bird.html
http://vmc.snr.uvm.edu/summary/general013.htm

Forest Environmental Monitoring (Canopy Tower)

Project Objective(s): improve our knowledge of how atmospheric conditions vary at different elevations in the forest canopy and how the interactions between the forest canopy and the atmosphere may vary between those elevations.

Project Measures: Carbon dioxide; Ozone

Web Link(s):
http://vmc.snr.uvm.edu/summary/general055.htm

Forest Pest Monitoring

Project Objective(s): Identify and observe trends in major insect pest populations, predict tree susceptibility based on the insect emergence-tree phenology relationship, and record levels of tree damage resulting from insect attack.

Project Measures:

disease/pest conditions	Forest Tent Caterpillar	Spring Hemlock Looper
Fall Hemlock Looper	Spruce Budworm	Gypsy Moth
Pear Thrips		

Web Link(s):
http://vmc.snr.uvm.edu/summary/general026.htm
http://vmc.snr.uvm.edu/subproj.asp?ID=81
http://vmc.snr.uvm.edu/subproj.asp?ID=79
http://vmc.snr.uvm.edu/subproj.asp?ID=80

Insect Diversity on Mount Mansfield

Project Objective(s): Survey insects to establish permanent monitoring sites for long-term trend information, establish site-specific data on species abundance and diversity, compare and contrast insect biodiversity in forest habitats on Mount Mansfield.

Project Measures: Invertebrate distribution and status; lepidopteron distribution and abundance; Diptera; Hymenoptera; Coleoptera

Web Link(s): http://vmc.snr.uvm.edu/proj.asp?ID=16
http://vmc.snr.uvm.edu/summary/general016.htm

Landscape Fall Color and Leaf Drop Monitoring

Project Objective(s): To develop a visual rating system for monitoring fall color and leaf drop on a landscape scale on Mount Mansfield.

Project Measures: Fall foliage color quality; Fall foliage color composition

Web Link(s): http://vmc.snr.uvm.edu/summary/general031.htm
http://vmc.snr.uvm.edu/summary.asp?tab=1

Long-term monitoring of high elevation understory and leaf litter arthropod communities

Project Objective(s): Investigate how temporal and spatial variation in insect (i.e. prey) biomass has affected the timing of the breeding season, nesting productivity, number of males feeding at a particular nest and chick provisioning rates.

Project Measures: Invertebrate distribution and status; Temporal distribution; Land use

Web Link(s): http://vmc.snr.uvm.edu/summary/general093.htm

Ozone Bioindicator Plant Monitoring

Project Objective(s): Ozone bioindicator plant monitoring is undertaken to detect ozone injury on sensitive native plants.

Project Measures: Herbaceous plants; Ozone; Leaf damage

Web Link(s): http://vmc.snr.uvm.edu/summary/general027.htm

Vermont Monitoring Cooperative

Pine Mountain Biodiversity Project

Project Objective(s): The variety of plants and animals, their genetic variability, their interrelationships, and the biological and physical systems, communities and landscapes in which they exist.

Project Measures: Species diversity; Natural communities; Geology; Water resources; Climate

Web Link(s): http://vmc.snr.uvm.edu/summary/generalpineMT.htm

Population Study of the Endangered Plant Species, Diapensia lapponica, on Mount Mansfield

Project Objective(s): To measure and compare soil depth and slope under the cushions, aspect, cushion area, cushion damage, number and identity of species growing near or with the cushion, and number of flowers.
The population found on Mount Mansfield is important because of its endangered status.

Project Measures: rare plant distribution and abundance; Soil depth; Soil slope; Stem counts; Community composition

Web Link(s): http://vmc.snr.uvm.edu/summary/general126.htm

Small Mammal Survey and Monitoring

Forest Ecosystem Management Demonstration Project

Project Objective(s): Estimate the diversity and relative abundance of small mammals on experimental treatment units of the FEMDP prior to the initiation of silvicultural treatments.

Project Measures: Mammalian distribution and abundance

Web Link(s): http://vmc.snr.uvm.edu/summary/general118.htm

Tree Phenology Monitoring

Project Objective(s): The purpose of this study is to determine how the timing of bud development varies within a tree canopy and at different elevations on the mountain.
Long-term, annual measurements of fall color and leaf drop help establish the timing of late-season developmental events and trends.

Project Measures: Fall foliage color composition; Deciduous leaf drop timing; vegetative & flower bud development

Web Link(s): http://vmc.snr.uvm.edu/summary/general017.htm

Vermont Acid Precipitation Monitoring Program (VAPMP)

Project Objective(s): To assess the impact of the 1970 Clean Air Act, which mandated the improvement of air quality in the vicinity of mid-western and southeastern fossil fuel burning plants.

Project Measures: Acid deposition pH Precipitation

Web Link(s): http://vmc.snr.uvm.edu/summary/general011.htm

Minuteman National Historic Park

Institute for Bird Populations

Monitoring Avian Productivity and Survivorship

Avian Inventory Program

Project Objective(s): indices of adult population size and post-fledging productivity from data on the numbers and proportions of young and adult birds captured.
estimates of adult population size, adult survival rates, proportions of residents, and recruitment into the adult population from mark-recapture data on adult birds.

Project Measures: avian distribution and abundance

Web Link(s): http://www.birdpop.org
http://www.birdpop.org/avianinv.htm
http://www.birdpop.org/maps.htm

Massachusetts Audubon

Important Bird Areas (IBA)

Project Objective(s): To identify, nominate, and designate key sites that contribute to the preservation of significant bird populations or communities.
To provide information that will help land managers evaluate areas for habitat management and/or land acquisition.
To activate public and private participation in bird conservation efforts.
To provide public education and community outreach opportunities.

Project Measures:

avian distribution and abundance	Habitat usage	threatened & endangered
breeding		

Web Link(s): http://www.massaudubon.org/index.php
http://www.massaudubon.org/Birds_&_Beyond/IBAs/index.php

Massachusetts Department of Environmental Protection

Air Program Planning Unit

Addressing Air Toxics in Massachusetts

Project Objective(s): In order to protect the health of Massachusetts' residents and preserve our environment; aims to reduce the emissions and ambient air impact of a number of toxic air pollutants likely to be used by business, industry, and individuals in the state.
TURA (Massachusetts Toxic Use Reduction Act)focusing on pollution prevention as a way to comply with regulatory standards while increasing the economic competitiveness of Massachusetts industry.
Ozone Reduction is the reduction of volatile organic compound (VOCs) emissions from a variety of sources, including industry and mobile sources.

Project Measures:

polycyclic aromatic hydrocarbons	Chromium	benzene
toluene	xylenes	perchloroethylene
methylene chloride	Cadmium	mercury monitoring

Web Link(s): http://www.state.ma.us/dep/bwp/daqc/files/airtox.htm

Wetlands Conservancy Program

Project Objective(s): The DEP is mapping the state's wetlands using aerial photography and photointerpretation to delineate wetland boundaries which is used to document the extent and type of the state's wetlands.

Project Measures: Wetland community composition and distribution

Web Link(s): http://www.state.ma.us/dep/brp/
http://www.state.ma.us/dep/brp/ww/rpwwhome.htm
http://www.state.ma.us/dep/brp/ww/files/wcpbroch.pdf

Massachusetts Division of Fisheries and Wildlife

Natural Heritage & Endangered Species Program

Natural Communities

Project Objective(s): The Massachusetts Natural Heritage Program actively inventories and tracks the distribution and status of uncommon and exemplary natural communities across the state.
Conservation priority should be given to: natural communities with limited distribution across ecoregions within the state, those with restricted global distribution, and those common types for which the best documented examples occur in Massachusetts.

Project Measures: Rare community distribution and composition

Web Link(s): http://www.state.ma.us/dfwele/dfw/nhesp/nhcommun.htm
http://www.state.ma.us/dfwele/dfw/nhesp/nhesp.htm

Rare Animal Species

Project Objective(s): The Program's highest priority is protecting the approximately 190 species of vertebrate and invertebrate animals that are officially listed as endangered, threatened or of special concern in Massachusetts.

Project Measures: rare vertebrate distribution and abundance; rare invertebrate distribution and abundance

Web Link(s): http://www.state.ma.us/dfwele/dfw/nhesp/nhspecies.htm; http://www.state.ma.us/dfwele/dfw/nhesp/nhesp.htm

Rare Plant Species

Project Objective(s): The Program's highest priority is protecting the approximately 258 species of native plants that are officially listed as Endangered, Threatened or of Special Concern in Massachusetts.

Project Measures: rare plant distribution and abundance; Habitat usage

Web Link(s): http://www.state.ma.us/dfwele/dfw/nhesp/nhspecies.htm; http://www.state.ma.us/dfwele/dfw/nhesp/nhesp.htm

Vernal Pools

Project Objective(s): The NHESP serves the important role of officially "certifying" vernal pools that are documented by citizens. Finding vernal pools is the first step for protection.

Project Measures: Rare community distribution and composition; Habitat usage; Wetland community composition and distribution

Web Link(s): http://www.state.ma.us/dfwele/dfw/nhesp/nhvernal.htm; http://www.state.ma.us/dfwele/dfw/nhesp/nhesp.htm

National Atmospheric Deposition Program

Mercury Depostion Network (MDN)

Project Objective(s): The objective of the MDN is to develop a national database of weekly concentrations of total mercury in precipitation and the seasonal and annual flux of total mercury in wet deposition.

The data will be used to develop information on spatial and seasonal trends in mercury deposited to surface waters, forested watersheds, and other sensitive receptors.

Project Measures: mercury monitoring; Precipitation composition; methylmercury

Web Link(s): http://nadp.sws.uiuc.edu/mdn/

U.S. Fish and Wildlife Service

Gulf of Maine Coastal Program

Gulf of Maine Watershed Habitat Analysis

Project Objective(s): Identified, mapped, and ranked important fish and wildlife habitat for priority species throughout the Gulf of Maine watershed.

Project Measures: Habitat usage; fish distribution and abundance; waterfowl reproductive success

Web Link(s): http://gulfofmaine.fws.gov/gomanalysis/gomanalysis.html; http://gulfofmaine.fws.gov/gomanalysis/documents/gomanalysis.pdf

U.S. Forest Service

Forest Health Monitoring

Forest Inventory and Analysis

Project Objective(s): The Forest Inventory and Analysis Program tracks 3 Criteria and 67 Indicators. Criteria are: 1)Conservation of Biological Diversity; 2) Maintenance of Productive Capacity of Forest Ecosystems; 3)Maintenance of Forest Ecosystem Health & Vitality.

Collect and disseminate information about the forests of the Northeastern United States relating to forest distribution, forest condition, ownership patterns, timber utilization, and forest mensuration techniques.

Develop and apply scientific knowledge and technology in support of the inventory and analysis project.

Project Measures: Soil characteristics; Tree condition; Lichens; Air quality

Web Link(s): http://www.fs.fed.us/projects/; http://fia.fs.fed.us/rpa.htm; http://www.fs.fed.us/ne/fia/; http://www.fs.fed.us/research/sustain/

U.S. Geologic Survey

North American Breeding Bird Survey

North American Breeding Bird Survey

Project Objective(s): To monitor the status and trends of North American bird populations.

Project Measures: avian distribution and abundance

Web Link(s): http://www.mp2-pwrc.usgs.gov/bbs/

Morristown National Historic Park

National Atmospheric Deposition Program

Mercury Deposition Network (MDN)

Project Objective(s): The objective of the MDN is to develop a national database of weekly concentrations of total mercury in precipitation and the seasonal and annual flux of total mercury in wet deposition.
The data will be used to develop information on spatial and seasonal trends in mercury deposited to surface waters, forested watersheds, and other sensitive receptors.

Project Measures: mercury monitoring | Precipitation composition | methylmercury

Web Link(s): http://nadp.sws.uiuc.edu/mdn/

New Jersey Audubon

Important Bird and Birding Area Program (IBBA)

Project Objective(s): Identify both areas that are essential habitats for sustaining native avian populations (Important Bird Areas), and areas that are exceptional for birdwatching (Important Birding Areas).

Project Measures: breeding | Habitat usage

Web Link(s): http://www.njaudubon.org/Conservation/IBBA/OurIBBA.html
http://www.njaudubon.org/

New Jersey Department of Environmental Protection

Natural Heritage Program

Rare Plants and Animals

Project Objective(s): Identifies the state's most significant natural areas through a comprehensive inventory of rare plant and animal species and representative natural communities.

Project Measures: rare plant distribution and abundance | rare invertebrate distribution and abundance | rare vertebrate distribution and abundance

Web Link(s): http://www.natureserve.org/nhp/us/nj/

U.S. Forest Service

Forest Health Monitoring

Forest Inventory and Analysis

Project Objective(s): The Forest Inventory and Analysis Program tracks 3 Criteria and 67 Indicators. Criteria are: 1)Conservation of Biological Diversity; 2) Maintenance of Productive Capacity of Forest Ecosystems; 3)Maintenance of Forest Ecosystem Health & Vitality.
Collect and disseminate information about the forests of the Northeastern United States relating to forest distribution, forest condition, ownership patterns, timber utilization, and forest mensuration techniques.
Develop and apply scientific knowledge and technology in support of the inventory and analysis project.

Project Measures: Soil characteristics | Tree condition | Lichens
Air quality

Web Link(s): http://www.fs.fed.us/projects/
http://fia.fs.fed.us/rpa.htm
http://www.fs.fed.us/ne/fia/
http://www.fs.fed.us/research/sustain/

Northeast Temperate Network

National Atmospheric Deposition Program

National Atmospheric Deposition Program/National Trends Network (NADP/NTN)

Project Objective(s): The purpose of the network is to collect data on the chemistry of precipitation for monitoring of geographical and temporal long-term trends.

Project Measures:

Precipitation composition	Hydrogen (acidity as pH)	Sulfate
Nitrate	Ammonium	Chloride
Base Cations (such as: Ca, Mg, K, Na)		

Web Link(s): http://nadp.sws.uiuc.edu/

Northeast Aquatic Nuisance Species Panel

Northeast Aquatic Nuisance Species Panel

Project Objective(s): The NEANS Panel addresses issues and concerns relative to the freshwater and marine resources of the states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, and New York, and the Canadian provinces of Quebec, New Brunswick, and Nova Scotia. The panel's members represent state, federal, and provincial governments, academia, commercial and recreational fishing interests, recreational boaters, commercial shipping, power and water utilities, environmental organizations, aquaculture, nursery and aquarium trades, tribal concerns, lake associations, and the bait industry, among others.

Project Measures: Invasive species

Web Link(s): http://www.northeastans.org/contactus.htm

Northeast States for Coordinated Air Use Management

Northeast States for Coordinated Air Use Management

Regional

Project Objective(s): Purpose is to exchange technical information, and to promote cooperation and coordination of technical and policy issues regarding air quality control among the member states.

Project Measures:

Ozone	Acid deposition	Carbon monoxide
nitrogen dioxide	Hydrogen (acidity as pH)	

Web Link(s): http://www.nescaum.org/committees/airqual.html

U.S. Forest Service

Forest Health Protection Program

Project Objective(s): There are 5 areas of concern: 1) wildfires & forest health; 2) nonnative invasive insects & pathogens; 3) Invasive plant species; 4) outbreaks of native insects; 5) changing ecological processes.

Project Measures: disease/pest conditions; Invasive species

Web Link(s): http://www.fs.fed.us/projects/
http://www.fs.fed.us/foresthealth/

U.S. Geologic Survey

Geographic Analysis and Monitoring Program

Project Objective(s): Understand what changes are occurring on the land surface and why.
Understand the impacts of these land surface changes on ecosystem health, climate variability, biogeochemical cycles, hydrology, and human health
Understand what the best methods are to incorporate GAM science findings in the decision making process.

Project Measures: Geography

Web Link(s): http://gam.usgs.gov/
http://mapping.usgs.gov/gam.html
http://gam.usgs.gov/gamcurrentstudies.shtml

U.S. Geologic Survey

National Water Quality Assessment Program

Project Objective(s): The condition of our Nation's streams and ground water; 2)How these conditions are changing over time; 3)how do natural features and human activities affect these conditions.

Project Measures:

Temperature	Conductivity	Dissolved Oxygen
pH	Nitrate	Suspended solids
Organic carbon		

Web Link(s): http://www.state.ma.us/czm/usgs_national_water_quality_asse.htm
http://water.usgs.gov/nawqa/

North American Breeding Bird Survey

North American Breeding Bird Survey

Project Objective(s): To monitor the status and trends of North American bird populations.

Project Measures: avian distribution and abundance

Web Link(s): http://www.mp2-pwrc.usgs.gov/bbs/

Northeast Amphibian Research and Monitoring Initiative

Stream Salamanders

Project Objective(s): Using quadrat and transect survey methods to count and estimate stream salamander populations. Our goals are to determine the status and trends of stream salamanders in the Northeast with long-term monitoring and to assess population sizes in relation to landscape, habitat, and water quality variables.

Project Measures: caudate community composition

Web Link(s): http://armi.usgs.gov/monitoring.asp
http://www.mp2-pwrc.usgs.gov/nearmi/
http://www.mp2-pwrc.usgs.gov/nearmi/projects/ - streamsal

Vernal Pool Amphibians

Project Objective(s): Using egg mass counts as an index of population sizes at vernal pools within National Parks and National Wildlife Refuges in the Northeast.
Our goals are to determine the status and trends of wood frog and spotted salamander populations in the Northeast through long-term monitoring.
to assess species presence and population sizes in relation to surrounding land use, road density or distance to nearest road, proximity to or density of other potential breeding sites, water quality variables, hydroperiod, and climatic conditions.

Project Measures: Amphibian egg mass count

Web Link(s): http://armi.usgs.gov/monitoring.asp
http://www.mp2-pwrc.usgs.gov/nearmi/
http://www.mp2-pwrc.usgs.gov/nearmi/projects/ - eggmasscounts

Roosevelt-Vanderbilt National Historic Sites

Institute for Bird Populations

Monitoring Avian Productivity and Survivorship

Avian Inventory Program

Project Objective(s): indices of adult population size and post-fledging productivity from data on the numbers and proportions of young and adult birds captured.
estimates of adult population size, adult survival rates, proportions of residents, and recruitment into the adult population from mark-recapture data on adult birds.

Project Measures: avian distribution and
abundance

Web Link(s): http://www.birdpop.org
http://www.birdpop.org/avianinv.htm
http://www.birdpop.org/maps.htm

National Atmospheric Deposition Program

Atmospheric Integrated Research Monitoring Network (AIRMoN)

AIRMonN-Wet & AIRMoN-Dry

Project Objective(s): Determining the effectiveness of emission controls mandated by the Clean Air Act.
Evaluating the potential impacts of new sources of emissions on protected areas such as Class I Wilderness Areas.
Identifying source/receptor relationships in atmospheric models.
AIRMoN was designed to provide data with a greater temporal resolution.

Project Measures: Precipitation composition | nitrogen | Ozone
sulfur dioxide | gaseous nitric acid

Web Link(s): http://nadp.sws.uiuc.edu/airmon/

Mercury Deposition Network (MDN)

Project Objective(s): The objective of the MDN is to develop a national database of weekly concentrations of total mercury in precipitation and the seasonal and annual flux of total mercury in wet deposition.
The data will be used to develop information on spatial and seasonal trends in mercury deposited to surface waters, forested watersheds, and other sensitive receptors.

Project Measures: mercury monitoring | Precipitation composition | methylmercury

Web Link(s): http://nadp.sws.uiuc.edu/mdn/

New York Audubon

Important Bird Areas (IBA)

Project Objective(s): Identify a network of sites that are essential for sustaining naturally occurring populations of bird species, and to protect or manage these sites for the long-term conservation of birds, other wildlife, and their habitats.

Project Measures: breeding | Habitat usage

Web Link(s): http://ny.audubon.org/iba/index.html

New York State Department of Environmental Conservation

Natural Heritage Program

Ecological Communities

Project Objective(s): An ecological community is a variable assemblage of interacting plant and animal populations that share a common environment; in NY a classification has been developed to help assess and protect the biological diversity of the state.

Project Measures: Community composition

Web Link(s): http://www.dec.state.ny.us/website/dfwmr/heritage/
http://www.dec.state.ny.us/website/dfwmr/heritage/ecology.htm

New York State Department of Environmental Conservation

New York Natural Heritage Program

Herp Atlas

Project Objective(s): Herp Atlas was a ten year survey that was designed to document the geographic distribution of New York State's herpetofauna.

Project Measures: herptile distribution and abundance

Web Link(s): http://www.dec.state.ny.us/website/dfwmr/wildlife/herp/

Rare Animal Species

Project Objective(s): Actively surveys rare animal species of all vertebrate groups and selected rare species from the invertebrate groups.

Project Measures: rare vertebrate distribution and abundance; rare invertebrate distribution and abundance

Web Link(s): http://www.dec.state.ny.us/website/dfwmr/heritage/animallist.pdf
http://www.dec.state.ny.us/website/dfwmr/heritage/
http://www.dec.state.ny.us/website/dfwmr/heritage/animals.htm

Rare Plant Species

Project Objective(s): The New York Natural Heritage Program keeps track of the status of the state's rare flowering plants, conifers, ferns and fern allies, and mosses.

Project Measures: rare plant distribution and abundance

Web Link(s): http://www.dec.state.ny.us/website/dfwmr/heritage/plants.htm
http://www.dec.state.ny.us/website/dfwmr/heritage/index.htm

U.S. Forest Service

Forest Health Monitoring

Forest Inventory and Analysis

Project Objective(s): The Forest Inventory and Analysis Program tracks 3 Criteria and 67 Indicators. Criteria are: 1)Conservation of Biological Diversity; 2) Maintenance of Productive Capacity of Forest Ecosystems; 3)Maintenance of Forest Ecosystem Health & Vitality.

Collect and disseminate information about the forests of the Northeastern United States relating to forest distribution, forest condition, ownership patterns, timber utilization, and forest mensuration techniques.

Develop and apply scientific knowledge and technology in support of the inventory and analysis project.

Project Measures: Soil characteristics; Tree condition; Lichens; Air quality

Web Link(s): http://www.fs.fed.us/projects/
http://fia.fs.fed.us/rpa.htm
http://www.fs.fed.us/ne/fia/
http://www.fs.fed.us/research/sustain/

Saint-Gaudens National Historic Site

Institute for Bird Populations

Monitoring Avian Productivity and Survivorship

Avian Inventory Program

Project Objective(s): indices of adult population size and post-fledging productivity from data on the numbers and proportions of young and adult birds captured.
estimates of adult population size, adult survival rates, proportions of residents, and recruitment into the adult population from mark-recapture data on adult birds.

Project Measures: avian distribution and abundance

Web Link(s): http://www.birdpop.org
http://www.birdpop.org/avianinv.htm
http://www.birdpop.org/maps.htm

Long Term Ecological Research Network

Hubbard Brook

Project Objective(s): Core Research Questions : (i) Dynamic patterns and control of primary production, over time, and in relation to natural and induced stresses or disturbances; (ii) Dynamics of selected populations of seed plants, saprophytic organisms, invertebrates, fish, birds and mammals in relation to time as well as natural and induced stresses or disturbances; (iii) Patterns and control of organic accumulation (biomass) in surface layers and substrate (or sediment) in relation to time or natural and Induced stresses or disturbances; (iv) Patterns of inorganic contributions (atmospheric or hydrologic) and movement through soils, groundwater, streams and lakes in relation to time and natural or induced stresses or disturbances; (v) Patterns and frequency of apparent site interventions (disturbances) over space and time (drought, fire, windthrow, insects or other perturbations) that may be a product of, or induce, long-term trends.

Project Measures:

Climate	Weather	Hydrology
Forest community composition and distribution	Habitat classification/profiling	Natural communities
Water chemistry		

Web Link(s): www.hubbardbrook.org

New Hampshire Audubon

Backyard Bird Survey

Backyard Winter Bird Survey

Project Objective(s): Backyard Winter Bird Survey participants report any bird species visiting their yard and/or feeders in New Hampshire on the second weekend of February. Originally begun as a "Cardinal-Tufted Titmouse Census," it was expanded in 1987 to gather information on the distribution and abundance of many winter species in New Hampshire.

Project Measures: avian distribution and abundance

Web Link(s): http://www.nhaudubon.org

Important Bird Areas (IBA)

Project Objective(s): The goal of the program is to identify and conserve areas that are critical to one or more bird species for breeding, feeding, wintering, or migration.

Project Measures: breeding; Habitat usage

Web Link(s): http://www.nhaudubon.org/birdinfo/iba.htm
http://www.nhaudubon.org/

New Hampshire Division of Forests and Lands

Natural Heritage Bureau

Natural Communities

Project Objective(s): The NH Natural Heritage Bureau tracks "exemplary" natural community occurrences.
To qualify as exemplary, a natural community in a given place must be of a rare type, such as a pitch pine/scrub oak barrens, or must be an exceptional occurrence of a common type, such as an old growth spruce/fir forest.

Project Measures:

Community composition	Wetland community composition and distribution	Forest community composition and distribution
Grassland community composition and distribution		

Web Link(s): http://www.nhdfl.org/formgt/nhiweb/

Rare Animal Species

Project Objective(s): The NH Natural Heritage Bureau tracks rare animal species.

Project Measures: rare vertebrate distribution and abundance; rare invert distribution

Web Link(s): http://www.nhdfl.org/formgt/nhiweb/

Rare Plant Species

Project Objective(s): The NH Natural Heritage Bureau tracks the state's rarest and most imperiled plant species.

Project Measures: rare plant distribution and abundance

Web Link(s): http://www.nhdfl.org/formgt/nhiweb/

U.S. Fish and Wildlife Service

Gulf of Maine Coastal Program

Gulf of Maine Watershed Habitat Analysis

Project Objective(s): Identified, mapped, and ranked important fish and wildlife habitat for priority species throughout the Gulf of Maine watershed.

Project Measures: Habitat usage; fish distribution and abundance; waterfowl reproductive success

Web Link(s): http://gulfofmaine.fws.gov/gomanalysis/gomanalysis.html
http://gulfofmaine.fws.gov/gomanalysis/documents/gomanalysis.pdf

U.S. Forest Service

Forest Health Monitoring

Forest Inventory and Analysis

Project Objective(s): The Forest Inventory and Analysis Program tracks 3 Criteria and 67 Indicators. Criteria are: 1)Conservation of Biological Diversity; 2) Maintenance of Productive Capacity of Forest Ecosystems; 3)Maintenance of Forest Ecosystem Health & Vitality.

Collect and disseminate information about the forests of the Northeastern United States relating to forest distribution, forest condition, ownership patterns, timber utilization, and forest mensuration techniques.

Develop and apply scientific knowledge and technology in support of the inventory and analysis project.

Project Measures: Soil characteristics; Tree condition; Lichens; Air quality

Web Link(s): http://www.fs.fed.us/projects/
http://fia.fs.fed.us/rpa.htm
http://www.fs.fed.us/ne/fia/
http://www.fs.fed.us/research/sustain/

U.S. Geologic Survey

North American Breeding Bird Survey

North American Breeding Bird Survey

Project Objective(s): To monitor the status and trends of North American bird populations.

Project Measures: avian distribution and abundance

Web Link(s): http://www.mp2-pwrc.usgs.gov/bbs/

Vermont Department of Environmental Conservation

Air Pollution Control Division

Ambient Air Toxics Monitoring in Vermont

Project Objective(s): The Vermont Air Pollution Control Division (APCD) has been monitoring a battery of toxics in the ambient air at several locations in the state since 1993.

The toxics monitored include volatile organic compounds (VOCs), carbonyls, metals and semi-volatiles.

Project Measures: toxic elements; Carbon monoxide; Ozone; Nitrogen Oxides; particulate matter; sulfur dioxide

Web Link(s): http://www.anr.state.vt.us:8500/public/dec/air/Planning/htm/AirToxMonitoring.htm

Vermont Institute of Natural Science

Mountain Bird Watch

Mountain Bird Watch

Project Objective(s): Mountain Birdwatch is a long-term monitoring program for songbirds that breed in high-elevation forests of the Northeast. Skilled volunteers conduct annual surveys along 1-km routes that are located on mountains in New York, Vermont, New Hampshire, and Maine. Primary emphasis is placed on Bicknell's Thrush, the region's only endemic bird species, and a montane fir specialist that is vulnerable to ongoing and projected habitat loss. Other focal species include Blackpoll Warbler, Swainson's Thrush, White-throated Sparrow, and Winter Wren. In 2002, Mountain Birdwatchers gathered observations from 142 locations, with point count surveys completed on 118 routes.

Project Measures: avian distribution and abundance

Web Link(s): http://www.vinsweb.org/cbd/mtn_birdwatch.html

Vermont Butterfly Survey

Project Objective(s): The Vermont Butterfly Survey is a five-year census to document the relative abundance and distribution of butterflies across Vermont.
To learn which butterfly species exist in Vermont.
Allow Vermonters to contribute to a greater understanding of the nature of their state.

Project Measures: lepidopteron distribution and abundance

Web Link(s): http://www.uvm.edu/~vbap/index.html

Vermont Monitoring Cooperative

Basic Meteorological Monitoring

Project Objective(s): The continuous monitoring of a variety of meteorological variables.
The information collected at this site can be used in conjunction with biological or physical information gathered in other projects at or near the site.

Project Measures:

Temperature	Wind direction	Wind speed
Relative humidity	Barometric pressure	Precipitation

Web Link(s): http://vmc.snr.uvm.edu/summary/general006.htm

Forest Bird Monitoring

Project Objective(s): To determine long-term bird population changes in protected, non-fragmented habitats.
Results will help provide insights into how forest fragmentation in unprotected areas may affect the relative abundance of forest-breeding songbirds.

Project Measures:

avian distribution and abundance	breeding	Habitat usage
Habitat classification/profiling		

Web Link(s): http://vmc.snr.uvm.edu/bird.html
http://vmc.snr.uvm.edu/summary/general013.htm

Pine Mountain Biodiversity Project

Project Objective(s): The variety of plants and animals, their genetic variability, their interrelationships, and the biological and physical systems, communities and landscapes in which they exist.

Project Measures:

Species diversity	Natural communities	Geology
Water resources	Climate	

Web Link(s): http://vmc.snr.uvm.edu/summary/generalpineMT.htm

Saratoga National Historic Park

Institute for Bird Populations

Monitoring Avian Productivity and Survivorship

Avian Inventory Program

Project Objective(s): indices of adult population size and post-fledging productivity from data on the numbers and proportions of young and adult birds captured.
estimates of adult population size, adult survival rates, proportions of residents, and recruitment into the adult population from mark-recapture data on adult birds.

Project Measures: avian distribution and abundance

Web Link(s): http://www.birdpop.org
http://www.birdpop.org/avianinv.htm
http://www.birdpop.org/maps.htm

National Atmospheric Deposition Program

Atmospheric Integrated Research Monitoring Network (AIRMoN)

AIRMonN-Wet & AIRMoN-Dry

Project Objective(s): Determining the effectiveness of emission controls mandated by the Clean Air Act.
Evaluating the potential impacts of new sources of emissions on protected areas such as Class I Wilderness Areas.
Identifying source/receptor relationships in atmospheric models.
AIRMoN was designed to provide data with a greater temporal resolution.

Project Measures: Precipitation composition | nitrogen | Ozone
sulfur dioxide | gaseous nitric acid

Web Link(s): http://nadp.sws.uiuc.edu/airmon/

Mercury Deposition Network (MDN)

Project Objective(s): The objective of the MDN is to develop a national database of weekly concentrations of total mercury in precipitation and the seasonal and annual flux of total mercury in wet deposition.
The data will be used to develop information on spatial and seasonal trends in mercury deposited to surface waters, forested watersheds, and other sensitive receptors.

Project Measures: mercury monitoring | Precipitation composition | methylmercury

Web Link(s): http://nadp.sws.uiuc.edu/mdn/

New York Audubon

Important Bird Areas (IBA)

Project Objective(s): Identify a network of sites that are essential for sustaining naturally occurring populations of bird species, and to protect or manage these sites for the long-term conservation of birds, other wildlife, and their habitats.

Project Measures: breeding | Habitat usage

Web Link(s): http://ny.audubon.org/iba/index.html

New York State Department of Environmental Conservation

Natural Heritage Program

Ecological Communities

Project Objective(s): An ecological community is a variable assemblage of interacting plant and animal populations that share a common environment; in NY a classification has been developed to help assess and protect the biological diversity of the state.

Project Measures: Community composition

Web Link(s): http://www.dec.state.ny.us/website/dfwmr/heritage/
http://www.dec.state.ny.us/website/dfwmr/heritage/ecology.htm

New York State Department of Environmental Conservation

New York Natural Heritage Program

Herp Atlas

Project Objective(s): Herp Atlas was a ten year survey that was designed to document the geographic distribution of New York State's herpetofauna.

Project Measures: herptile distribution and abundance

Web Link(s): http://www.dec.state.ny.us/website/dfwmr/wildlife/herp/

Rare Animal Species

Project Objective(s): Actively surveys rare animal species of all vertebrate groups and selected rare species from the invertebrate groups.

Project Measures: rare vertebrate distribution and abundance; rare invertebrate distribution and abundance

Web Link(s): http://www.dec.state.ny.us/website/dfwmr/heritage/animallist.pdf
http://www.dec.state.ny.us/website/dfwmr/heritage/
http://www.dec.state.ny.us/website/dfwmr/heritage/animals.htm

Rare Plant Species

Project Objective(s): The New York Natural Heritage Program keeps track of the status of the state's rare flowering plants, conifers, ferns and fern allies, and mosses.

Project Measures: rare plant distribution and abundance

Web Link(s): http://www.dec.state.ny.us/website/dfwmr/heritage/plants.htm
http://www.dec.state.ny.us/website/dfwmr/heritage/index.htm

U.S. Forest Service

Forest Health Monitoring

Forest Inventory and Analysis

Project Objective(s): The Forest Inventory and Analysis Program tracks 3 Criteria and 67 Indicators. Criteria are: 1)Conservation of Biological Diversity; 2) Maintenance of Productive Capacity of Forest Ecosystems; 3)Maintenance of Forest Ecosystem Health & Vitality.

Collect and disseminate information about the forests of the Northeastern United States relating to forest distribution, forest condition, ownership patterns, timber utilization, and forest mensuration techniques.

Develop and apply scientific knowledge and technology in support of the inventory and analysis project.

Project Measures: Soil characteristics; Tree condition; Lichens; Air quality

Web Link(s): http://www.fs.fed.us/projects/
http://fia.fs.fed.us/rpa.htm
http://www.fs.fed.us/ne/fia/
http://www.fs.fed.us/research/sustain/

Saugus Ironworks National Historic Site

Institute for Bird Populations

Monitoring Avian Productivity and Survivorship

Avian Inventory Program

Project Objective(s): indices of adult population size and post-fledging productivity from data on the numbers and proportions of young and adult birds captured.
estimates of adult population size, adult survival rates, proportions of residents, and recruitment into the adult population from mark-recapture data on adult birds.

Project Measures: avian distribution and abundance

Web Link(s): http://www.birdpop.org
http://www.birdpop.org/avianinv.htm
http://www.birdpop.org/maps.htm

Massachusetts Audubon

Important Bird Areas (IBA)

Project Objective(s): To identify, nominate, and designate key sites that contribute to the preservation of significant bird populations or communities.
To provide information that will help land managers evaluate areas for habitat management and/or land acquisition.
To activate public and private participation in bird conservation efforts.
To provide public education and community outreach opportunities.

Project Measures:

avian distribution and abundance	Habitat usage	threatened & endangered
breeding		

Web Link(s): http://www.massaudubon.org/index.php
http://www.massaudubon.org/Birds_&_Beyond/IBAs/index.php

Massachusetts Department of Environmental Protection

Air Program Planning Unit

Addressing Air Toxics in Massachusetts

Project Objective(s): In order to protect the health of Massachusetts' residents and preserve our environment; aims to reduce the emissions and ambient air impact of a number of toxic air pollutants likely to be used by business, industry, and individuals in the state.
TURA (Massachusetts Toxic Use Reduction Act)focusing on pollution prevention as a way to comply with regulatory standards while increasing the economic competitiveness of Massachusetts industry.
Ozone Reduction is the reduction of volatile organic compound (VOCs) emissions from a variety of sources, including industry and mobile sources.

Project Measures:

polycyclic aromatic hydrocarbons	Chromium	benzene
toluene	xylenes	perchloroethylene
methylene chloride	Cadmium	mercury monitoring

Web Link(s): http://www.state.ma.us/dep/bwp/daqc/files/airtox.htm

Wetlands Conservancy Program

Project Objective(s): The DEP is mapping the state's wetlands using aerial photography and photointerpretation to delineate wetland boundaries which is used to document the extent and type of the state's wetlands.

Project Measures: Wetland community composition and distribution

Web Link(s): http://www.state.ma.us/dep/brp/
http://www.state.ma.us/dep/brp/ww/rpwwhome.htm
http://www.state.ma.us/dep/brp/ww/files/wcpbroch.pdf

Massachusetts Division of Fisheries and Wildlife

Natural Heritage & Endangered Species Program

Natural Communities

Project Objective(s): The Massachusetts Natural Heritage Program actively inventories and tracks the distribution and status of uncommon and exemplary natural communities across the state.
Conservation priority should be given to: natural communities with limited distribution across ecoregions within the state, those with restricted global distribution, and those common types for which the best documented examples occur in Massachusetts.

Project Measures: Rare community distribution and composition

Web Link(s): http://www.state.ma.us/dfwele/dfw/nhesp/nhcommun.htm
http://www.state.ma.us/dfwele/dfw/nhesp/nhesp.htm

Rare Animal Species

Project Objective(s): The Program's highest priority is protecting the approximately 190 species of vertebrate and invertebrate animals that are officially listed as endangered, threatened or of special concern in Massachusetts.

Project Measures: rare vertebrate distribution and abundance; rare invertebrate distribution and abundance

Web Link(s): http://www.state.ma.us/dfwele/dfw/nhesp/nhspecies.htm
http://www.state.ma.us/dfwele/dfw/nhesp/nhesp.htm

Rare Plant Species

Project Objective(s): The Program's highest priority is protecting the approximately 258 species of native plants that are officially listed as Endangered, Threatened or of Special Concern in Massachusetts.

Project Measures: rare plant distribution and abundance; Habitat usage

Web Link(s): http://www.state.ma.us/dfwele/dfw/nhesp/nhspecies.htm
http://www.state.ma.us/dfwele/dfw/nhesp/nhesp.htm

Vernal Pools

Project Objective(s): The NHESP serves the important role of officially "certifying" vernal pools that are documented by citizens. Finding vernal pools is the first step for protection.

Project Measures: Rare community distribution and composition; Habitat usage; Wetland community composition and distribution

Web Link(s): http://www.state.ma.us/dfwele/dfw/nhesp/nhvernal.htm
http://www.state.ma.us/dfwele/dfw/nhesp/nhesp.htm

National Atmospheric Deposition Program

Mercury Depostion Network (MDN)

Project Objective(s): The objective of the MDN is to develop a national database of weekly concentrations of total mercury in precipitation and the seasonal and annual flux of total mercury in wet deposition.
The data will be used to develop information on spatial and seasonal trends in mercury deposited to surface waters, forested watersheds, and other sensitive receptors.

Project Measures: mercury monitoring; Precipitation composition; methylmercury

Web Link(s): http://nadp.sws.uiuc.edu/mdn/

National Oceanic and Atmospheric Administration

Marine Monitoring Programs in the Gulf of Maine

MARMAP

Project Objective(s): 1)Assess the seasonal, interannual, and decadal variability in the planktonic and oceanographic components of the Northeast Shelf Ecosystem.
2) characterize changes in these variables as an indication of broad-scale ecological and environmental changes.
3) develop appropriate indices of the changing states of the marine ecosystem.

Project Measures: Phytoplankton; Zooplankton abundance and composition; Water column temperature; Surface salinity; Meteorological conditions

Web Link(s): http://www.stat.psu.edu/~gpp/marmap_system_partnership.htm
http://gulfofmaine.org/library/pdf/mon_inventory.pdf
http://gulfofmaine.org/library/monitoring_inventory.html

U.S. Army Corps of Engineers

Disposal Area Monitoring System (DAMOS)

New England District

Project Objective(s): Manage and monitor offshore dredged material disposal sites from Long Island Sound to Maine.

Project Measures: Sediment contaminant composition

Web Link(s): http://www.nae.usace.army.mil/environm/damos/splash_page.htm

U.S. Fish and Wildlife Service

Gulf of Maine Coastal Program

Gulf of Maine Watershed Habitat Analysis

Project Objective(s): Identified, mapped, and ranked important fish and wildlife habitat for priority species throughout the Gulf of Maine watershed.

Project Measures: Habitat usage; fish distribution and abundance; waterfowl reproductive success

Web Link(s): http://gulfofmaine.fws.gov/gomanalysis/gomanalysis.html
http://gulfofmaine.fws.gov/gomanalysis/documents/gomanalysis.pdf

U.S. Forest Service

Forest Health Monitoring

Forest Inventory and Analysis

Project Objective(s): The Forest Inventory and Analysis Program tracks 3 Criteria and 67 Indicators. Criteria are: 1)Conservation of Biological Diversity; 2) Maintenance of Productive Capacity of Forest Ecosystems; 3)Maintenance of Forest Ecosystem Health & Vitality.

Collect and disseminate information about the forests of the Northeastern United States relating to forest distribution, forest condition, ownership patterns, timber utilization, and forest mensuration techniques.

Develop and apply scientific knowledge and technology in support of the inventory and analysis project.

Project Measures: Soil characteristics; Tree condition; Lichens; Air quality

Web Link(s): http://www.fs.fed.us/projects/
http://fia.fs.fed.us/rpa.htm
http://www.fs.fed.us/ne/fia/
http://www.fs.fed.us/research/sustain/

U.S. Geologic Survey

North American Breeding Bird Survey

North American Breeding Bird Survey

Project Objective(s): To monitor the status and trends of North American bird populations.

Project Measures: avian distribution and abundance

Web Link(s): http://www.mp2-pwrc.usgs.gov/bbs/

Weir Farm National Historic Site

Connecticut Audubon

Important Bird Areas (IBA)

Project Objective(s): Sites that are important to endangered or threatened species, species of high conservation priority that contain rare habitat.

Project Measures: avian distribution and abundance

Web Link(s): http://greenwich.center.audubon.org/
http://greenwich.center.audubon.org/research.html

Connecticut Department of Environmental Conservation / U.S. Environmental Protection Agency

Air Program Planning Unit

CONNECTICUT'S MANAGEMENT OF TOXIC AIR POLLUTANTS

Project Objective(s): The Department has taken a proactive and innovative approach to monitoring for toxic chemicals in the ambient air.
monitoring of ozone and its precursors in areas with persistently high ozone levels. The purpose of this program is to measure changes in levels of these pollutants.
Dioxin ambient monitoring program show statewide compliance with the annual average ambient air limit of one picogram (one trillionth of a gram) per cubic meter for dioxin.
A three-year ambient air monitoring project was initiated in 1996. Eight monitoring stations have been established to measure atmospheric mercury concentrations as well as to evaluate both wet and dry deposition of mercury.
Stack Monitoring: five years of monitoring have revealed that all waste combustion facilities have consistently operated in compliance with Connecticut's Air Toxics Control regulation.
Five years of monitoring have revealed that all waste combustion facilities have consistently operated in compliance with Connecticut's Air Toxics Control regulation.

Project Measures:

Nickel	Dioxin	formaldehyde
benzene	toluene	mercury monitoring
Arsenic	Beryllium	Cadmium
Chromium	Lead	Manganese

Web Link(s): http://dep.state.ct.us/air2/toxics/monitiat.htm

Connecticut Department of Environmental Protection

Environmental and Geographic Information Center

Connecticut Butterfly Atlas

Project Objective(s): Collect data, in the form of vouchers and field forms, over one or more of five field seasons from 1995 through 1999. Vouchers are either specimens or photographs, and provide the information needed to produce a map of each species' distribution.

Project Measures:

lepidopteron distribution and abundance	Invertebrate distribution and status

Web Link(s): http://george.peabody.yale.edu/cbap/
http://dep.state.ct.us/cgnhs/nddb/Nddb2.htm

Rare Animal Species

Project Objective(s): To conserve, protect, restore and enhance any endangered or threatened species and their essential

Project Measures:

rare vertebrate distribution and abundance	rare invertebrate distribution and abundance

Web Link(s): http://dep.state.ct.us/cgnhs/nddb/nddb2.htm
http://dep.state.ct.us/cgnhs/index.htm

Rare Plant Species

Project Objective(s): Conserve, protect, restore and enhance any endangered or threatened species and their essential habitat.

Project Measures: rare plant distribution and abundance

Web Link(s): http://dep.state.ct.us/cgnhs/nddb/nddb2.htm
http://dep.state.ct.us/cgnhs/index.htm

Connecticut Department of Environmental Protection

Environmental and Geographic Information Center

Whip-poor-Will and Nighthawk Survey

Project Objective(s): Survey these species to determine whether or not the birds are undergoing a decline in their populations. Both species have been listed as a state species of special concern since 1991.

Project Measures: avian distribution and abundance breeding

Web Link(s): http://dep.state.ct.us/cgnhs/nddb/volun.htm
http://dep.state.ct.us/cgnhs/nddb/nddb2.htm
http://dep.state.ct.us/cgnhs/index.htm

Institute for Bird Populations

Monitoring Avian Productivity and Survivorship

Avian Inventory Program

Project Objective(s): indices of adult population size and post-fledging productivity from data on the numbers and proportions of young and adult birds captured.
estimates of adult population size, adult survival rates, proportions of residents, and recruitment into the adult population from mark-recapture data on adult birds.

Project Measures: avian distribution and abundance

Web Link(s): http://www.birdpop.org
http://www.birdpop.org/avianinv.htm
http://www.birdpop.org/maps.htm

National Atmospheric Deposition Program

Mercury Depostion Network (MDN)

Project Objective(s): The objective of the MDN is to develop a national database of weekly concentrations of total mercury in precipitation and the seasonal and annual flux of total mercury in wet deposition.
The data will be used to develop information on spatial and seasonal trends in mercury deposited to surface waters, forested watersheds, and other sensitive receptors.

Project Measures: mercury monitoring Precipitation composition methylmercury

Web Link(s): http://nadp.sws.uiuc.edu/mdn/

U.S. Army Corps of Engineers

Disposal Area Monitoring System (DAMOS)

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U.S. Forest Service

Forest Health Monitoring

Forest Inventory and Analysis

Project Objective(s): The Forest Inventory and Analysis Program tracks 3 Criteria and 67 Indicators. Criteria are: 1)Conservation of Biological Diversity; 2) Maintenance of Productive Capacity of Forest Ecosystems; 3)Maintenance of Forest Ecosystem Health & Vitality.
Collect and disseminate information about the forests of the Northeastern United States relating to forest distribution, forest condition, ownership patterns, timber utilization, and forest mensuration techniques.
Develop and apply scientific knowledge and technology in support of the inventory and analysis project.

Project Measures: Soil characteristics Tree condition Lichens
Air quality

Web Link(s): http://www.fs.fed.us/projects/
http://fia.fs.fed.us/rpa.htm
http://www.fs.fed.us/ne/fia/
http://www.fs.fed.us/research/sustain/

APPENDIX J: Weather Stations near Northeast Temperate Network Parks

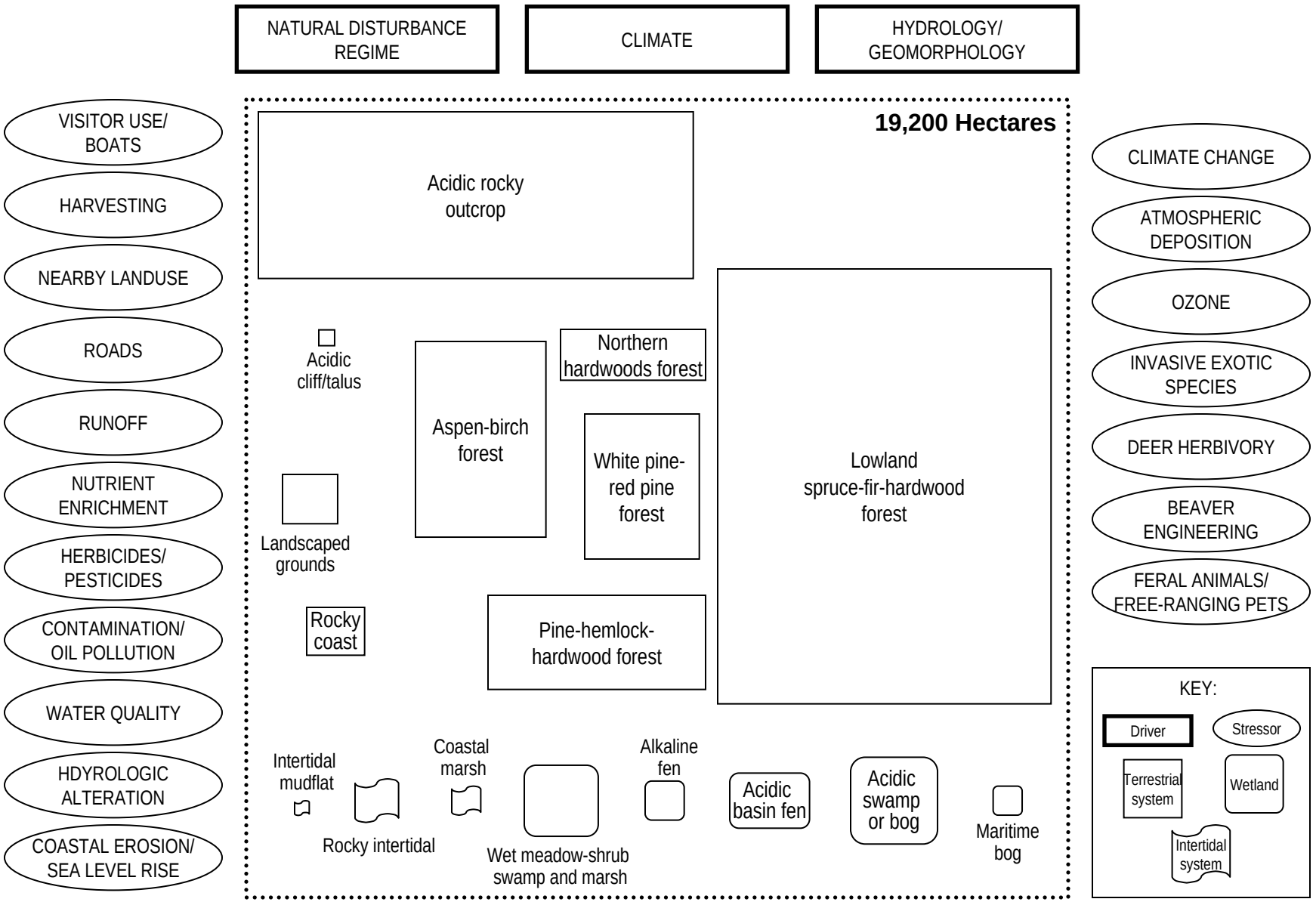
PARK	PROGRAM	DESCRIPTION
ACAD	Meteorology	**Meteorological Station**: Bar Harbor, Maine **Station identifier**: KBHB **Weather data**: wind, visibility, sky conditions, temperature, wind chill, dew point, relative humidity, pressure, precipitation **Location**: 44-27 N 068-22 W **Web address**: http://weather.noaa.gov/weather/current/KBHB.html **Distance from park to weather station**: near park perimeter
	Doppler	**Doppler Radar sites**: Portland, Maine **Web address**: http://weather.noaa.gov/radar/latest/DS.p19r0/si.kgyx.shtml **Distance from park to Doppler site**: 174 miles from park
	Tidal Gauges	**Tidal gauges**: Bar Harbor, Maine **Station Identifier**: 8413320 **Location**: 44 23.5 N 68 12.3 W **Web address**: http://co-ops.nos.noaa.gov/data_retrieve.shtml?input_code=100030000vci http://co-ops.nos.noaa.gov/data_res.html
BOHA	Meteorology	**Meteorological Station**: Boston Logan International Airport **Station identifier**: KBOS **Weather data**: wind, visibility, sky conditions, temperature, wind chill, dew point, relative humidity, pressure, precipitation **Location**: 42-21-38 N 071-00-38W **Web address**: http://weather.noaa.gov/radar/latest/DS.p19r0/si.kbox.shtml **Distance from park to weather station**: near perimeter of park
	Doppler	**Doppler Radar sites**: Boston, Massachusetts **Web address**: http://weather.noaa.gov/radar/latest/DS.p19r0/si.kbox.shtml **Distance from park to Doppler site**: near park perimeter
	Tidal Gauges	**Tidal gauges**: Boston, Massachusetts Boston Light, Massachusetts **Station Identifier**: 8443970 8444162 **Location**: 42 21.3 N 71 3.1 W 42 19.7 N 70 53.5 W **Web address**: http://co-ops.nos.noaa.gov/data_res.html

PARK	PROGRAM	DESCRIPTION
MABI	Meteorology	**Meteorological Station**: Rutland State Airport (VT) Lebanon Municipal Airport (NH) **Station identifier**: KRUT KLEB **Weather data**: wind, visibility, sky conditions, temperature, wind chill, dew point, relative humidity, pressure, precipitation **Location**: 43-32 N 072-57 W 43-37-38 N 072-18-21 W **Web address**: http://weather.noaa.gov/weather/current/KRUT.html http://weather.noaa.gov/weather/current/KLEB.html **Distance from park to weather station**: 30 miles from park 19 miles from park
	Doppler	**Doppler Radar sites**: Burlington, Vermont Portland, Maine **Web address**: http://weather.noaa.gov/radar/latest/DS.p19r0/si.kcxx.shtml http://weather.noaa.gov/radar/latest/DS.p19r0/si.kgyx.shtml **Distance from park to Doppler site**: 96 miles from park 181 miles from park
MIMA	Meteorology	**Meteorological Station**: Bedford Hanscom Field **Station identifier**: KBED **Weather data**: wind, visibility, sky conditions, temperature, wind chill, dew point, relative humidity, pressure, precipitation **Location**: 42-28-06 N 071-17-40W **Web address**: http://weather.noaa.gov/weather/current/KBED.html **Distance from park to weather station**: near park perimeter
	Doppler	**Doppler Radar sites**: Boston, Massachusetts **Web address**: http://weather.noaa.gov/radar/latest/DS.p19r0/si.kbox.shtml **Distance from park to Doppler site**: 19 miles from park
MORR	Meteorology	**Meteorological Station**: Morristown Municipal **Station identifier**: KMMU **Weather data**: wind, visibility, sky conditions, temperature, wind chill, dew point, relative humidity, pressure, precipitation **Location**: 40-48 N 074-25W **Web address**: http://weather.noaa.gov/weather/current/KMMU.html **Distance from park to weather station**: near park perimeter
	Doppler	**Doppler Radar sites**: Mt Holly, New Jersey **Web address**: http://weather.noaa.gov/radar/latest/DS.p19r0/si.kdix.shtml **Distance from park to Doppler site**: 78 miles from park

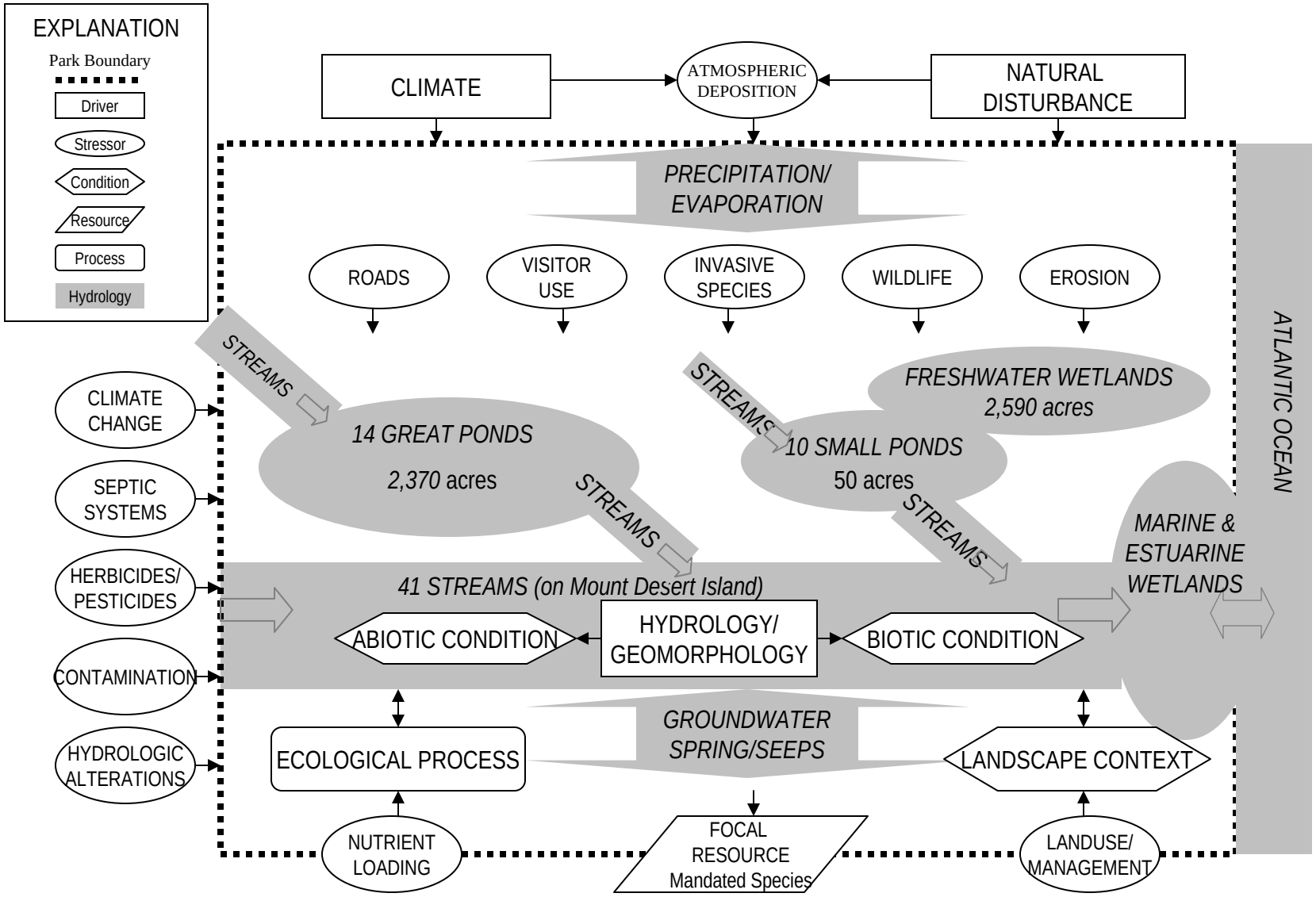
PARK	PROGRAM	DESCRIPTION
ROVA	Meteorology	**Meteorological Station**: Poughkeepsie, Dutchess County Airport **Station identifier**: KPOU **Weather data**: wind, visibility, sky conditions, temperature, wind chill, dew point, relative humidity, pressure, precipitation **Location**: 41-37-36 N 073-53-03 W **Web address**: http://weather.noaa.gov/weather/current/KPOU.html **Distance from park to weather station**: 6 miles from park
	Doppler	**Doppler Radar sites**: Hartford, Connecticut Mt Holly, New Jersey **Web address**: http://weather.wtnh.com/doppler/doppler.html http://weather.noaa.gov/radar/latest/DS.p19r0/si.kdix.shtml **Distance from park to Doppler site**: 105 miles from park 161 miles from park
SAGA	Meteorology	**Meteorological Station**: Lebanon, Lebanon Municipal Airport **Station identifier**: KLEB **Weather data**: wind, visibility, sky conditions, temperature, wind chill, dew point, relative humidity, pressure, precipitation **Location**: 43-37-38 N 072-18-21W **Web address**: http://weather.noaa.gov/weather/current/KLEB.html **Distance from park to weather station**: 11miles from park
	Doppler	**Doppler Radar sites**: Burlington, Vermont Portland, Maine **Web address**: http://weather.noaa.gov/radar/latest/DS.p19r0/si.kcxx.shtml http://weather.noaa.gov/radar/latest/DS.p19r0/si.kgyx.shtml **Distance from park to Doppler site**: 106 miles from park 171 miles from park
SAIR	Meteorology	**Meteorological Station**: Boston Logan International Airport **Station identifier**: KBOS **Weather data**: wind, visibility, sky conditions, temperature, wind chill, dew point, relative humidity, pressure, precipitation **Location**: 42-21-38N 071-00-38W **Web address**: http://weather.noaa.gov/weather/current/KBOS.html **Distance from park to weather station**: 10 miles from park
	Doppler	**Doppler Radar sites**: Boston, Massachusetts **Web address**: http://weather.noaa.gov/radar/latest/DS.p19r0/si.kbox.shtml **Distance from park to Doppler site**: 10 miles from park

PARK	PROGRAM	DESCRIPTION
SARA	Meteorology	**Meteorological Station**: Schenectady Airport **Station identifier**: KSCH **Weather data**: wind, visibility, sky conditions, temperature, wind chill, dew point, relative humidity, pressure, precipitation **Location**: 42-51 N 073-56 W **Web address**: http://weather.noaa.gov/weather/current/KSCH.html **Distance from park to weather station**: 20 miles from park
	Doppler	**Doppler Radar sites**: Mt Holly, New Jersey Albany, New York **Web address**: http://weather.noaa.gov/radar/latest/DS.p19r0/si.kdix.shtml http://weather.noaa.gov/radar/latest/DS.p19r0/si.kenx.shtml **Distance from park to Doppler site**: 236 miles from park 23 miles from park
WEFA	Meteorology	**Meteorological Station**: Danbury Municipal Airport **Station identifier**: KDXR **Weather data**: wind, visibility, sky conditions, temperature, wind chill, dew point, relative humidity, pressure, precipitation **Location**: 41-22-18 N 073-29-04 W **Web address**: http://weather.noaa.gov/weather/current/KDXR.html **Distance from park to weather station**: 17 miles from park
	Doppler	**Doppler Radar sites**: Hartford, Connecticut **Web address**: http://weather.wtnh.com/doppler/doppler.html **Distance from park to Doppler site**: 72 miles from park

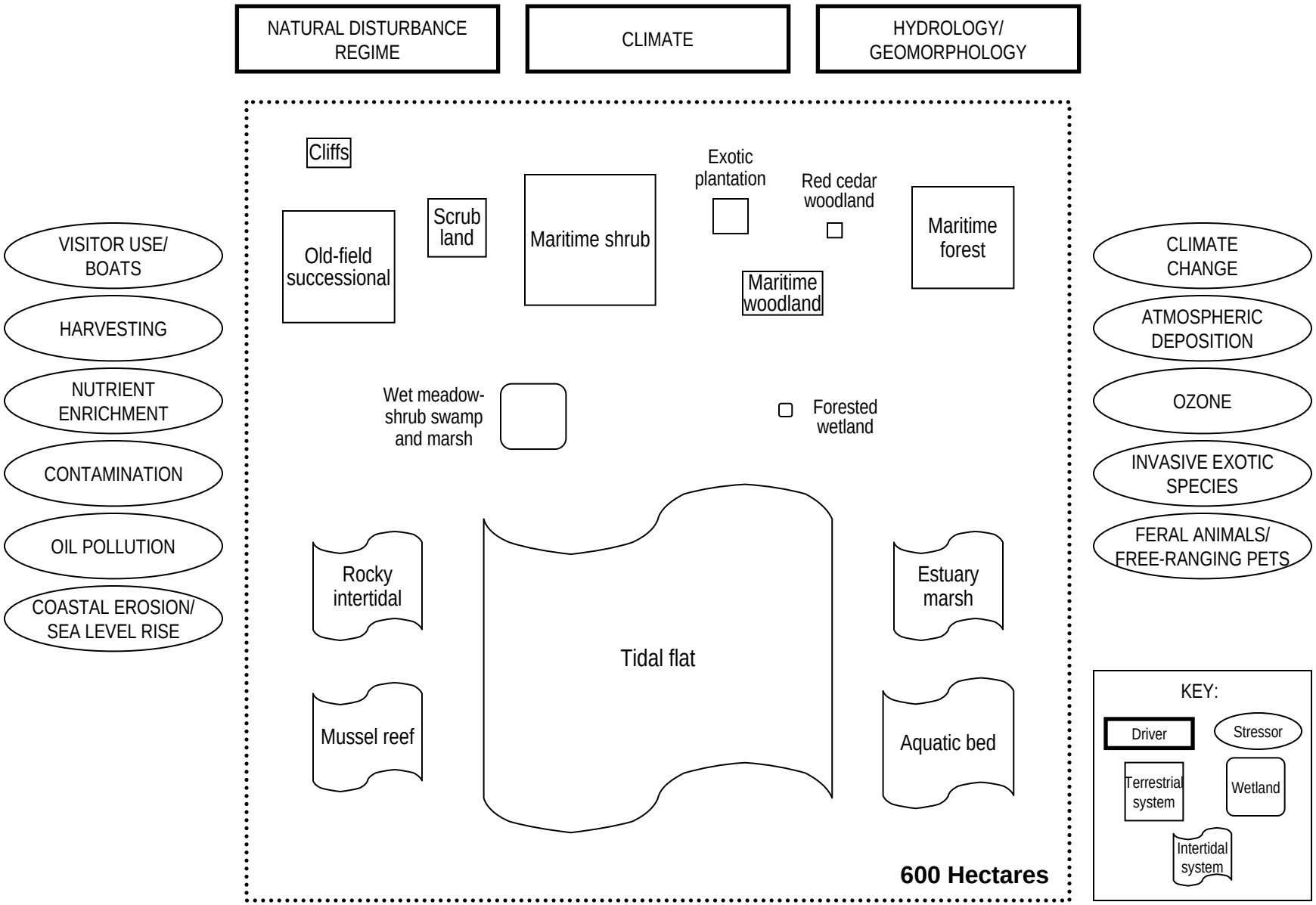
Conceptual Model for Acadia National Park: Systems, Drivers, and Stressors



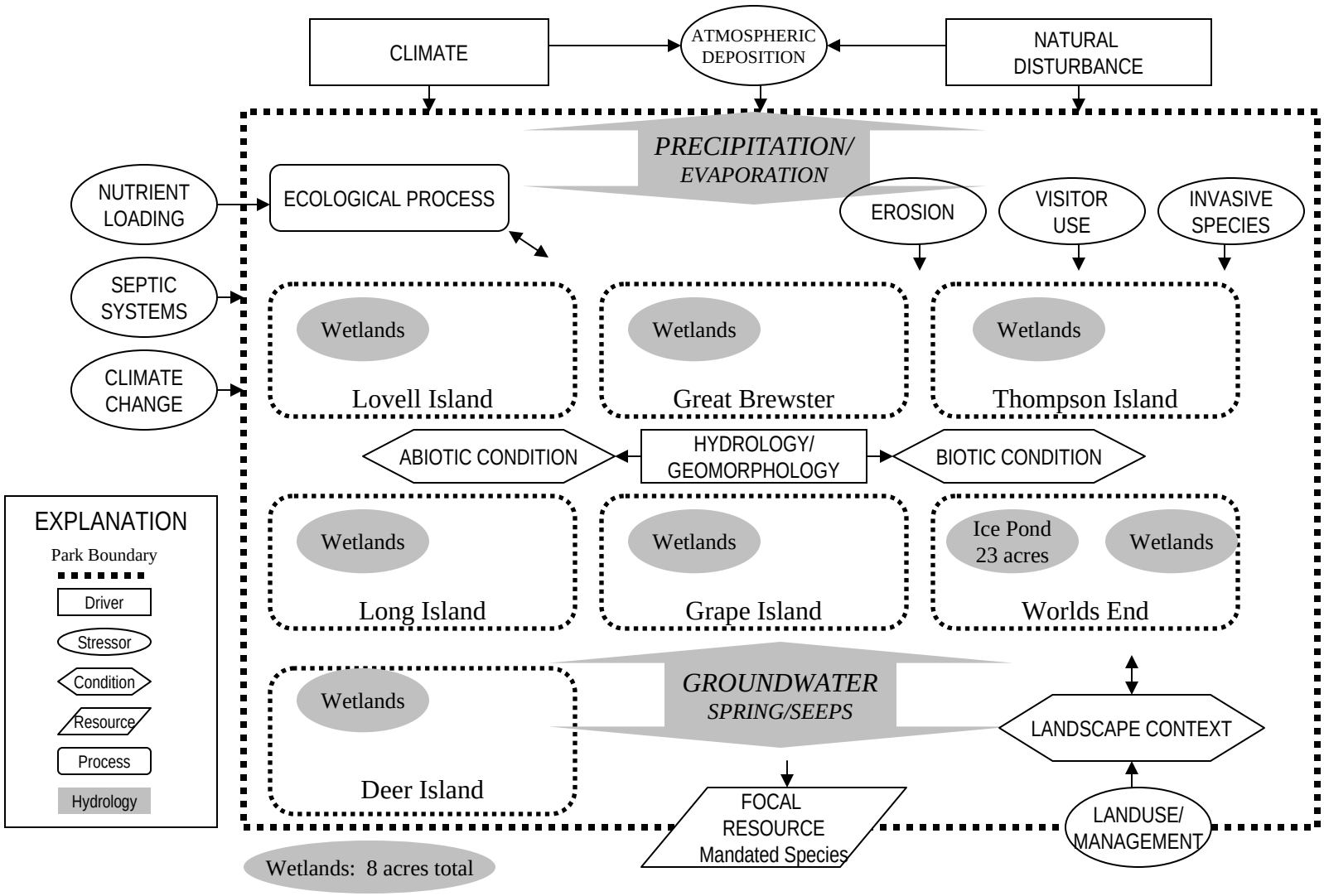
Conceptual Model for Acadia National Park: Aquatic Systems, Drivers, and Stressors



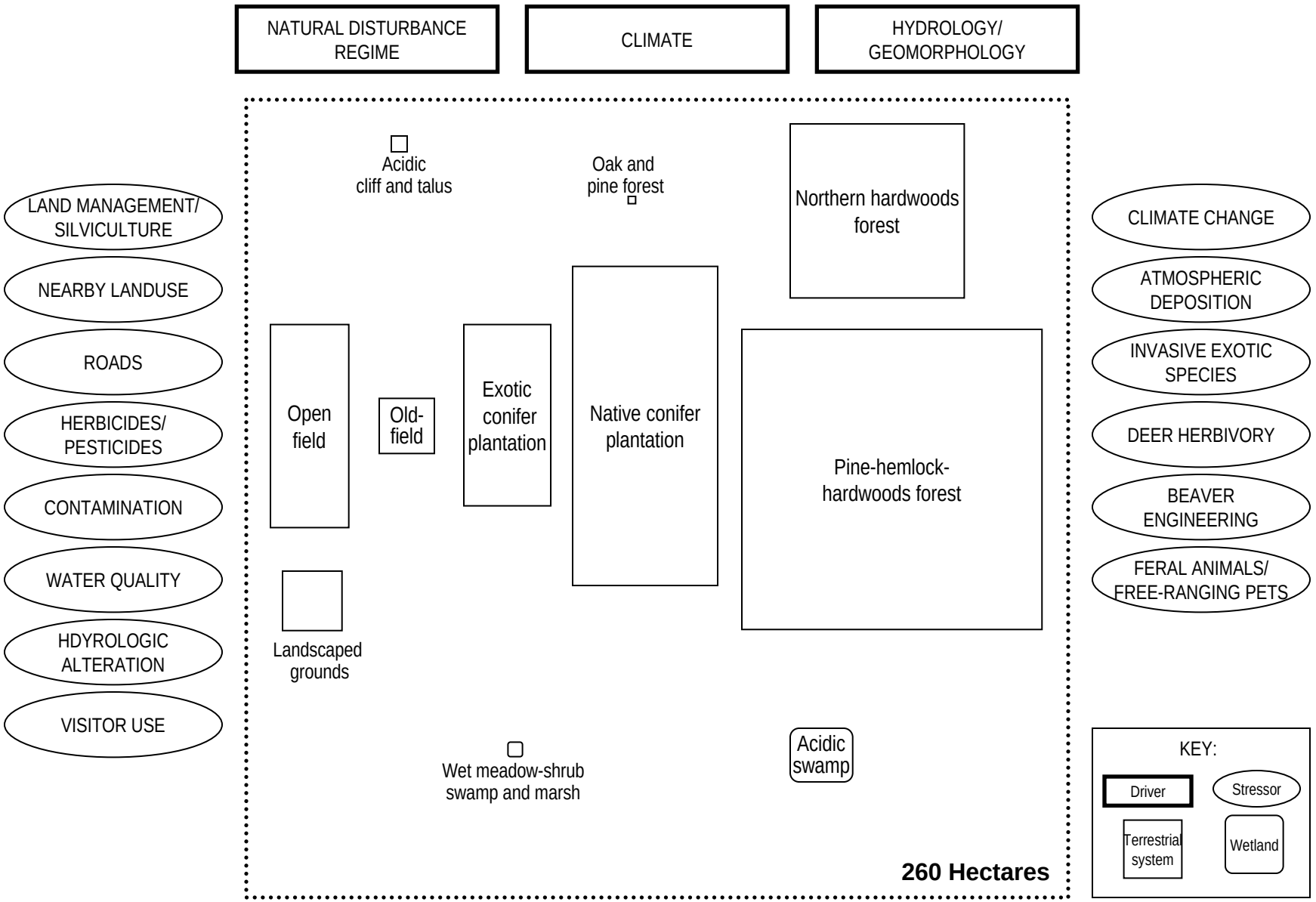
Conceptual Model for Boston Harbor Islands NPA: Systems, Drivers, and Stressors



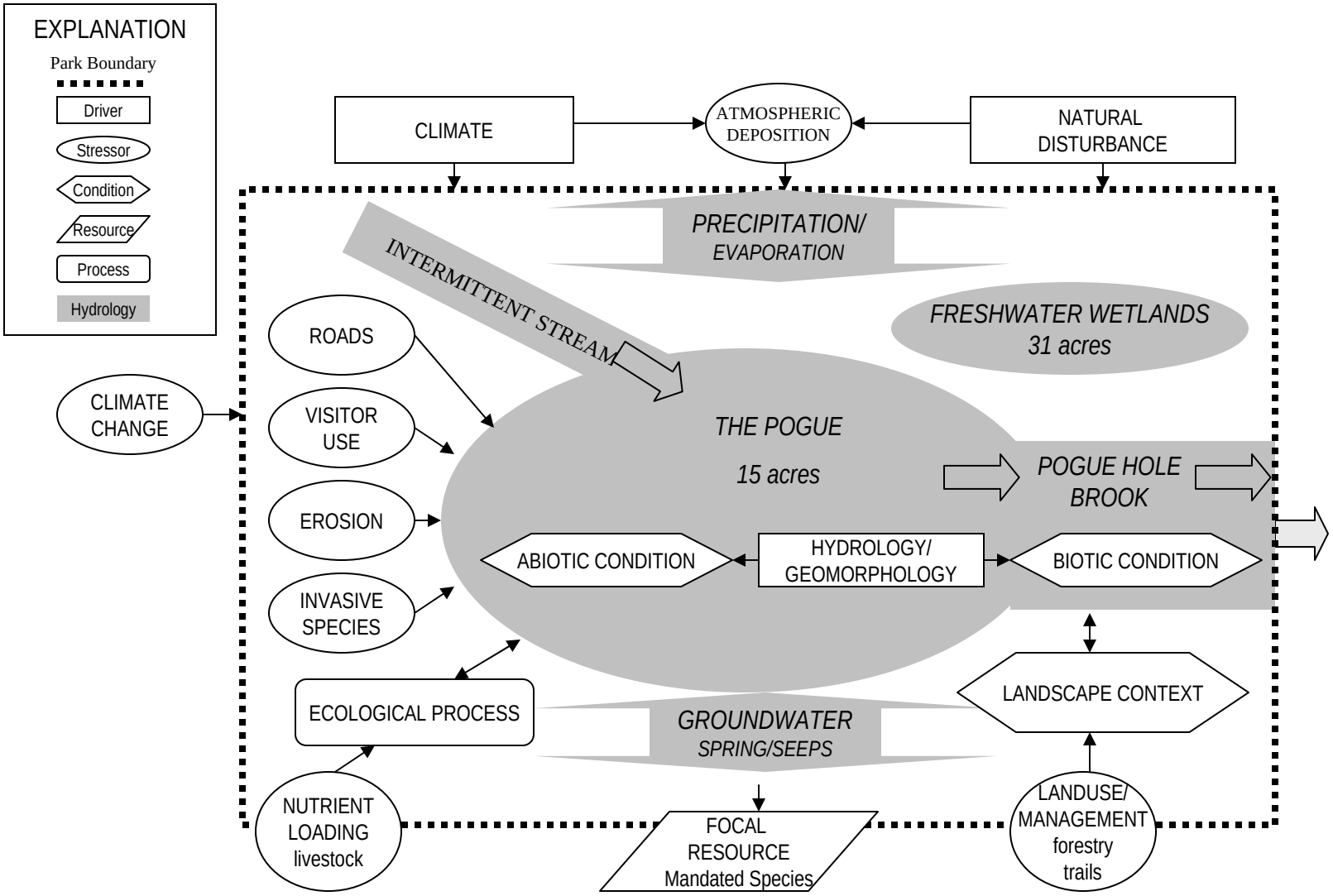
Conceptual Model for Boston Harbor Islands NPA: Aquatic Systems, Drivers, and Stressors



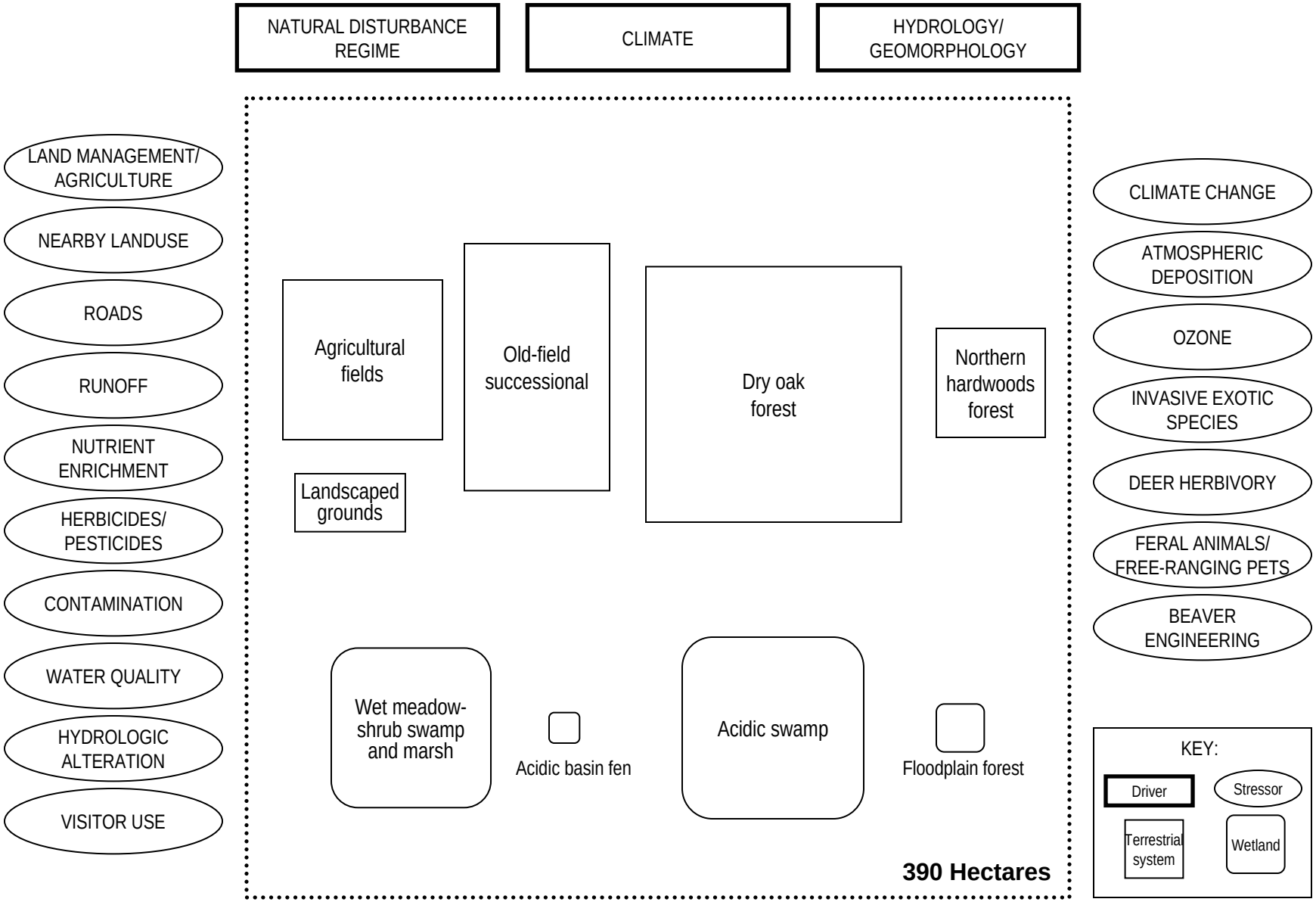
Conceptual Model for Marsh-Billings-Rockefeller National Historical Park: Systems, Drivers, and Stressors



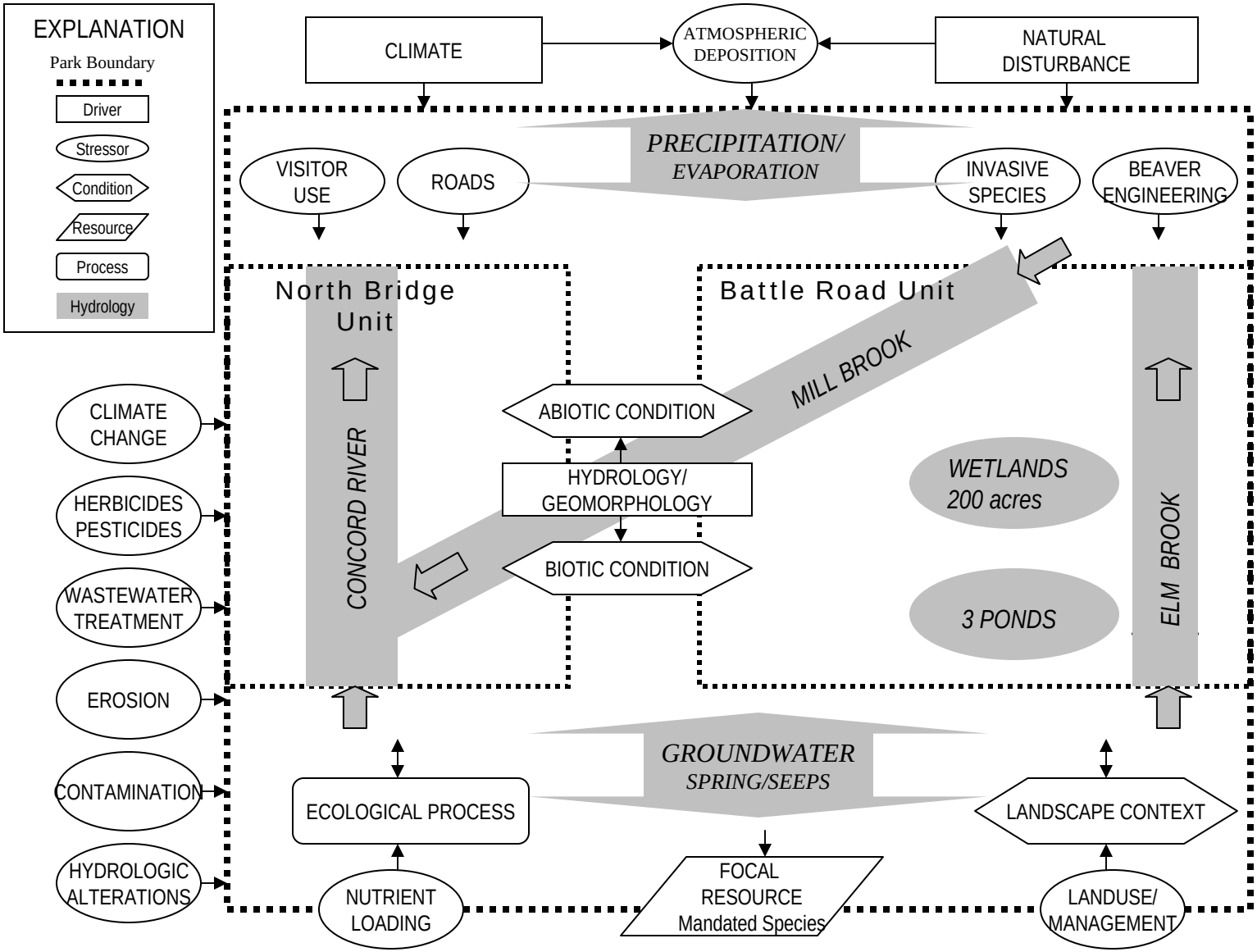
Conceptual Model for Marsh-Billings-Rockefeller National Historical Park: Aquatic Systems, Drivers, and Stressors



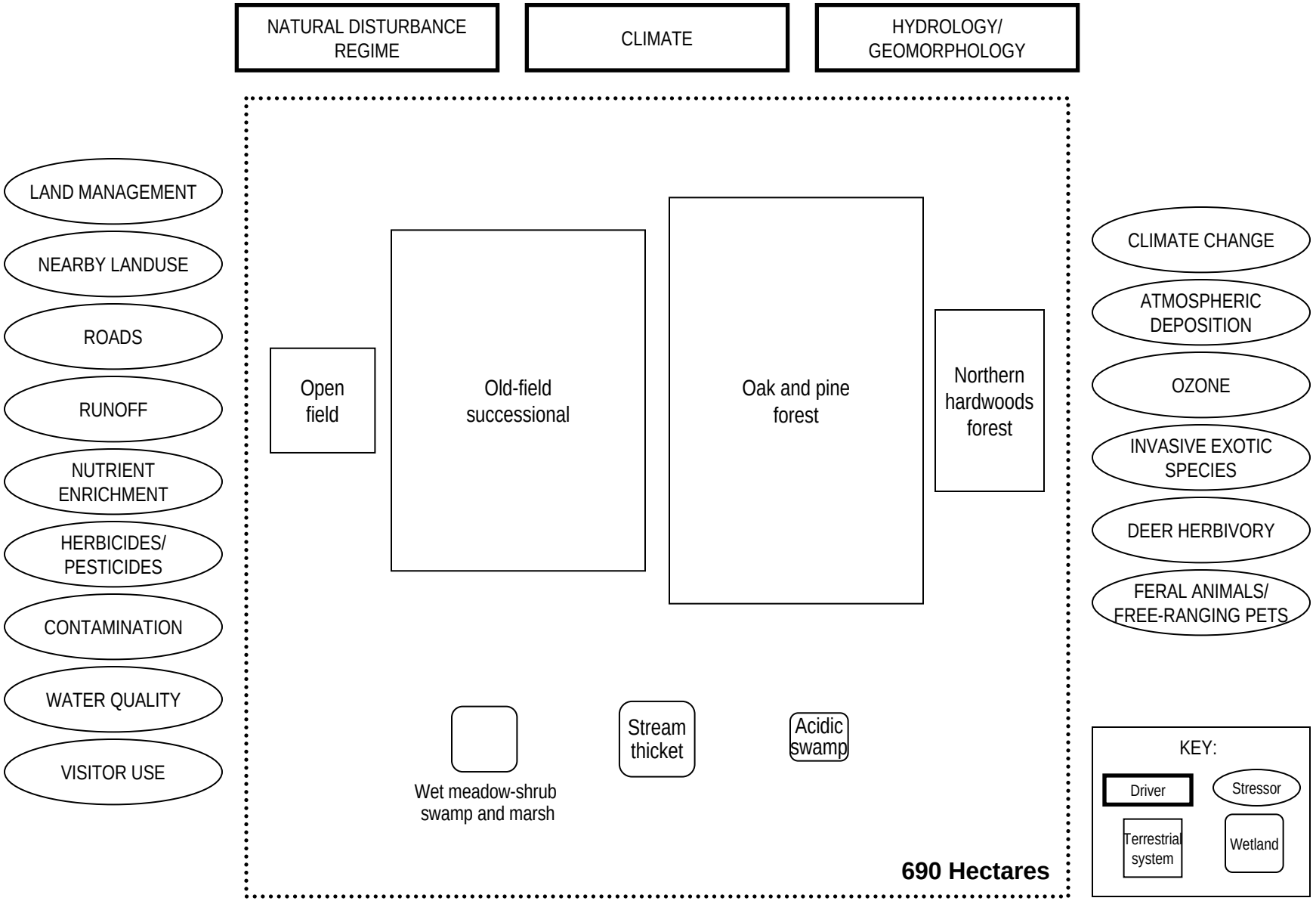
Conceptual Model for Minute Man National Historical Park: Systems, Drivers, and Stressors



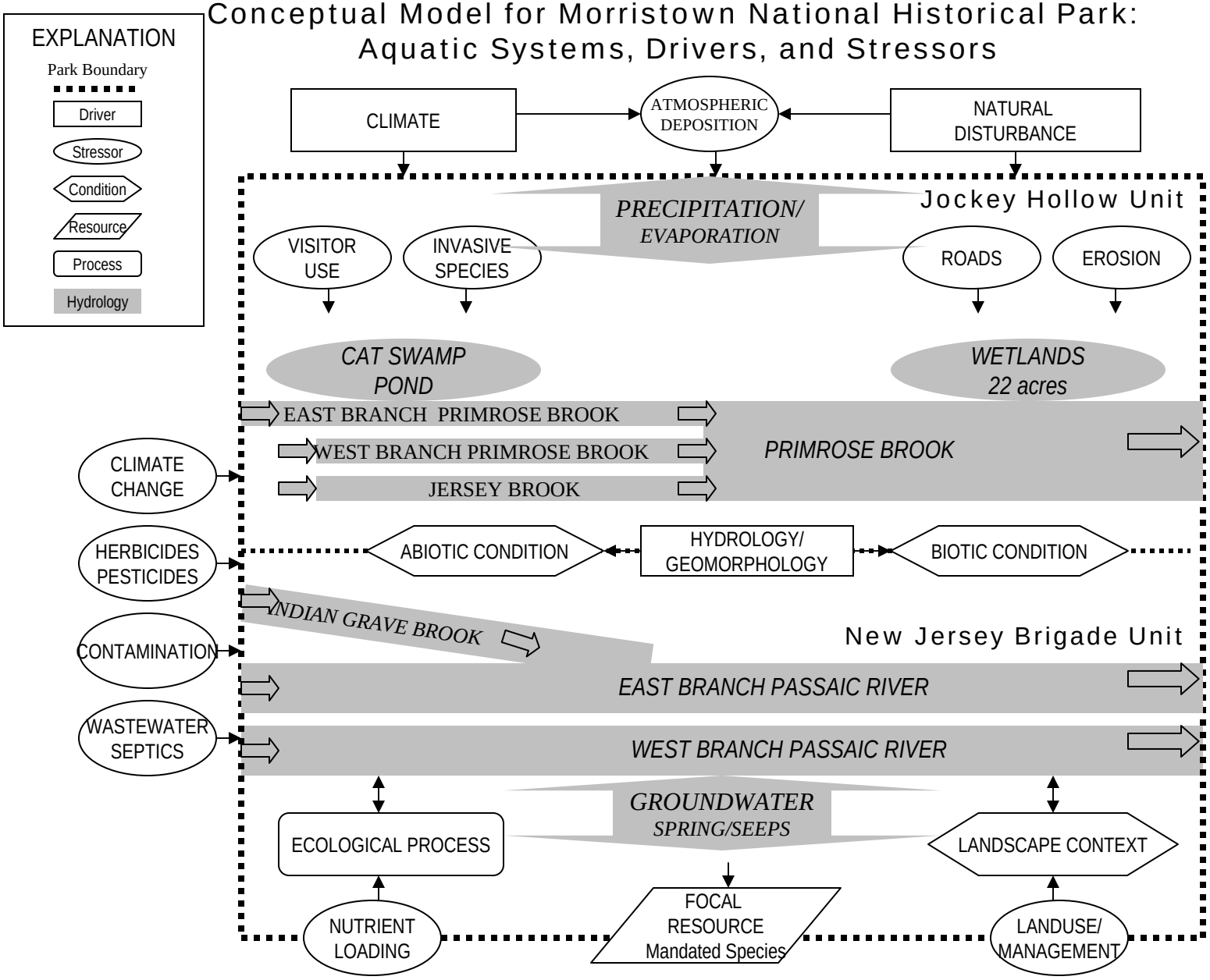
Conceptual Model for Minute Man National Historical Park: Aquatic Systems, Drivers, and Stressors



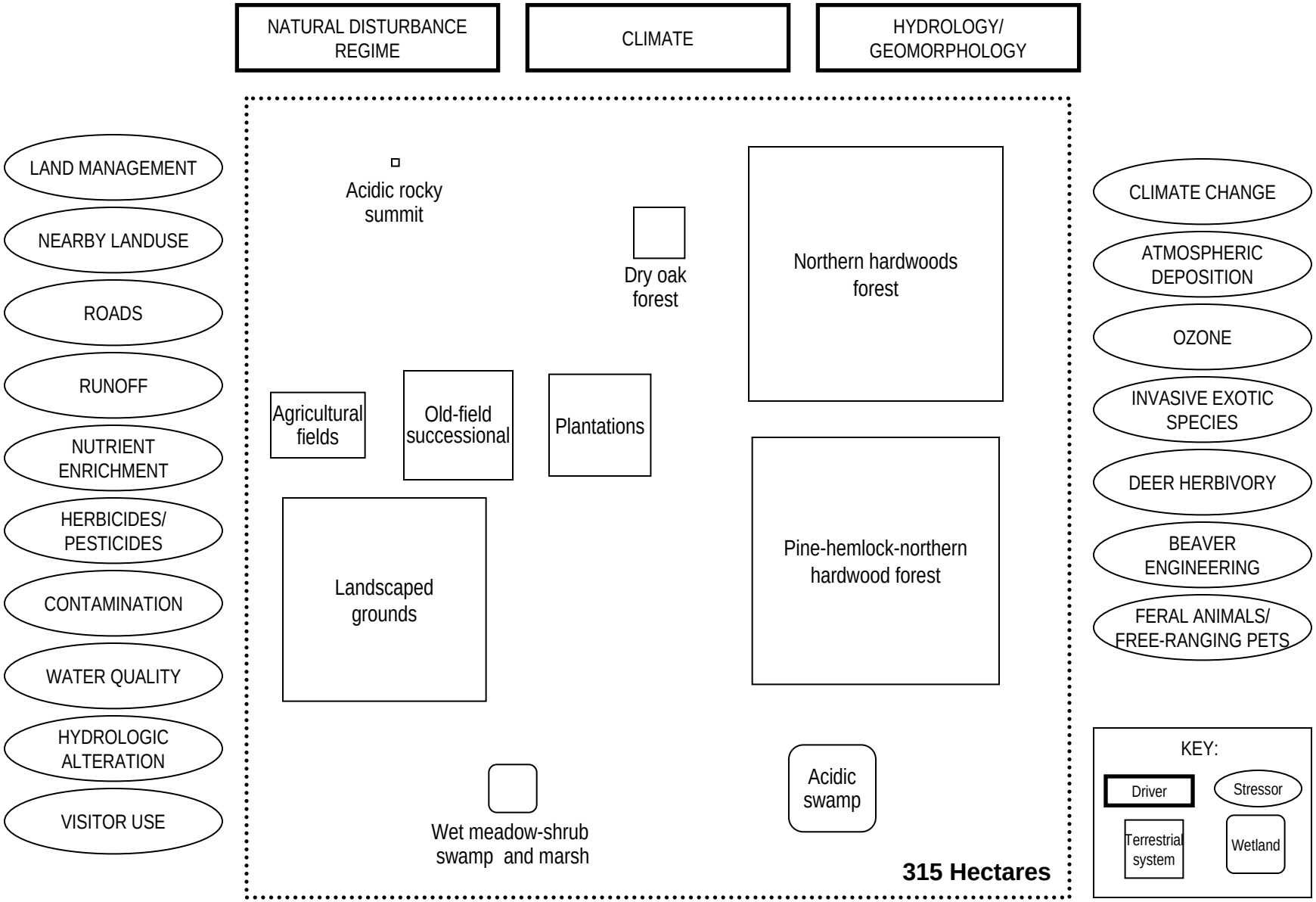
Conceptual Model for Morristown National Historical Park: Systems, Drivers, and Stressors



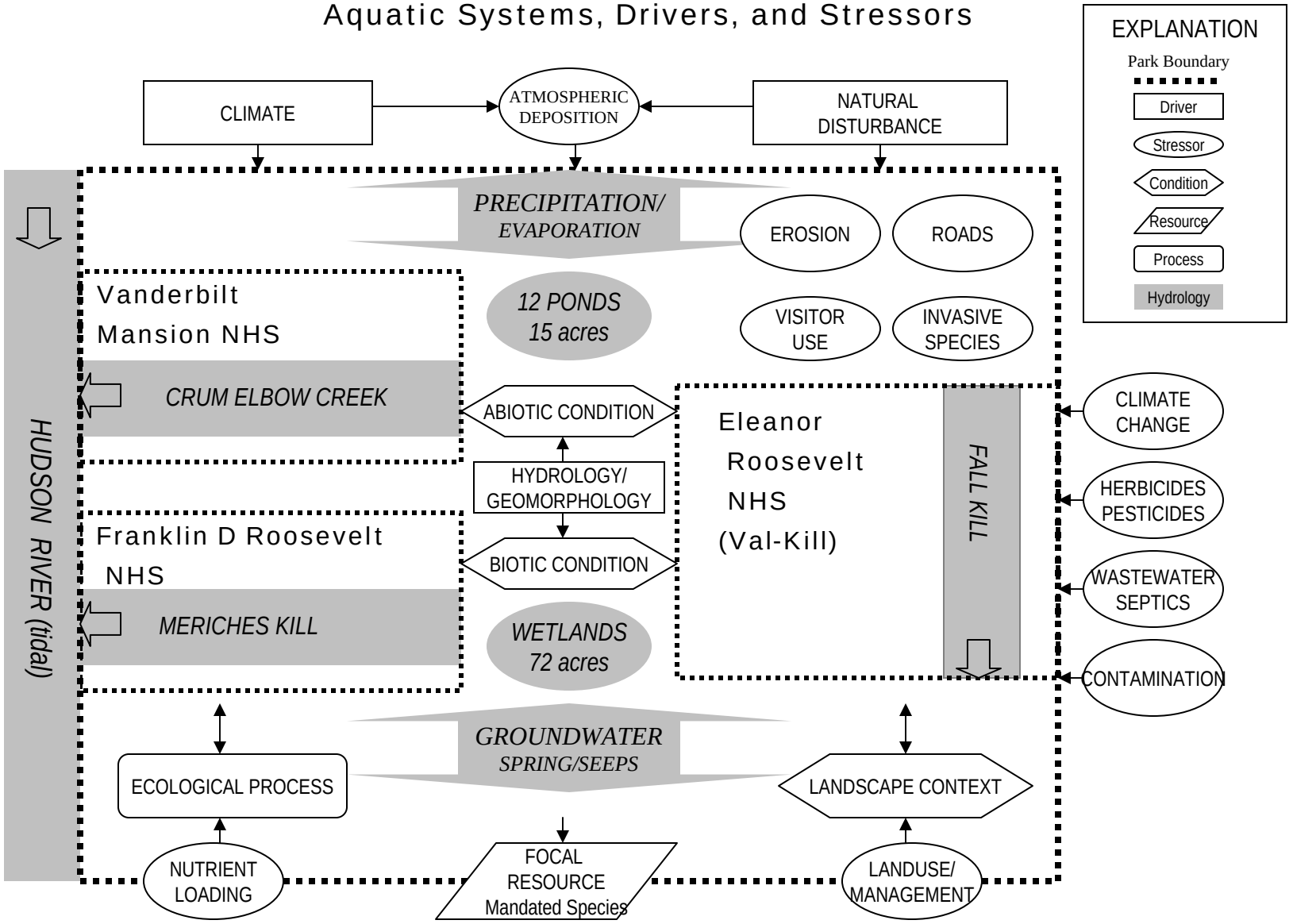
Conceptual Model for Morristown National Historical Park: Aquatic Systems, Drivers, and Stressors



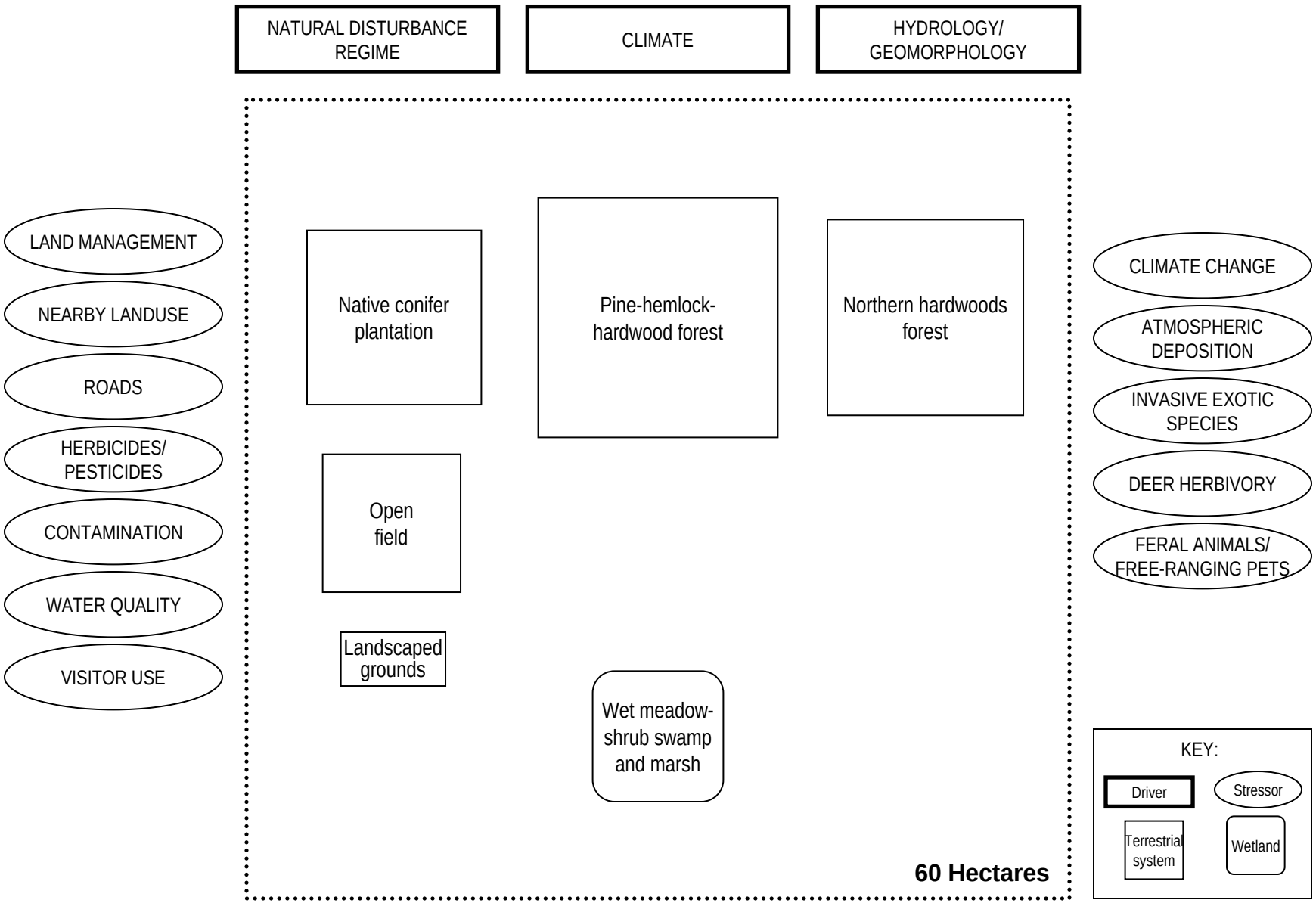
Conceptual Model for Roosevelt-Vanderbilt National Historic Site: Systems, Drivers, and Stressors



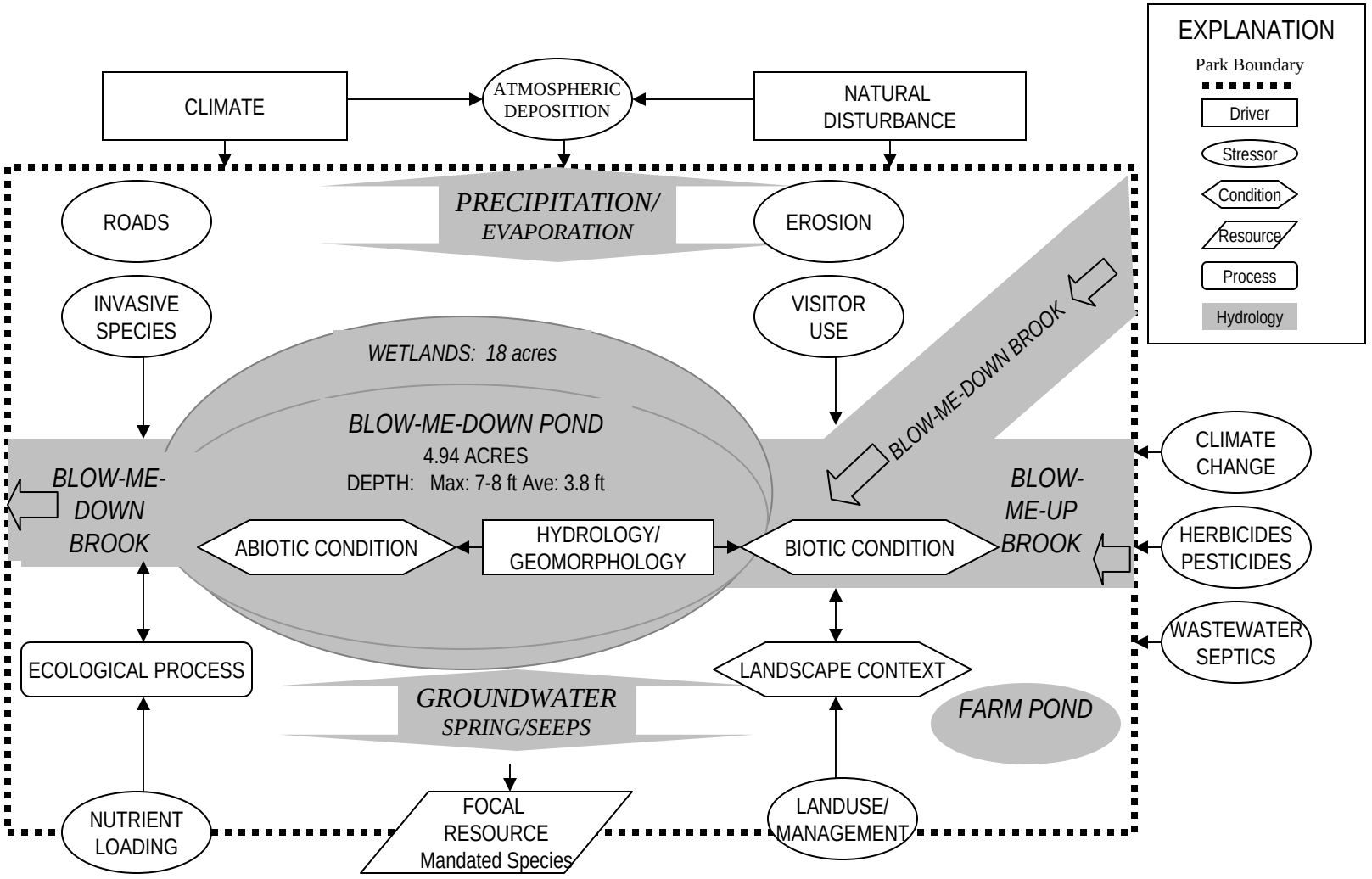
Conceptual Model for Roosevelt-Vanderbilt National Historic Site: Aquatic Systems, Drivers, and Stressors



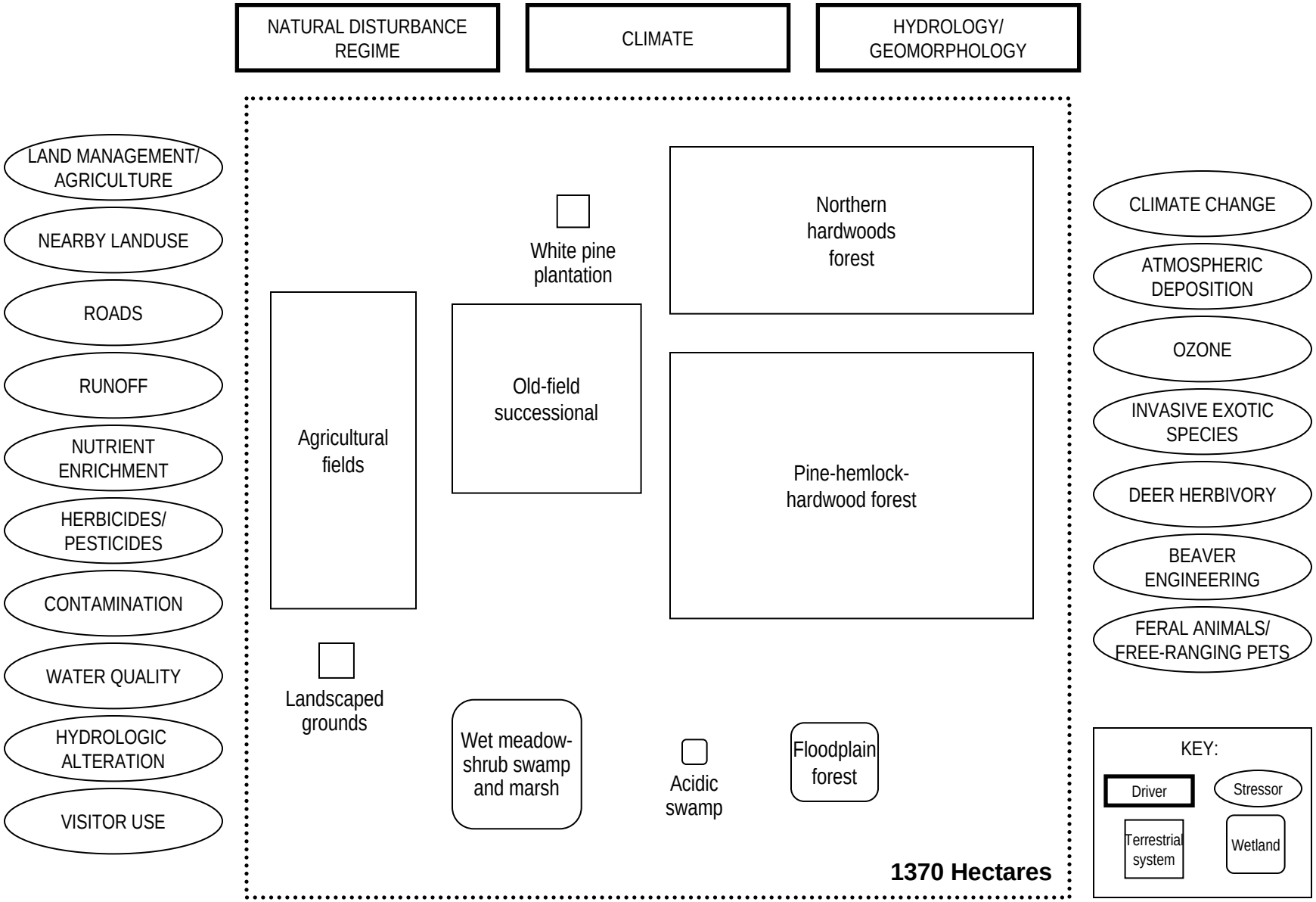
Conceptual Model for Saint Gaudens National Historic Site: Systems, Drivers, and Stressors



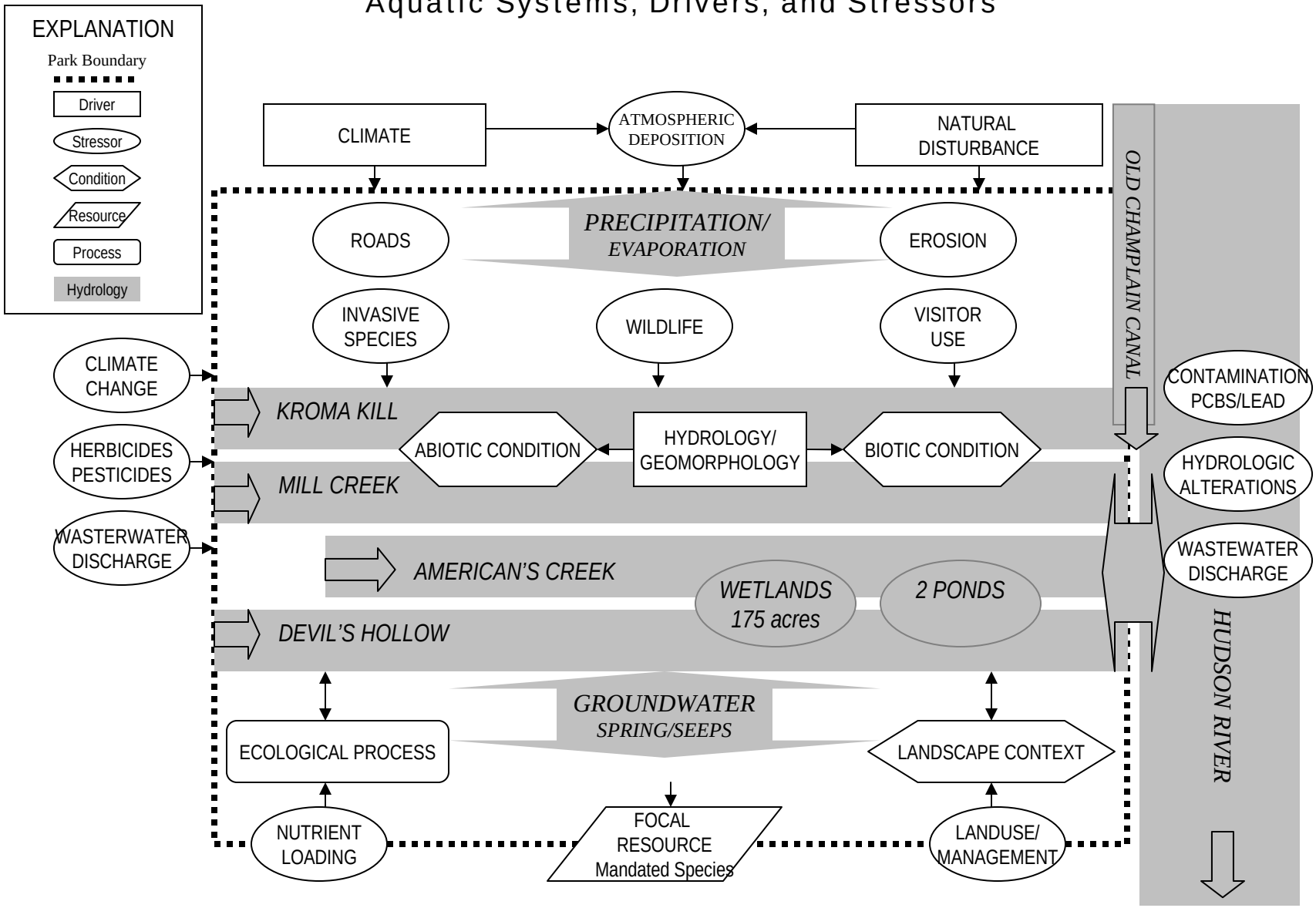
Conceptual Model for Saint Gaudens National Historic Site: Aquatic Systems, Drivers, and Stressors



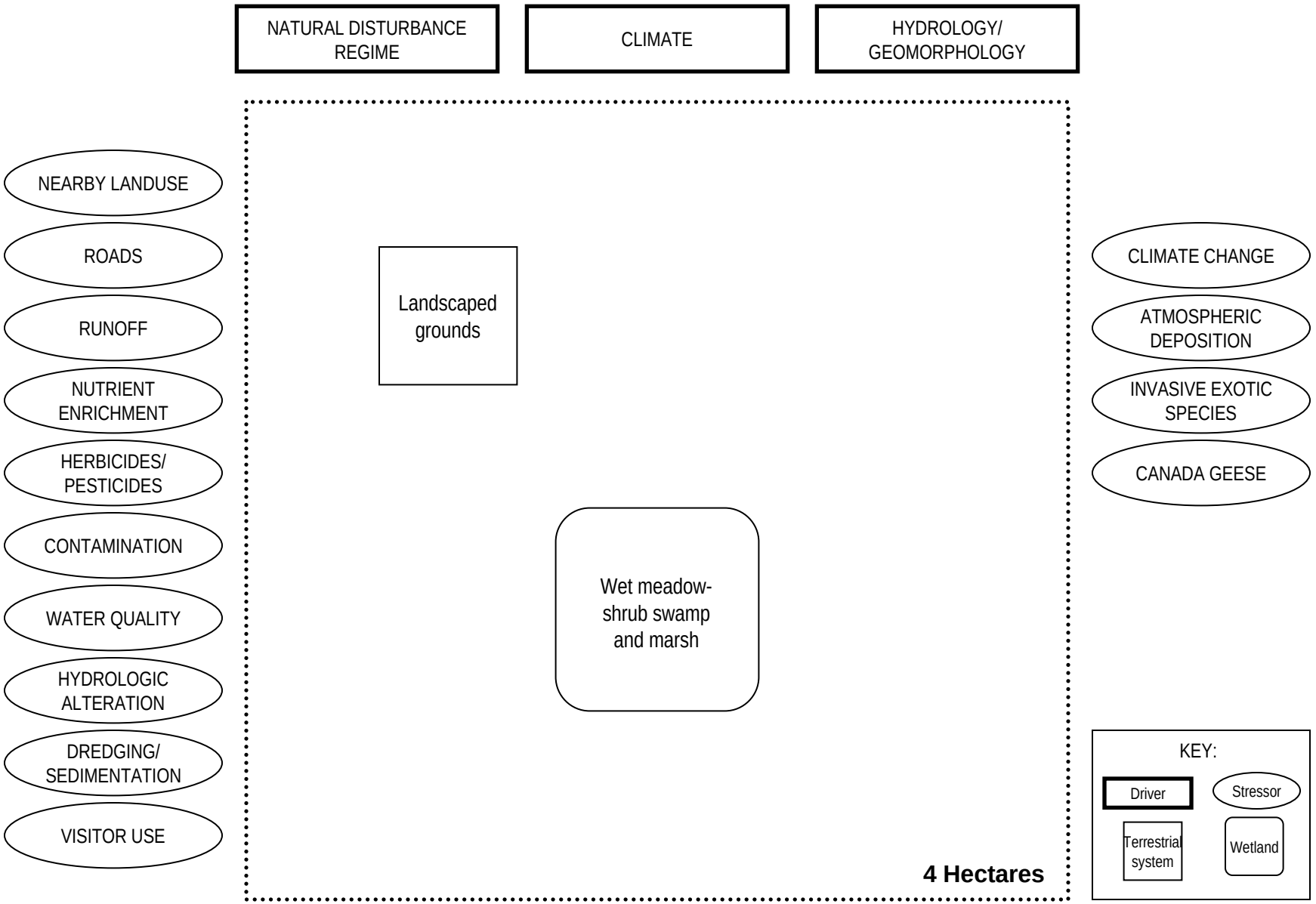
Conceptual Model for Saratoga National Historical Park: Systems, Drivers, and Stressors



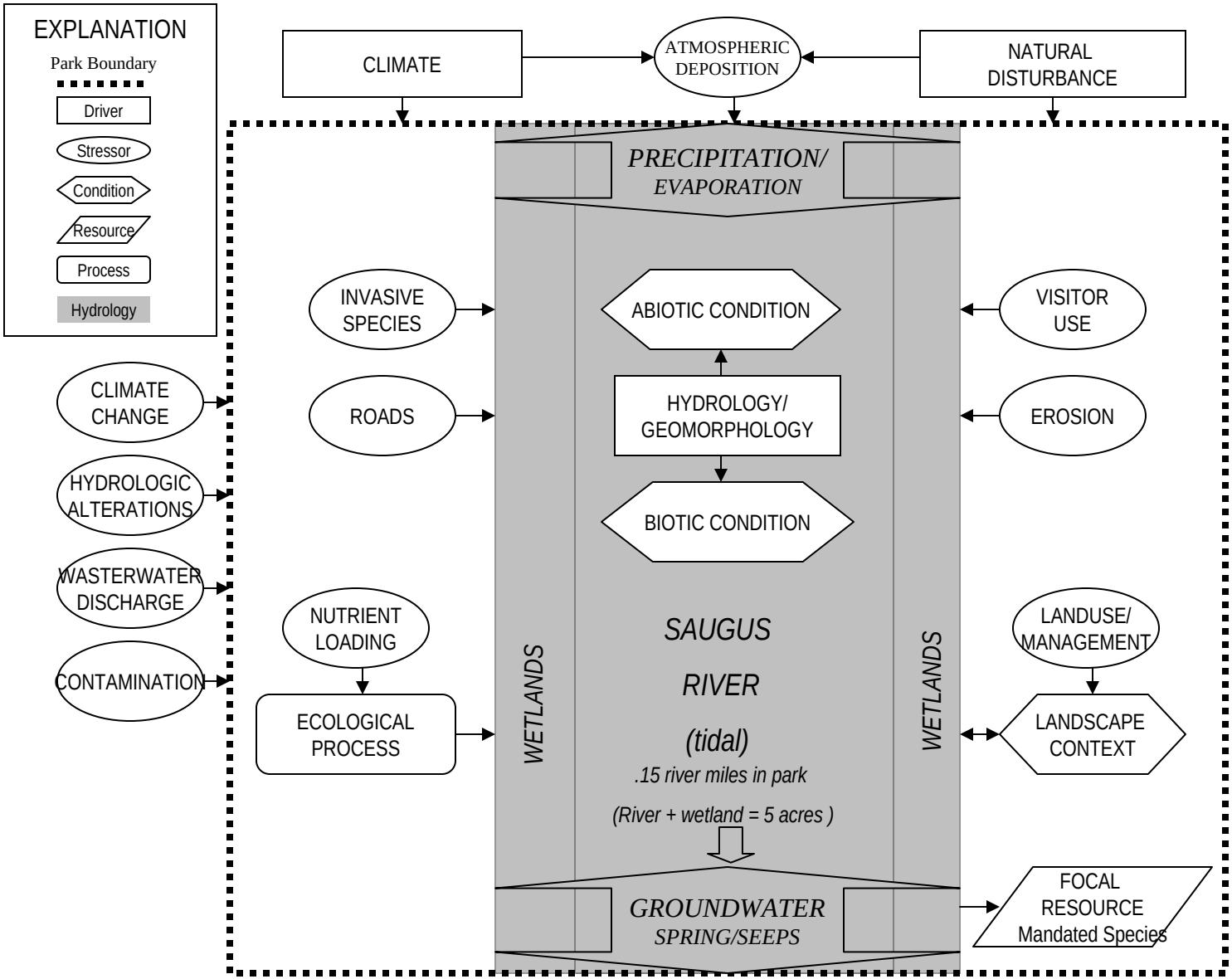
Conceptual Model for Saratoga National Historical Park: Aquatic Systems, Drivers, and Stressors



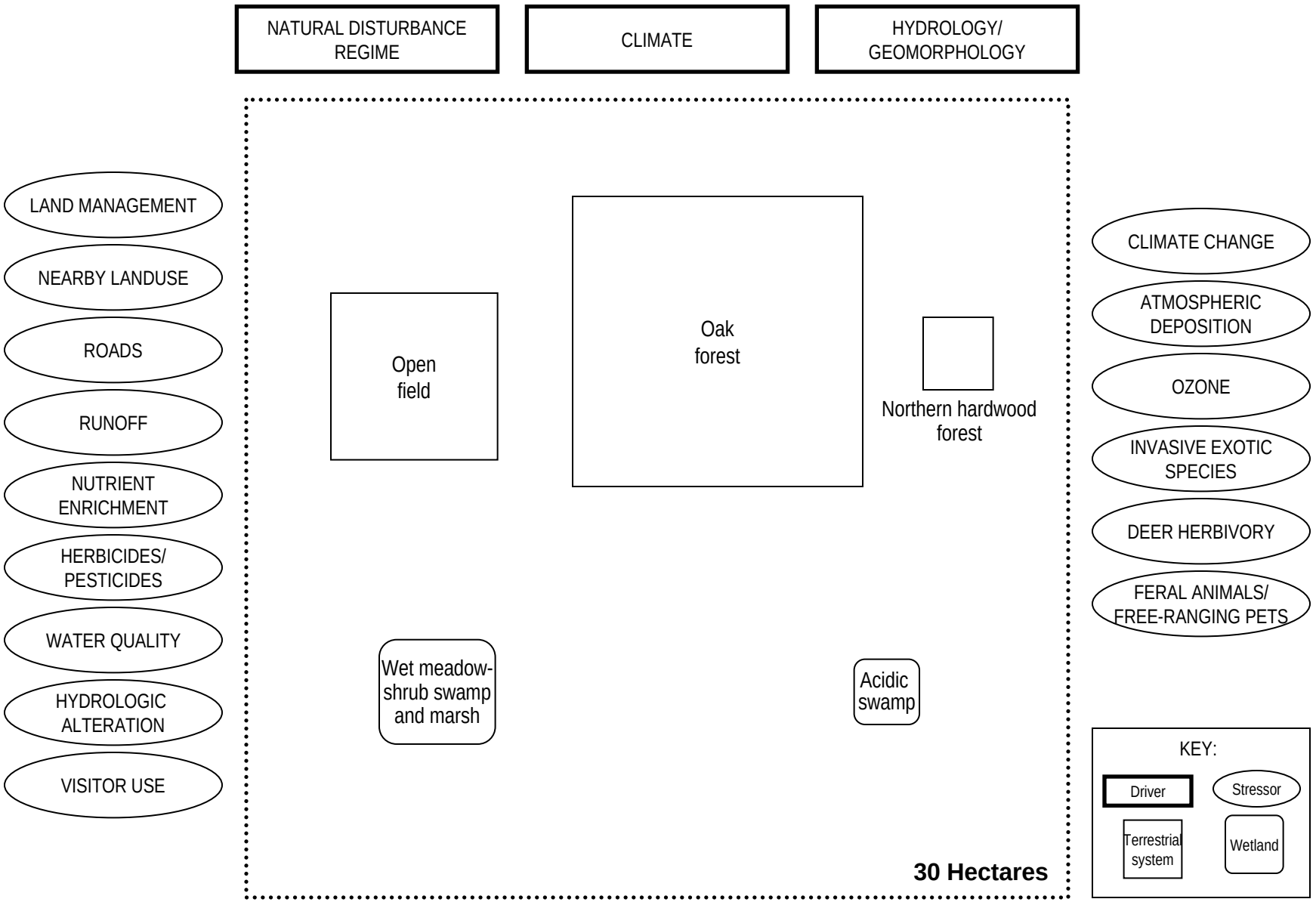
Conceptual Model for Saugus Iron Works National Historic Site: Systems, Drivers, and Stressors



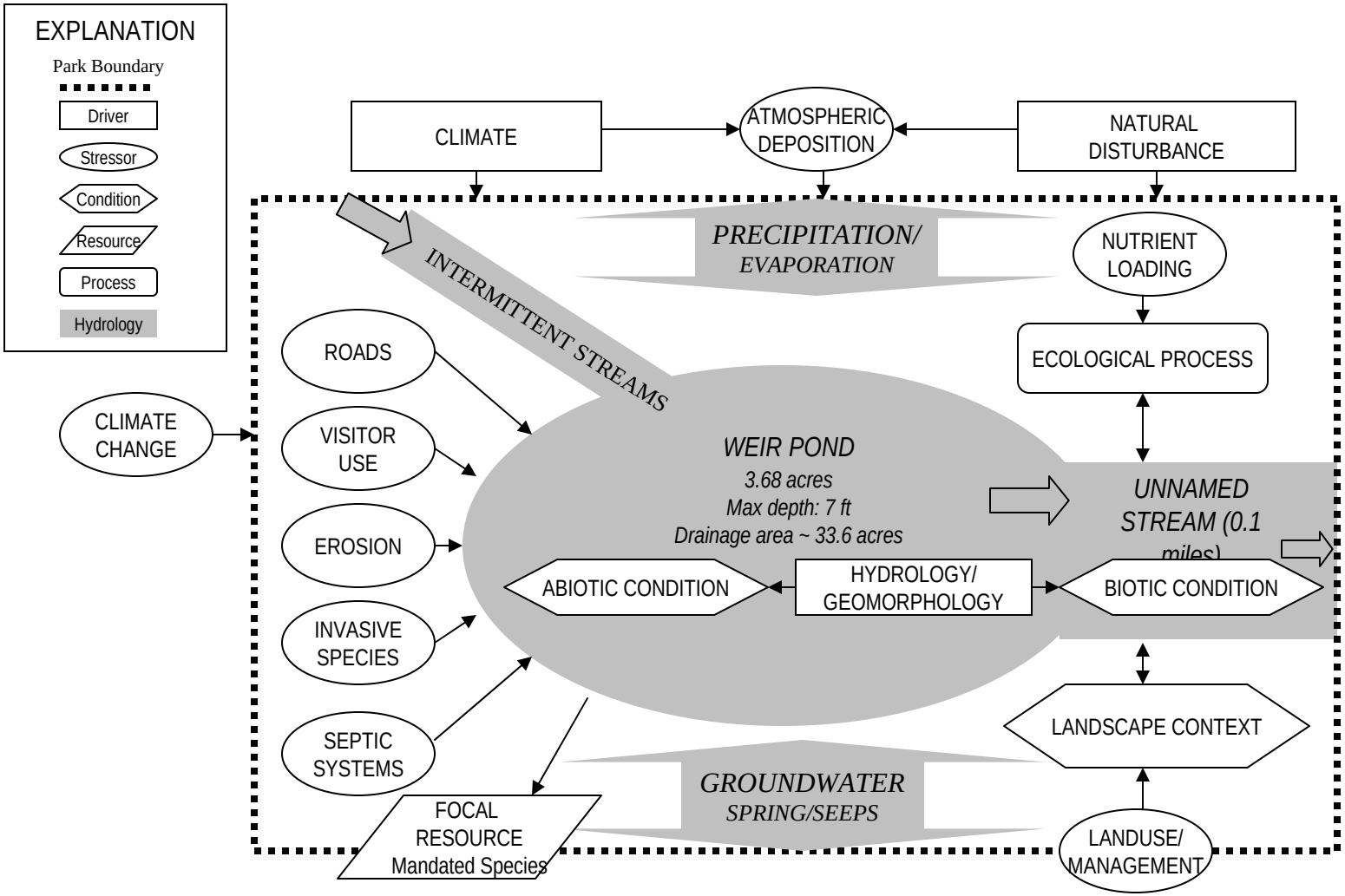
Conceptual Model for Saugus Iron Works National Historic Site: Aquatic Systems, Drivers, and Stressors



Conceptual Model for Weir Farm National Historic Site: Systems, Drivers, and Stressors



Conceptual Model for Weir Farm National Historic Site: Aquatic Systems, Drivers, and Stressors



APPENDIX L: Comprehensive List of NETN Vital Signs

Comprehensive list of NETN vital signs showing the average score based on pre-workshop ranking. Vital signs were categorized as follows; high priority = 10-12, medium priority = 8-10, and low priority = <8.

Category	Potential Vital Sign	Average Score (max = 12)
Climate	Basic climate	9.8
Disturbance	Disturbance regime: Landscape-scale	9.5
	Disturbance Regime: Drought	6.8
	Disturbance Regime: Fire	8.8
	Disturbance Regime: Flood	7.5
	Disturbance Regime: Storm	6.5
	Disturbance Regime: Wind events	6.3
Hydrology/Geomorphology	Channel morphology	8.5
	Groundwater	6.8
	Hydroperiod	9.7
	Lake morphometry	9.0
	Relative surface elevation	10.5
	Shoreline erosion	8.5
	Spring/seep distribution	7.0
	Spring/seep duration/seasonality/volume	8.0
	Streamflow	10
	Surface water level	9.7
	Tidal patterns	9.0
	Water level	11.0
Abiotic Condition	Stream alkalinity/ANC	10.0
	Water - Conductivity	11.5
	Water - Dissolved oxygen	12.0
	Water - pH	12.0
	Riparian shading	9.5
	Sediment redox potential	6.5
	Soil aggregate stability	8.5
	Soil compaction	8.3
	Substrate composition	9.0
	Water - Total dissolved ions	9.0
	Water - Total organic carbon	7.5
	Water - Temperature	12.0
	Water - Clarity	11.5
Biotic Condition	Algal biomass	11.5
	Amphibians	9.0
	Aquatic Vegetation	11.0
	Canopy species composition	10.7
	Coarse woody debris	9.0
	Fish presence	10.5
	Focal taxa - Alpine zone	8.7
	Focal taxa - Mudflat	8.0

Category	Potential Vital Sign	Average Score (max = 12)
Biotic Condition	Focal taxa - Rocky intertidal	8.0
	Focal taxa - Rocky shore	8.7
	Focal taxa -Open uplands	8.7
	Focal taxa - Forest interior breeding birds	8.7
	Live legacy trees	9.3
	Ecosystem nitrogen loss	9.3
	Focal taxa – Aquatic macroinvertebrates	9.0
	Predator composition	8.3
	Focal species - Red backed salamanders in forests	8.7
	Shrub/herb composition	9.3
	Snags	9.3
	Focal taxa - Soil biota in forests	6.7
	Focal taxa - Soil biota in plantations	6.0
	Species composition	10.0
	Species migration - climate	7.7
	Focal taxa - Spring ephemerals	8.3
	Stand biomass	9.7
	Stand structure	9.7
	Tree health/vigor	8.7
	Tree mortality	10.3
	Tree sapling regeneration	10.3
	Vegetation – regeneration	8.5
	Vegetation condition	10.0
	Focal species - White tailed deer	9.7
Ecological Process	Forest gap dynamics	6.7
	Nutrient cycling	10.3
	Phenology	8.7
	Productivity	8.7
	Soil respiration	6.0
	Trophic dynamics	7.0
Focal Park Resource	Focal taxa - Amphibians in vernal pools	10.3
	Focal taxa - Bats	6.7
	Focal species - Beavers	10.0
	Focal taxa - Breeding birds	9.3
	Dark night sky	6.3
	Focal taxa - Fish	7.5
	Focal taxa - Grassland birds in fields	8.3
	Focal taxa - Harbor seals	7.7
	Mandated Species	8.0
	Focal taxa - Obligate lepidopterans/odonates in fields	7.3
	Rare community	9.0
	Rare species	8.5
	Viewshed	7.0
	Visibility	8.0
Landscape Context	Buffer - aquatic	10.5
	Patch edge type	10.7
	Landcover - ecological system type	9.7

APPENDIX L: Comprehensive List of NETN Vital Signs

Category	Potential Vital Sign	Average Score (max = 12)
	Landcover - fragmentation	8.7
	Landcover - patch size	9.3
	Landcover - proximity	8.5
	Landcover - succession	8.7
	Landuse	11.0
	Minimum dynamic area	7.3
	Buffer - Natural vegetation	9.0
	Park boundary	9.0
	Patch connectivity	9.3
	Patch size distribution	9.3
	Vernal pool density	9.0
	Buffer - wetland	11.3
Management	Park infrastructure	9.0
	Pasture management	10.7
	Trail construction & maintenance	9.0
	Wetland restoration success	8.7
Stressor	Acid stress	10.7
	Acidic deposition	10.0
	Air contaminants	9.3
	Beaver engineering	9.0
	Bioaccumulation (Hg, Pb, PCB, Cd, Zn)	9.0
	Contaminant spills	9.0
	Contamination	9.5
	Invasive exotic earthworms	9.3
	Invasive exotic insect pests & diseases	8.7
	Feral animals/free-ranging pets	8.0
	Fertilizer use	9.0
	Fire suppression	9.5
	Fishing (and shellfish)	8.5
	Forest management	11.3
	Heavy metal deposition	10.0
	Herbicide/pesticide use	9.0
	Herbivore composition	7.7
	Hunting	9.0
	Hydrologic alteration	9.5
	Illegal taking	6.7
	Invasive exotic aquatic vegetation	10.3
	Invasive exotic fish	9.5
	Invasive exotic plant species	10.3
	Invasive exotic terrestrial plants	10.7
	Invasive exotics - other	10.3
	Landscape runoff	9.3
	Livestock	9.0
	Metal contaminants	8.5
	Aquatic microorganisms	10.0
	Noise	6.0
	Ozone pollution	9.0

Category	Potential Vital Sign	Average Score (max = 12)
Stressor	Particulates	8.0
	Road impacts	10.0
	Road network	11.0
	Road runoff	9.0
	Roadkill	7.7
	Sea level rise	7.8
	Septic systems	9.0
	Social trail formation	7.7
	Soil erosion	10.0
	Trampling disturbance	8.3
	UVB	8.0
	Visitor use	8.5
	Aquatic volatile organic compounds	8.0
	Water withdrawal	8.8
	White tailed deer herbivory	10.0

Appendix M: Northeast Temperate Network Budget Projections

Introduction

In preparation for the Vital Signs Selection workshop, we prepared the following tables of 3 hypothetical staffing scenarios that could be used to implement the NETN monitoring plan. The primary objective of this exercise was to provide a fiscal framework to aid in the prioritization of Vital Signs *apriori* and avoid re-prioritization of Vital Signs *post-hoc* once the financial limits of implementation are realized. The results of this exercise are not meant to present the only implementation scenarios possible for the Network, nor do they provide a comprehensive set of possibilities, but they do indicate how staffing and expenses can affect a long-term program with no guarantee of increased budgets and should assist in Vital Signs selection.

We developed 3 basic staffing scenarios to implement the NETN monitoring plan and projected the overall costs to the program based on the present level of annual funding (Tables 1-3; Figure 1). To estimate salary and benefits we used the locality pay table, added 30% of the salary for benefits, and included a 4% annual cost of living increase. We projected each position through the standard step increases within each pay grade to estimate the total permanent personnel expenses. We included administrative, travel, and equipment expenses for each year and summed the salary and expenses to estimate total expenses. The balance after accounting for these expenses is the amount the Network could use for projects, agreements, and/or field crew staff to implement the monitoring plan. We calculated the cost of 1 seasonal staff person for 6-months and divided the remaining balance by the field staff salary to determine the number of field crew employees the Network could afford with each staffing scenario. We then determined how many seasonal employees we could distribute (evenly) among the 10 (not including the AT for implementation at this time) Network parks.

Staffing Scenarios

1) Core I&M staff + 3 crew leaders – Scenario 1 would add 3 new positions to the Network that would act primarily as field crew leaders. These positions would be graded at GS09 and distributed throughout the Network to support the I&M program at Acadia, the Boston Area Parks (BOHA, MIMA, SAIR), and the southern parks (MORR, ROVA, WEFA), leaving the core I&M staff (Coordinator and Data manager) to implement the monitoring in SAGA, MABI, and SARA. This scenario provides effective logistical support to implement the monitoring in "sub-networks" of parks by locating crew leaders in parks. These personnel become familiar with the monitoring protocols, train field crews, and by being locally stationed, they could develop partnerships with local conservation organizations to better implement the monitoring and disseminate the information.

This scenario expends 49% of the budget in year1 and 61% in year10 for personnel, leaving 39% of the budget for field crews or projects after other accounting for other expenses (Table 1). Although having staff distributed throughout the Network to service multiple parks is logistically positive, it does add a layer of administrative complexity and relying on GS09 graded positions (likely recent masters level graduates) to implement monitoring, training field crews, QA/QC data, and submit data to the Network may be more responsibility than the grade implies.

2) Core I&M staff + 1 Network Ecologist – Scenario 2 would add 1 Network ecologist (GS12) to the core staff that would assist in all aspects of monitoring program implementation (Table 2). This scenario provides the opportunity for a staff person to be partly dedicated to the analysis, interpretation, and reporting of monitoring results and the integration of these results with other park and non-park programs.

Scenario 2 expends 47% of the budget in year1 and 58% in year10 for personnel, leaving 53% of the budget for field crews and projects after other expenses are accounted (Table 2). Having a Network ecologist whose primary focus was to analyze, interpret, and report the monitoring program data would provide the necessary link between the monitoring program information and managers, planners, and superintendents that will need these data presented in an accurate and timely fashion.

3) Core I&M staff only – Scenario 3 would maintain the Network at the present staffing level (coordinator and data manager) and obviously leaves the largest percentage of the budget for projects or field crew (Table 3 and 4).

This scenario expends 35% of the budget in year1 and 43% in year10 on personnel and other expenses. Creating an efficient monitoring program is necessary for success; however, understaffing can cause problems in maintaining, interpreting, and disseminating the information.

Figure 1. Summary of projected Network remaining funds given three hypothetical staffing scenarios during the first 10 years of the program. The "core staff only" scenario leaves the greatest remaining funds ($361,368) while the "3 crew leader" scenario only leaves $156,525 after 10 yrs. Values indicate the amount of the network budget that remains after accounting for permanent staff, travel, and expenses.

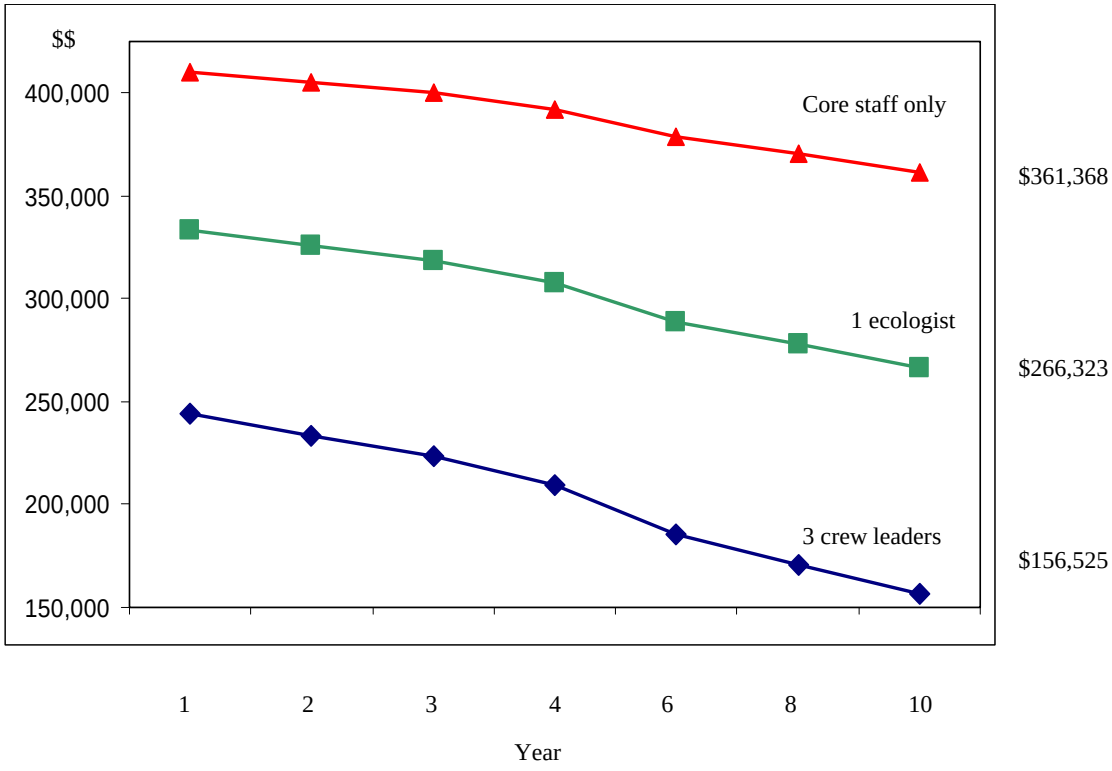


Table 1. Northeast Temperate Network staffing scenario 1. This scenario would have three (3) I&M crew leaders stationed throughout the network to assist in monitoring program implementation. Total network staffing would befive (5) permanent I&M staff, 49%-61% of the total income would be expended on salaries and benefits leaving 39%-25% of the total income for field crew or projects over a 10 yr period, respectively.

	year1	year2	year3	year4	year6	year8	year10
Vital Signs Income	631,200	631,200	631,200	631,200	631,200	631,200	631,200
(excluding water quality funding: $60,000)							
Personnel (Full-time, permanent)							
1 Crew Leader, Acadia (GS9)	53,185	54,957	56,730	58,503	62,077	63,902	65,728
1 Crew Leader, Boston (GS9)	55,909	57,773	59,637	61,501	65,256	67,176	69,095
1 Crew Leader, Hyde Park, NY (GS9)	56,875	58,771	60,667	62,563	66,384	68,338	70,290
1 Network Coordinator, VT (GS12)	77,125	79,697	82,268	84,839	90,020	92,667	95,315
1 Data Manager, VT (GS11)	68,974	71,273	73,571	75,871	80,504	82,870	85,238
Permanent Personnel Expenses Total	312,067	322,471	332,873	343,277	364,240	374,953	385,667
% of total income	49%	51%	53%	54%	58%	59%	61%
Admin./Travel/Equipment Expenses							
Admin.(MABI, ACAD, MIMA, ROVA)	35,000	35,000	35,000	36,750	38,588	40,517	42,543
Travel	30,000	30,000	30,000	31,500	33,075	34,729	36,465
Equipment	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Admin./Travel/Equipment Expenses Total	75,000	75,000	75,000	78,250	81,663	85,246	89,008
% of total income	12%	12%	12%	12%	13%	14%	14%
Total Expenses	387,067	397,471	407,873	421,527	445,902	460,199	474,675
% of total income	61%	63%	65%	67%	71%	73%	75%
Balance after core personnel & expenses	244,133	233,729	223,327	209,673	185,298	171,001	156,525
% of total income	39%	37%	35%	33%	29%	27%	25%
Potential Field Crew for Implementation							
1 Seasonal (GS5) 6-months/year	15,407	15,920	16,434	16,947	17,461	17,975	18,488
Number of Seasonal Employees/year	16	15	14	12	11	10	8
Number of Seasonal Employees/year/park	2	1	1	1	1	1	1

All full-time personnel expenses include 30% benefits and a 4% annual cost of living increase, seasonal staff include 10% benefits.

Table 2. Northeast Temperate Network staffing scenario 2. This scenario would augment the I&M core staff by adding a network ecologist to assist in monitoring program implementation. With 3 permanent I&M staff in the NETN, 35%-44% of the total income would be expended on salaries and benefits leaving 53%-42% of the total income for field crew or projects over a 10 yr period, respectively.

	year1	year2	year3	year4	year6	year8	year10
Vital Signs Income	631,200	631,200	631,200	631,200	631,200	631,200	631,200
(excluding water quality funding: $60,000)							
Personnel (Full-time, permanent)							
1 Ecologist, Acadia (GS12)	77,125	79,697	82,268	84,839	90,020	92,667	95,315
1 Network Coordinator, VT (GS12)	77,125	79,697	82,268	84,839	90,020	92,667	95,315
1 Data Manager, VT (GS11)	68,974	71,273	73,571	75,871	80,504	82,870	85,238
Permanent Personnel Expenses Total	223,224	230,666	238,107	245,550	260,544	268,204	275,869
% of total income	35%	37%	38%	39%	41%	42%	44%
Admin./Travel/Equipment Expenses							
Admin.(MABI, ACAD, MIMA, ROVA)	35,000	35,000	35,000	36,750	38,588	40,517	42,543
Travel	30,000	30,000	30,000	31,500	33,075	34,729	36,465
Equipment	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Admin./Travel/Equipment Expenses Total	75,000	75,000	75,000	78,250	81,663	85,246	89,008
% of total income	12%	12%	12%	12%	13%	14%	14%
Total Expenses	298,224	305,666	313,107	323,800	342,207	353,450	364,877
% of total income	47%	48%	50%	51%	54%	56%	58%
Balance after core personnel & expenses	332,976	325,534	318,093	307,400	288,994	277,750	266,323
% of total income	53%	52%	50%	49%	46%	44%	42%
Potential Field Crew for Implementation							
1 Seasonal (GS5) 6-months/year	15,407	15,920	16,434	16,947	17,461	17,975	18,488
Number of Seasonal Employees/year	22	20	19	18	17	15	14
Number of Seasonal Employees/year/park	2	2	2	2	2	2	1

All full-time personnel expenses include 30% benefits and a 4% annual cost of living increase. Seasonal staff includes 10% benefits.

Table 3. Northeast Temperate Network staffing scenario 3 = I&M core staff implement monitoring program. With 2 permanent I&M staff in the NETN 23%-29% of the total income would be expended on salaries and benefits leaving 65%-57% of the total income for field crew or projects over a 10 yr period, respectively.

	year1	year2	year3	year4	year6	year8	year10
Vital Signs Income	631,200	631,200	631,200	631,200	631,200	631,200	631,200
(excluding water quality funding: $60,000)							
Personnel (Full-time, permanent)							
1 Network Coordinator, VT (GS12)	77,125	79,697	82,268	84,839	90,020	92,667	95,315
1 Data Manager, VT (GS11)	68,974	71,273	73,571	75,871	80,504	82,870	85,238
Permanent Personnel Expenses Total	146,099	150,970	155,839	160,710	170,524	175,537	180,554
% of total income	23%	24%	25%	25%	27%	28%	29%
Admin./Travel/Equipment Expenses							
Admin.(MABI, ACAD, MIMA, ROVA)	35,000	35,000	35,000	36,750	38,588	40,517	42,543
Travel	30,000	30,000	30,000	31,500	33,075	34,729	36,465
Equipment	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Admin./Travel/Equipment Expenses Total	75,000	75,000	75,000	78,250	81,663	85,246	89,008
% of total income	12%	12%	12%	12%	13%	14%	14%
Total Expenses	221,099	225,970	230,839	238,960	252,186	260,783	269,562
% of total income	35%	36%	37%	38%	40%	41%	43%
Balance after core personnel & expenses	410,101	405,230	400,361	392,240	379,014	370,417	361,638
% of total income	65%	64%	63%	62%	60%	59%	57%
Potential Field Crew for Implementation							
1 Seasonal (GS5) 6-months/year	15,407	15,920	16,434	16,947	17,461	17,975	18,488
Number of Seasonal Employees/year	27	25	24	23	22	21	20
Number of Seasonal Employees/year/park	3	3	2	2	2	2	2

All full-time personnel expenses include 30% benefits and a 4% annual cost of living increase. Seasonal staff includes 10% benefits.

Table 4. Summary of Northeast Temperate Network staffing scenarios showing total expenses (personnel, admin, travel, equipment) and balance remaining after expenses for each scenario (Tables 1-3).

	year1	year2	year3	year4	year6	year8	year10
Vital Signs Income	631,200	631,200	631,200	631,200	631,200	631,200	631,200
(excluding water quality funding: $60,000)							
Scenario 1: I&M core staff & 3 crew leaders							
Total Expenses	387,067	397,471	407,873	421,527	445,902	460,199	474,675
% of total income	61%	63%	65%	67%	71%	73%	75%
Balance after core personnel & expenses	244,133	233,729	223,327	209,673	185,298	171,001	156,525
% of total income	39%	37%	35%	33%	29%	27%	25%
Scenario 2: I&M core staff plus 1 ecologist							
Total Expenses	298,224	305,666	313,107	323,800	342,207	353,450	364,877
% of total income	47%	48%	50%	51%	54%	56%	58%
Balance after core personnel & expenses	332,976	325,534	318,093	307,400	288,994	277,750	266,323
% of total income	53%	52%	50%	49%	46%	44%	42%
Scenario 3: I&M core staff only							
Total Expenses	221,099	225,970	230,839	238,960	252,186	260,783	269,562
% of total income	35%	36%	37%	38%	40%	41%	43%
Balance after core personnel & expenses	410,101	405,230	400,361	392,240	379,014	370,417	361,638
% of total income	65%	64%	63%	62%	60%	59%	57%

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Introduction

The Northeast Temperate Network (NETN) of the National Park Service Inventory and Monitoring Program hosted a 2 day workshop (19-20 May 2004) where subject matter experts convened to identify "high" priority Vital Signs for the NETN. Prior to the meeting, the core planning team developed workshop materials in order to set the stage for identifying and prioritizing NETN Vital Signs. In addition, the core planning team established four workgroups representing the dominant ecological communities within network parks:

- Aquatic resources (lakes, ponds, rivers, streams)
- Freshwater wetlands (Forested wetlands, open/shrub wetlands, peatlands, vernal pools)
- Intertidal (cobble beaches, rocky intertidal, soft-sediments)
- Terrestrial (forests, open uplands, plantations, old-fields)

Each workgroup was asked to review a pre-ranked list of Vital Signs to first determine if the list was complete. Next, each workgroup was asked to review the Vital Sign list and assign "high," "medium," or "low" levels of priority when the vital sign was considered with a regional or network level perspective, and to briefly justify why the network should consider the Vital Sign in the early stages of program development. High priority Vital Signs were defined by the Technical Steering Committee as those the NETN should consider as a starting point for implementation. Medium and low ranked Vital Signs, though excluded from the initial list of vital signs, will not be discarded from the list of potential Vital Signs because they could be added over time as the program matures, new concerns warrant a reevaluation of a vital sign's priority designation, and/or the network develops working partnerships with other agencies and ongoing monitoring programs. During this step in the process, workgroup members could also rename Vital Signs and/or change the category. After identifying the high priority vital signs, we asked the workgroups to identify mandatory and optional measures for each high priority Vital Sign. Finally, the workgroups re-convened for a brief overview of the high priority Vital Signs to identify commonalities among workgroups and workgroup specific Vital Signs.

The following content summarizes the results of each workgroup's efforts to identify a prioritized vital sign list and list of potential measures. The workgroup facilitators captured the basic discussion information using a database at the workshop and summarized these discussions in the text provided below. Each workgroup has a discrete section that presents any changes made to the initial list of Vital Signs, identifies the high priority Vital Signs, and defines the mandatory and optional measures for each high priority Vital Sign. The final section of this document presents all the high priority Vital Signs independent of workgroup and summarizes the results of the workshop and any outstanding issues.

Aquatic Breakout Session

Overview of Vital Signs

The objective of the aquatic workgroup was to review and rank the preliminary list of vital signs. In the initial review, workgroup participants could add, remove, rename or

regroup vital signs. The second part of the review process was to rank the new list. The types of changes fell into four categories: renaming, lumping, splitting, and deleting (Table 1).

The vital sign "Core water chemistry" was changed to "Water chemistry" and now includes total dissolved ions, and total organic carbon as mandatory measures in addition to the previous mandatory measures of pH, temperature, dissolved oxygen, and specific conductance. The high priority remained. The vital sign "Water quality-lake trophic status" was changed to the more general "Water quality-trophic status" in order to include streams. The water quality vital signs of "algal biomass," "water clarity," and "nutrient loading" or "nutrients" were incorporated into trophic status. Although lake trophic status was originally ranked as medium, the addition of the other components to this new vital sign caused the workgroup to upgrade the rank to high.

One of the more significant changes the workgroup made was a splitting of "species composition-flora" and "species composition-fauna" into the more specific taxonomic groups: community compositions of fish, macroinvertebrates, and zooplankton for fauna; and phytoplankton, periphyton, and macrophytes for flora. Each community composition vital sign was ranked individually for lakes versus streams, and the highest ranking for each vital sign was chosen for the appropriate target resource. The workgroup ranked fish and macroinvertebrates in streams and zooplankton in lakes as high, while phytoplankton and macrophytes in lakes and periphyton in streams were ranked medium.

"Focal taxa fish," "species of concern," and "mandated species" all remained low priorities. Although the importance of these potential vital signs was recognized, the group felt that by definition, they would not be good indicators of ecological integrity and would perhaps more appropriately be monitored by park specific programs. "Water quality-microorganisms", was recognized as important for human health, but was a low priority in terms of its usefulness in assessing ecological integrity.

The vital signs "basic climate" and "acidic deposition and stress" were renamed "climate" and "atmospheric deposition," respectively. The importance of these vital signs was not questioned, but the ability of this program to improve greatly on the information that is already being collected by other networks was questioned. They remained high priority vital signs with the recognition that the inventory and monitoring program may not be collecting data, but rather compiling this information from other sources.

"Natural disturbance regime," "trophic dynamics," "phenology," and "nutrient cycling" were all considered beyond the scope of the inventory and monitoring program, although some of the measures and components of "trophic dynamics" and "nutrient cycling" were incorporated into "trophic status." There was a recognition that these vital signs may be important for understanding and interpreting data in the future, but for the present would be ranked as low priority for assessment.

The group felt strongly that a distinction should be made between inventory vital signs and monitoring vital signs. Inventory vital sign information would be collected or compiled at the start of the monitoring program, could potentially guide the design of the monitoring program, and would be critical for interpreting monitoring data by providing context. Inventory vital signs included "lake morphometry," "channel morphology," "spring/seep distribution," "landcover/landuse" and "contamination."

"Landcover/landuse" included the original vital signs of "landcover," "landuse," "landscape buffer" and "park boundary," while "contamination" included "heavy metal contamination." The frequency of collection/compilation of these inventory variables could range from biannually to once every decade, and would be guided by changes in the watershed including operational changes at a park.

"Water quantity" remained a high priority. The workgroup recognized that lake levels would perhaps be easy and relatively inexpensive, while continuous stream gauging might be prohibitively expensive.

The group did not reach consensus regarding "substrate composition." Some workgroup members felt it would be more appropriately named "benthic habitat." This received a rank of medium recognizing that in some parks it may be possible and (or) critical while in other parks it may be not as important and difficult to characterize across the entire park.

The vital sign called "park management" includes "land management," "park infrastructure," and "trail network." This vital sign was ranked low because workgroup participants felt that these features were probably already well monitored by the parks and (or) documented information that was available or could be accessed as necessary. "Visitor use" remained its own vital sign, ranked medium, with the primary concern relating to fish stocking/harvesting. This has a big impact at some parks such as Acadia, and is not currently being monitored. At other parks it is not a significant issue.

There was a fair amount of discussion regarding the category of stressors and how they should fit into a monitoring program of ecological integrity. The conclusions of the workgroup were that "invasive exotic species" and "septic/waste water discharge" were ranked high, "roads" was ranked medium, and the rest were ranked low. The group felt that "fertilizer use" and "herbicide/pesticide" use would be captured in "landcover/landuse"; "soil erosion" was not a serious network wide issue, but could become important on a case by case basis; "hydrologic alterations" (now including "beaver engineering") would be captured by "water quantity"; "UVB" was beyond the scope of this program; and "shoreline erosion/sea level rise" was more of an intertidal issue than one of freshwater aquatics.

High priority vital signs

The vital signs presented below are all high priority vital signs as assessed by the aquatic workgroup. These vital signs address the ecological integrity of the parks and were selected to address the physical, chemical, and biological aspects of the ecosystem. In most cases the workgroup recommended at least one mandatory measure, and in several cases they recommended multiple mandatory measures and additional optional measures. The workgroup also discussed and concluded that vital signs may be high priority for specific targets (lakes, streams, or springs/seeps) or may be high priority for all targets. Groundwater is only considered as a target where specifically addressed.

1. Climate

Climate data provide background explanation for changes or variation in other vital signs. Measures of climate such as precipitation and temperature are critical to understanding the ecological condition of aquatic resources and biota (Hynes, 1975; Poff, 1997).

Climate data are available so the parks probably will not have to collect them, but rather compile these data from other sources such as the National Oceanic and Atmospheric Administration (monthly reports) or the National Climatic Data Center (Sorenson and others, 1997). The short term response variability for climate is clear; however the response variability of changing climate over long time scales is still under investigation.

Mandatory measures include air temperature and precipitation. Optional measures to compile include windspeed and direction, precipitation by type, snow depth, snow water equivalent, relevant humidity, and solar radiation. Project managers would need to account for spatial variability to extrapolate regional information to parks.

2. Inventory - Stream Geomorphology

Baseline stream geomorphology will be important to collect and (or) compile from other sources because it is a major physical component of lotic ecosystems. This information falls into the category of inventory because it will involve infrequent/periodic measurements rather than annual sampling. Channel geomorphologic units change due to both natural and anthropogenic factors (Leopold, 1994). Bankfull discharge, which has a recurrence interval from between a year and a half to two years, has also been called the "channel forming discharge" and/or effective flow (Andrews, 1980; Leopold, 1994). Over-bank flow, or floods, occur at less frequent intervals and can affect riparian zones and land use as well as have significant effects on erosion, bed load transport, sediment accretion and deposition in the channel, and modification of geomorphic structure of the channel (Leopold and others, 1964; Hill and others, 1991). Anthropogenic developments in the basin can alter the recharge and runoff to the stream and affect runoff by increasing the amount of peak runoff and reducing the duration of runoff.

Mandatory measures include stream order, drainage area and gradient. In most cases, this will involve compiling available variables in a database. Optional measures could include run/riffle/pool geometry, bank full cross sectional geometry, stream sinuosity from aerial photos or topographic maps, and a substrate map of the stream bottom (areal extent of gravel, sand, silt, boulders, rubble/coble). Channel geomorphologic unit delineation and measurement can be accomplished with existing protocols from the USGS National Water Quality Assessment program or EPA's Environmental Monitoring and Assessment Program (Fitzpatrick and others, 1998; Lozorchak and others, 1998). Representative reaches (20 times the mean channel width from NAWQA or 40 times the mean channel width from EMAP) can be assessed by two people in two to three hours.

Optional more frequent measurements would include surveys of channel geomorphologic units to quantify habitat types for aquatic biota. Each geomorphologic channel unit provides unique combinations of depth, velocity, and substrate composition. Substrate composition was its own vital sign and is discussed below.

3. Inventory - Lake Morphometry

Morphometric mapping of lakes provides baseline data for future reference, and may be available from existing sources. Mapping which includes substrate types and extent of macrophyte growth could be used to interpret macrophyte growth patterns which respond to changes in light penetration, substrates, nutrients, and water depth (Goldstein, 2000).

Mandatory measures include surface area, maximum and mean depth, drainage area, lake type and origin, bathemetry and elevation. An optional measure would be flushing rate. Lake morphometry can be easily mapped with depth finders (fish finders) and GPS. This baseline information will be compiled initially, and could guide monitoring site selection.

4. Water Quantity

Information about water quantity is necessary for the interpretation of other vital signs such as eutrophication, sediment processes, or contaminants because stream discharge is used in calculating annual loads and annual watershed yields. Furthermore, water quantity determines the physical extent and volume of aquatic habitat at the parks. Numerous factors affect water quantity including, precipitation, evapo-transpiration, water withdrawals, and ground water recharge.

All measures are optional including streamflow, lake water levels, ground water levels, spring seep volume, and groundwater inputs, but measures such as lake water levels are considerably more easily obtained than streamflow, and thus are highly recommended. Existing stream gages with long historical records may be used to extend and interpret incidental measurements and (or) stage gages within parks if a relationship between the two sites is established. Although only two NETN parks have streamflow gages within or adjacent to park boundaries, the closest long-term streamflow gages have been identified in all cases.

5. Inventory - Springs and Seeps Distribution

Springs and seeps create unique aquatic resources. They are an integral component of groundwater fed streams and can be critical for understanding the thermal regime and biodiversity of aquatic habitats because they indicate the quantity and quality of water in surficial aquifers as well as the interaction of surface and ground water. Furthermore, they are a good indicator of ecological integrity because they can indicate which contaminants that have been applied in the watershed are reaching surficial groundwater and subsequently other aquatic resources (e.g., Cowdery, 1997).

Baseline inventory data should include the location and possibly the seasonality of springs and seeps in the park. Frequent monitoring water quality and quantity of springs and seeps may be beyond the scope of this program, but springs and seeps should be considered as a target for water quantity and water quality on a site specific basis. The relative importance of this information will depend on the size of the park/drainage basin. At smaller parks, the locations may be known; at the larger parks, aerial photography with thermal mapping can be used to locate springs and seeps after/during snowmelt. The size of the springs and seeps will change with climatic conditions and groundwater withdrawals. Water quality will depend on surrounding geology and land use in the watershed.

6. Water Chemistry

Water chemistry directly addresses one of the inventory and monitoring objectives: to detect change in the status of physical, chemical, or biological attributes or vital signs of the ecosystem. It is an essential indicator to any long-term aquatic monitoring program (Gilliom and others, 1995). It is widely applicable, and critical for interpreting the biotic condition, and ecological processes of a resource. Water chemistry affects the

bioavailability of contaminants, and the metabolism of aquatic species. For example ionic conditions affect osmo-regulation (Hoar and Randall 1969) and contaminant uptake (Sinley and others, 1974; Luoma 1989; Spry and Weiner 1991), dissolved oxygen and temperature affect metabolic rate (Hoar and Randall 1969). Successful reproduction requires the appropriate chemical conditions for fertilization and development of eggs and larvae (Holtze and Hutchinson 1989).

Water quality parameters are sufficiently well known that abnormal conditions and trends can be recognized or determined statistically. Mandatory measures include water temperature, specific conductance, pH, dissolved oxygen, % dissolved oxygen saturation, color and turbidity. Targets include lakes, streams, springs & seeps unless specified. Groundwater chemistry could be considered where monitoring wells are in place.

Optional measures include anions, cations, alkalinity/ANC, aluminum, iron, and dissolved organic carbon. Protocols for collection of water samples and standard methods of chemical analysis are widely available (e.g., Shelton 1994). Most of the mandatory water chemistry measures can be obtained in the field or with relatively inexpensive laboratory analyses. Optional measures will vary depending on the needs of individual parks.

7. Fish Community Composition - Streams

Fish species richness and composition is a highly relevant and applicable vital sign because fish communities integrate their physical, chemical, and biological environment through time (Tonn and others, 1983; Gurtz, 1993). The integration is manifest in the species richness and composition. Species richness and composition in small streams can be obtained easily with the proper equipment (electro-fishing or small seine) (Meador and others, 1993; Moulton and others, 2002). An alternative, non-evasive method is direct observation and counts by divers with mask and snorkel (Goldstein, 1978). On average, a site can be sampled in about two hours. The size of the stream dictates the number of individuals needed, which will range from two to five (Moulton and others, 2002). Although a representative sample of a fish community can be obtained from small to moderate sized streams, such a sample is not readily obtainable from larger rivers (Moulton and others 2002). Fish species composition can be evaluated with multimetric indices of biological integrity such as an IBI or by examination of species traits (Karr and others, 1986) (Goldstein and Meador 2004). These indices evaluate the quality of the resource by rating the ecological structure and functional composition of the community. While normally a reference site is used for comparison, for the monitoring program, the initial sample will constitute the baseline condition for comparison. Certain metrics can be diagnostic of specific environmental changes (Karr and others, 1986).

Mandatory measures include relative abundance and species richness in a representative sample, i.e., the numbers and identity of all species collected. Fish community composition in streams was ranked as high priority while fish community composition in lakes was medium priority.

8. Zooplankton Community Composition - Lakes

Zooplankton community composition and abundance is indicative of the trophic status of the lakes, reflects primary and secondary production (Porter, 1977), and also implies year

class strength of most lotic fish species because early life history stages feed primarily on zooplankton. Therefore, community composition and abundance of the zooplankton not only reflect the abundance and composition of the phytoplankton, but also provides a basis for predicting certain aspects of the fish community and fishery. If the timing of zooplankton blooms of the larger sized taxa is concurrent with the hatching of salmonid and centrarchid eggs, then zooplankton provide an abundant food source for these early fish life history stages (Goldstein and Simon, 1998) which implies greater survival, year class strength, and recruitment to the fishery. Like other biotic communities, zooplankton respond to changes in water chemistry, nutrients, and predation by fish and other invertebrates. Changes in zooplankton taxa composition and abundance in lakes has not been applied as an environmental indicator to the same degree as fish or invertebrates in streams.

The mandatory measures of zooplankton species richness and abundance are collected by either horizontal or vertical tows with a plankton net. Abundance (density) is based on the volume of water filtered. Identification and subsampling require special training. Zooplankton collection in lakes was a high priority while zooplankton collection in streams was a low priority.

9. Trophic Status

Eutrophication causes degradation of park aquatic resources. Nutrient inputs cause nuisance algal blooms, unwanted macrophyte growth, odors, and even fish kills (Clady, 1977; Porcella, 1978; Porter and others, 1993). As land use changes from forest to agriculture or urban, the potential sources of nutrients increase. Trophic status is indicative of nutrient stress (Wetzel 1983). It is widely understood by resource managers that when status levels change management actions such as application of best management practices (BMPs) may be necessary to reduce inputs. Sufficient information exists in the literature to quantify the trophic status of park lakes based on the measures listed below (Carlson, 1977).

Mandatory measures include algal biomass, measures of water clarity such as secchi disk, and total and dissolved phosphorus. Optional measures include macrophyte distribution, diel oxygen curves, periphyton abundance, and dissolved oxygen profiles. Many of these measures are seasonal. Standard protocols (e.g., Sorenson and others, 1999) can be rapid, cost effective and easily tracked over time. Secchi disc readings, plankton tows for algal biomass (density) or chlorophyll a, and water samples for nitrogen and phosphorus can all be accomplished in a short period of time.

10. Macroinvertebrate Community Composition - Streams

Invertebrate community taxa richness and composition is a highly relevant vital sign in streams because macroinvertebrates integrate their physical, chemical, and biological environment like fish, however, they do so in a shorter temporal period than fish (most invertebrate life cycles are accomplished in a single year vs. multiple years for fish). Therefore invertebrates may provide a "first response" vital sign. The integration is manifest in the taxa richness and composition. Macroinvertebrate community composition has been used to evaluate water quality and aquatic resources (Hilsenhof, 1987; Lenat, 1993). Collection of invertebrate samples is relatively easy. Numerous protocols exist (Lazorchak and others, 1998; Moulton and others, 2002). For direct

collections from natural stream substrates, two people can collect a sample in about an hour using standard equipment, nets with a 595/600 micron mesh (EPA uses this mesh size for the Environmental Monitoring and Assessment Program (Lazorchak and others, 1998). For indirect collections of artificial substrates or natural substrates placed in the stream for colonization, the collection time is less, but an initial site visit is necessary to insert the sampler. The analysis, counting and identification, is not a trivial matter and can take up to a day per sample. The identification of invertebrate taxa requires specialized training or a specialty laboratory (Moulton and others, 2000). Several invertebrate multimetric environmental indices are available for invertebrate data. The USGS has an Invertebrate Data Analysis System which calculates over 130 metrics available for use (Cuffney, 2003).

Mandatory measures include invertebrate taxa richness (measured to the lowest practicable taxa) and taxa abundance from a randomly selected subsample of 100 or 300 individuals from direct collections, but fewer individuals from indirect collections. Taxa abundance is the proportion of each taxa in the subsample. Macroinvertebrate collection in streams was a high priority while macroinvertebrate collection in lakes was a low priority.

11. Inventory Land Use/Land Cover

This vital sign includes "landcover," "landscape buffer," "landuse," and "park boundary." At a watershed level, land use and land cover affect the quality of aquatic environments (Stauffer and others, 2000; Meador and Goldstein, 2003). An initial inventory of land use and land cover will provide context for the observed ecological conditions. If changes occur in this condition, they can be interpreted in the context of land use or land cover at the watershed scale. Aquatic ecosystems respond to changes in landuse and this response is has been documented in urban, agricultural, and forested environmental settings (Meador and Goldstein, 2003).

This is a high priority vital sign, but the measures can be collected or compiled as part of an initial inventory and updated only as changes in the watershed become apparent. Most measures are optional depending on the park and need to reflect the varying scales and specific requirements of the parks. The only mandatory measure is a landcover/ecological system map. For most parks, these data already exist, are straight forward to interpret, and will help in site selection/prioritization.

Optional measures include a patch size distribution, patch connectivity and fragmentation, percent impervious surface in buffer or watershed, percent canopy shading for streams, buffer vegetation and buffer width. The park boundary already exists for all parks, and can be updated as necessary.

12. Atmospheric Deposition

"Atmospheric deposition" includes acid rain, inorganic toxics, mercury, etc. This vital sign was modified to include all atmospheric deposition (as opposed to just acidic deposition), and now includes only the deposition, rather than the response/stress to the aquatic resource. Estimates of atmospheric deposition are critical for understanding water chemistry and stress (Likens and Bormann, 1974). Swain and others (1992) estimated that 90% of the mercury entering remote lakes in Voyageurs National Park

(Minnesota) was derived from atmospheric deposition. However, these measures are expensive and may be covered sufficiently by other programs. Deposition at coarse resolutions is already measured as part of NADP and CASTNET networks. Information about deposition should drive site selection for measurements of water chemistry.

Optional measures include wet deposition, dry deposition, inorganic toxics and mercury. While mercury deposition is an issue throughout the Northeast, other types of atmospheric deposition may be mostly an issue in Acadia and the Appalachian Trail.

13. Inventory – Contamination

All members of the workgroup agreed that contamination (including heavy metal contamination) is ecologically relevant. The accumulation of trace elements and organic compounds in aquatic organisms can cause physiological problems and even death of aquatic organisms. Accumulated contaminants move upward through the food chain.

Initially there is a need for a better assessment of existing data to determine the sources and pathways of contamination. This vital sign may need to be added as a continuous monitoring variable at some parks after the initial inventory and assessment is complete. Some contaminants such as metals may be occurring at high levels "naturally." Responses may be difficult to interpret without long term data.

All measures are optional and site specific, and include measures of air toxic concentrations, MTBE/chloroforms/trichloroethylene in water, contaminant spills, toxic boat paint, use and concentrations in water, and bioaccumulation in indicator species. Initially it is recommended that an inventory of contaminant sources and historical sites of contamination be compiled in a database if this is not already done. This vital sign would, however, require very expensive laboratory analyses, and may be beyond the scope of this program financially. Composite sampling may help to keep costs down (Correll 2001).

14. Invasive Exotic Species

The presence and extent of invasive exotic species is a critical management concern at all parks in the network. Parks would benefit from quick identification and removal of new invasive species, and monitoring and removal of already established invasive exotic species. Catastrophic consequences to native species can result if this vital sign is not addressed with loss of biodiversity and replacement of native flora and fauna.

Routine surveys for the presence/absence of particular invasive species are mandatory at all parks. Lists of non-native species with the potential to invade individual parks already exist in most states**.** These lists will identify the types of habitats to examine for invasion. The relative abundance of established invasive species is optional.

15. Septic Systems/Wastewater Discharge

The workgroup felt it was important to collect the number of septic systems/wastewater discharges explicitly in order to understand trends in water quality and related measures of trophic status. Parks may not be able to affect change in nutrient inputs from wastewater sourcesoutside the park, but this information still helps to interpret trends in water quality.

Tracking the number of septic systems in the park is mandatory and is information that is most likely readily available. Tracking nearby septic permits and the location, quantity and quality of wastewater discharges are optional measures.

Other potential Vital Signs or issues

Although the workgroup is not recommending the following vital signs for immediate inclusion in a monitoring program, information regarding the vital signs is included below because either a minority of workgroup members felt that they should be high priority vital signs, or there was a general consensus that these medium vital signs should have their priority reassessed as potential vital signs further into the program as additional funding and (or) partnering with other agencies becomes available. Potential measures are included in some cases.

Phytoplankton Community Composition

Species richness and species abundance are optional measures. This vital sign was a medium priority for lakes and a low priority for streams. Phytoplankton respond to the physical and chemical conditions present at the time of collection; they reflect the water quality of the water mass they occupy (Clesceri and others, 1989; Porter and others, 1993).

Periphyton Community Composition

Species richness and species abundance are optional measures. Periphyton abundance (either cell volume or ash free dry mass) and chlorophyll a in streams can be a useful vital sign for nutrient enrichment, while species composition and abundance can be used in an Index of Biotic Integrity (Hill and others, 2000). This vital sign was a medium priority for streams and a low priority for lakes.

Macrophyte Community Composition

Species richness and species abundance are optional measures. Inherent in this vital sign are invasive aquatic plant species and a measure of lake eutrophication. Therefore, this sign was considered redundant. This vital sign was a medium priority for lakes and a low priority for streams.

Substrate Composition

This vital sign is an important indicator of aquatic habitat (Stauffer and Goldstein, 1997; Goldstein and others 2002), but may be reflected in invertebrate taxa composition and abundance. Sedimentation can be a major issue, so a rapid measure of embeddedness could be used. Questions remain as to the frequency of monitoring because changes in substrate composition are related to the frequency of high flow events (Andrews, 1980; Leopold, 1994). Detailed particle size analysis is expensive, but visual evaluation techniques and indices could be applied.

Visitor Use

Stocking/Fishing issues are significant management issues in some parks, but not in others. The workgroup recommended that this be a park specific vital sign to be monitored as needed. Parks generally do not know amounts of fish being harvested and (or) stocked where these activities are occurring.

Optional measures that the workgroup identified as higher priority include the number of fishing/shellfishing permits, and information regarding stocking (species stocked and location). Lower priority measures include the number of visitors by location and activity and the number of boats.

Roads

Roads were identified as a top management concern in most NETN parks. This vital sign was downgraded to medium because the aquatic workgroup felt that information surrounding roads as stressors could be picked up by other vital signs such as water chemistry, landcover/landuse and contamination. Site selection/sampling design should in some cases be driven by road locations. Specific road runoff studies are complex/expensive and may be beyond the scope of this monitoring program.

Optional measures include road network information, types of roads, measurements of quantity and quality of road runoff, amounts and types of de-icing chemicals applied, and the presence/quality of non-point source pollution control measures in place.

Conclusions

The workgroup was successful at meeting the objectives of reviewing and ranking the list of potential vital signs and providing initial justifications and measures for all of the vital signs ranked high and for most of the vital signs ranked medium. The goal of including vital signs for each of the three major components of ecosystems (physical, chemical, and biological) was accomplished and the list of high priority vital signs is well balanced among the three components. Many potential vital signs were consolidated into other vital signs during the process, but in retrospect it was useful to have all of these potential vital signs considered independently. The workgroup found it easier to consider individual vital signs and then group them rather than to separate vital signs with multiple components.

Table 1. Summary of Aquatic Workgroup vital signs, rankings, and workgroup justification

Category	***Original Vital Sign***	***Workgroup Vital Sign***	***Justification***	***Initial Rank***	***Workgroup Rank***
Climate	Basic climate	Climate	Measures such as temperature & precipitation critical to understanding ecological condition of aquatic resources. Provides background explanation for changes or variations in other vital signs. Available from other agencies- we can compile & regionalize.	M	H
Disturbance	Natural disturbance regime	Natural disturbance regime	High ecological relevance. Low management relevance.	L	L

Appendix N: NETN Vital Signs Selection Workshop Summary

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
Hydrology/ Geomorphology	Morphology - channel	Inventory- Stream morphology	Necessary to compile/collect this information in order to better design monitoring program. Could be monitored on a periodic/infrequent basis.	M	H
	Morphometry - lake	Inventory-Lake morpho-metry	Necessary to compile/collect this information in order to better design monitoring program.	M	H
	Spring/seep	Inventory-Spring/seep	Important to map distribution as inventory item. Include as target in other vital signs such as water quantity & quality	L	H
	Substrate composition	Substrate composition	Used on an optional/site specific basis at some parks. Too difficult to apply park-wide at all parks. May be reasonable at smaller parks.	M	M
	Water quantity	Water quantity	Important information, but optional because of cost/feasibility. Lake levels may be feasible, while streamflow could be prohibitively expensive.	H	H
Abiotic condition	Core water chemistry, Water quality - total dissolved ions, Water quality - total organic carbon	Water chemistry	Essential indicator for any long-term aquatic monitoring program. Critical for interpreting biotic condition & ecological processes. Easily collected-readily available protocols	M	H
	Focal taxa - Fish	Focal taxa-fish	By definition, not an indicator of ecological condition. May be more appropriately covered by other programs.	L	L
	Species composition - fauna	Fish community composition	Fish integrate physical, chemical & biological environment over long term-esp. in streams	H	H

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
	Species composition - fauna	Zooplankton community	Indicative of trophic status of lakes- respond to changes in water chemistry, nutrients, and predation by fish and other invertebrates. Hasn't been applied as widely as fish or macroinverts in streams.		H
	Species composition - flora	Phyto-plankton community	Medium priority in lakes, but not as important as other indicators		M
	Species composition - flora	Macrophyte community	Medium priority in lakes, but not as important as other indicators		M
	Species composition - flora	Periphyton community	Medium priority in streams, but not as important as other indicators		M
	Species of concern	Species of concern	Not necessarily a good indicator of ecological condition.	L	L
	Water quality - algal biomass, Water quality – clarity, Water quality - Lake trophic status, Water quality - nutrient loading	Water quality - trophic status	Indicative of stress- widely understood by land managers and often linked to management actions. Standard protocols can be rapid, cost effective & easily tracked.	H	H
	Water quality-macro-invertebrates	Macro-invertebrate community comp.	Macroinverts integrate physical, chemical & biological environment over short term- esp. in streams. Numerous protocols available.	M	H
	Water quality-micro-organisms	Water quality – micro-organisms	More a public health concern than indicator of ecological condition.	H	L
Ecological process	Nutrient cycling	Nutrient cycling	Low management relevance inititally. Could be useful to interpret other monitoring variables later in program	M	L

Appendix N: NETN Vital Signs Selection Workshop Summary

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
	Phenology	Phenology	Low management relevance inititally. Could be useful to interpret other monitoring variables later in program	M	L
	Trophic dynamics	Trophic dynamics	Low management relevance inititally. Could be useful to interpret other monitoring variables later in program	M	L
Focal park resource	Mandated Species	Mandated Species	By definition, not an indicator of ecological condition. May be more appropriately covered by other programs.	M	L
Landscape context	Landcover, Landscape buffer, Landuse, Park boundary	Inventory-Landcover/ Landuse	Important as an inventory variable- may need to update on a periodic basis as needed.	H	H
Management	Land management, Park infrastructure, Trail network	Park management	Minimal ecological relevance if already being tracked/evaluated by park staff.	M	L
	Visitor use	Visitor use	Fish stocking/fish harvesting the primary concern- only at some parks.	M	M
Stressor	Acidic deposition & stress	Atmospheric deposition	High ecological relevance. Best strategy may be to collect this information from other sources because of high cost/complexity	H	H
	Beaver engineering	Hydrologic alteration	Will be tracked with water quantity.	H	L
	Contamin-ation, Heavy metal contamination	Inventory-Contamin-ation	Important to map sources of contamination and compile this info in a database before the feasibility/necessity of a monitoring program can be assessed. Important at some parks, but expensive.	M	H
	Fertilizer use	Fertilizer use	Will be covered by landcover/landuse	M	L
	Herbicide/pesticide use	Herbicide/pesticide use	Will be covered by landcover/landuse	M	L

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
	Invasive exotic species	Invasive exotic species	Important management concern at all parks. Presence/absence surveys & early intervention critical for health/viability of native species.	H	H
	Roads	Roads	Top management concern, but could be picked up by other vital signs such as landuse & water chemistry. May guide site selection.	H	M
	Septic systems/Wastewater Discharge	Septic systems/ Wastewater Discharge	Important for understanding trends in water quality. Trophic status may give an indication of the extent of this problem, but worth collecting number of septic systems/discharges explicitly.	M	H
	Shoreline erosion/sea level rise	Shoreline erosion/sea level rise	Not a big concern for freshwater aquatics	H	L
	Soil erosion	Soil erosion	Site specific issue- not a widespread concern at most parks	H	L
	UVB	UVB	Low management relevance.	M	L

Table 2. Mandatory and optional measures for high priority Vital Signs recommended by the aquatic workgroup

Category	*Workgroup Vital Sign*	*Mandatory Measures*	*Optional Measures*
Climate	Climate	Air Temperature, Precipitation by type,	Relative humidity, Total solar radiation, Wind speed, Wind direction, Snow water equivalent, snow depth
Hydrology/ Geomorphology	Water Quantity		groundwater inputs, groundwater levels, lake water levels, sping/seep volume, stream flow
Abiotic condition	Inventory- Stream morphology	gradient, drainage area, stream order	run/riffle/pool survey, stream sinuousity, bankful cross sectional geometry

Category	*Workgroup Vital Sign*	*Mandatory Measures*	*Optional Measures*
	Inventory-Lake morphometry	surface area, drainage area, elevation, lake type/origin, maximum and mean depth, bathemetry	flushing rate
	Inventory-Spring/seep	distribution	seasonality
	Water chemistry	Specific conductance, % DO saturation, Temperature, Ph, color, turbidity	iron, cations, anions, alkalinity/ANC, aluminum, Dissolved organic carbon
Biotic condition	Fish community composition	Species abundance, Species Richness	
	Zooplankton community	Species abundance, Species Richness	
	Water quality - trophic status	algal biomass, measures of water clarity such as secchi disk, and total and dissolved phosphorus	macrophyte distribution, diel oxygen curves, periphyton abundance, and dissolved oxygen profiles
	Macroinvertebrate community comp.	Species abundance, Species Richness	
Landscape context	Inventory-Landcover/ Landuse	Landcover/ecological system map	buffer width, buffer vegetation, % impervious surface in buffer watershed, % canopy shading for streams, patch connectivity, patch fragmentation, patch size distribution
	Atmospheric deposition		Inorganic Toxics, dry deposition, mercury, wet deposition
Stressor	Inventory-Contamination		toxic boat paint use & concentrations in water, sediment contamination, MTBE/chloroforms/ trichloroethylene in water, contaminant spills, Air toxic concentrations, bioaccumulation in indicator species
	Invasive exotic species	presence/absence	abundance
	Septic systems/ Wastewater Discharge	Track number of septic systems in the park	Track nearby septic permits and the location, quantity and quality of wastewater discharges

Terrestrial Breakout Session

The terrestrial workgroup began with a short orientation to NETN parks and issues. The group then delved into the task at hand and 1) reviewed the list of 52 proposed terrestrial Vital Signs (Table 3) for comprehensiveness, 2) assigned each proposed Vital Sign a priority rank in accordance with the NETN rating criteria, and 3) discussed measures

associated with the high priority Vital Signs, as well as some medium priority Vital Signs that could easily be bundled together for sampling with the high priority Vital Signs.

Overview of Vital Signs

During the initial review, the group suggested changing the name or category of several Vital Signs, and also suggested lumping several into broader Vital Signs. These changes are itemized in Table 3, and the most significant changes are briefly summarized here. The group suggested eliminating the category of management drivers ("Management") and wished instead to consider those Vital Signs within the Stressor category. The group recommended that several Vital Signs assessing the biotic condition of vegetation be combined into a more comprehensive vegetation inventory now called "Vegetation community structure and demography." The group suggested lumping all four proposed Vital Signs within the Landscape context category into a single comprehensive Vital Sign, now called "Landcover/landuse." The proposed Trail network Vital Sign was incorporated into the Visitor impacts (formerly called "Visitor use"). These changes reduced the number of proposed Vital Signs for the terrestrial workgroup from the original 52 to just 45.

The group was asked to consider whether the proposed list was sufficiently comprehensive, and if not, to suggest additional useful Vital Signs, particularly additional focal taxa. In response, the group suggested three additional potential focal taxa for terrestrial systems – 1) lichens, as indicators of air pollution and of old growth conditions;[1] 2) pollinator groups, due to their functional significance; and 3) arctic/alpine plants, due to the particular challenge posed to this group by climate change. However, the group did not rate these potential Vital Signs, nor discuss them in depth.

Ranking the Proposed Vital Signs

The group discussed each proposed Vital Sign and assigned each a priority rank in accordance with the NETN rating criteria. Of the 45 revised proposed Vital Signs considered by the terrestrial workgroup, the group ranked 11 "high" priority, 16 "medium" priority and 18 "low" priority. The rankings, justifications for these rankings, and key issues raised during discussion, are summarized in Table 3.

The 11 high priority Vital Signs included a key system driver (Climate), seven stressors (Atmospheric deposition & stress, Heavy metal contamination, Invasive exotic species, Ozone, Roads, Visitor impacts, White-tailed deer herbivory), and measures of both landscape context (Landcover/landuse) and biotic condition (Focal taxa – forest breeding birds, Vegetation community structure and demography). In general, these high priority Vital Signs all were deemed to have considerable ecological relevance and some management significance. Standard methods are available to measure most of these Vital Signs, and background datasets are available for some. For the most part, the medium priority Vital Signs also had ecological relevance and management significance, but were deemed less critical than the high priority Vital Signs. Most of the low priority Vital

[1] See Steve Selva's work on *Lobaria pulmonaria* and *Usnea* lichens.

Signs were considered not useful, either because of low ecological relevance to terrestrial systems, or because they yield information that is too variable or difficult to interpret.

Vital Sign Measures

In the next phase of the breakout session, the group discussed specific measures for quantifying the high priority Vital Signs, as well as measures for medium priority Vital Signs which might be easily bundled together with the high priority group; these medium-priority Vital Signs included Natural disturbance regime, Nutrient cycling, Productivity, Park infrastructure, Species composition – flora, Vegetation/canopy condition, and several focal taxa. Key measures for these Vital Signs are discussed below, and summarized in Table 4.

High priority Vital Signs

1. Climate

Climate is a key driver of natural systems affecting system structure, composition, and function. Monitoring this basic variable will also provide a long-term record of the stress associated with climate change. While management applications related to climate are limited, climate data is useful for ruling out other causes for system responses. Some climate data is already collected in or near the NETN parks and can be compiled easily; collection of other data may be warranted in some cases. Continuous daily temperature and precipitation are mandatory climate measures; additional useful measures include snow depth on site, relative humidity, wind speed and direction, and solar radiation. It would be useful to co-locate other atmospheric measurements such as acid deposition and heavy metal inputs and atmospheric ozone concentrations with these climate measurements.

2. Vegetation Community Structure and Demography

The group rolled three original proposed Vital Signs into this more comprehensive vegetation inventory, to create a fundamental and anticipatory indicator of future cover, function, habitat quality and stress response. Standard methods are readily available, and the response variability associated with many of these measures is well understood. The group suggested reviewing the State of Maine's subset of the USFS FIA measures, used to monitor state ecological reserves, as a starting point for this Vital Sign. They recommended stratification to select sampling locations, and resampling of permanent plots, perhaps on a 5-year return interval. The group noted that many additional Vital Signs might be monitored in conjunction with these surveys, such as composition, canopy condition, white-tailed deer herbivory, additional focal taxa such as forest breeding birds or lichens, and invasive exotic species, particularly forest insect pests and earthworms. The group pointed out that legacy features might be useful to monitor even within parks that are not subject logging or forest management, because legacy features could potentially be artificially created within younger forests that lack such features.

3. Focal Taxa – Forest Breeding Birds

This was the only focal taxa designated high priority by the terrestrial workgroup. This taxa provides a useful biotic indicator of the effects of habitat fragmentation, and is a highly visible and charismatic taxa much loved by the public. The NPS has some

management control over fragmentation within the park, though fragmentation outside the park boundary is a critical stressor for many of the smaller parks. This Vital Sign provides an opportunity for NPS to coordinate with other organizations monitoring bird populations, and to incorporate volunteers into the I&M program. Many reference datasets and standard methods are available, and the response variability is fairly well understood. However, some members expressed concern that it can be hard to attribute variation in bird populations to a specific cause. The group indicated we should employ some measures of composition/relative abundance/species richness and distribution using point counts and/or distance sampling, and that we consult protocols compiled by the NPS and those developed by the Patuxent Center. We should carefully assess the power of our sampling design, and consider sampling more points less frequently (perhaps twice as many every other year) to increase statistical power.

4. Landcover/Landuse

Landcover data provides key information on the status and extent of ecological systems; landuse data for the larger park region provides important information on habitat alteration and a wide variety of stressors associated with landuse change. This Vital Sign includes measures of "buffers" to natural systems and to the parks in general, which are useful indicators of the degree of anthropogenic influence. This Vital Sign has some management significance, as parks have control over both landuse change within the park, and the size and composition of landscape buffers. Landcover/landuse data is readily available from remote sensing. Periodically updated landcover/landuse maps are essential components of this Vital Sign; these might be updated on a 10-25 year return interval. Additional mandatory measures are cover type patch size distribution, some measure of connectivity and fragmentation, and land ownership within park buffers. The amount of impervious surface within park watersheds would also be a useful measure. It should be possible to monitor aspects of many additional Vital Signs using remotely-sensed data; these include large disturbances, road networks, productivity, vegetation stress, rare plant communities and perhaps trail networks and focal species habitat. One member recommended we investigate new methods employed by Steve Sader at the University of Maine, perhaps using IKONOS imagery; these may allow remote sensing of regeneration. Data on park infrastructure development could be compiled into this spatial database.

5. Visitor Impacts

Visitor impacts ranked high priority despite localized ecological impacts due to the clear management implications of this fundamental park issue. Many of the NETN parks are heavily visited, and thus allow substantial opportunity for adaptive management of visitor impacts. Impacts related to trail use were considered of particular importance to the Appalachian Trail, and the group noted that poor trail maintenance could substantially impact resources along the trail. The group debated the utility of monitoring visitor activities, density and location versus visitor impacts – there are advantages to both approaches. The former can be monitored via motion detectors placed at key locations; the latter can be monitored along trails, and in back-country areas together with vegetation inventory surveys. It was noted that both snowmobiles and ATVs are currently in use within Acadia NP.

6. Atmospheric Deposition & Stress

Atmospheric deposition is a stressor of high ecological relevance to both terrestrial and aquatic systems throughout the NETN. Acidic deposition stresses terrestrial vegetation and alters system functioning and biogeochemical cycles. This issue has management significance at higher level than NPS, in the form of legislation controlling emissions. Standard methods available for monitoring both inputs and associated stress. The ecological response to this stress varies across the landscape in complex ways, only some of which are understood. Patterns of wet deposition data are currently monitored through the NADP network and are well understood; relevant data for NETN parks should be acquired from this network. Patterns of dry deposition are less well understood, but some dry deposition data could be acquired from the CASTNET network. Patterns of occult deposition, from clouds and fog, are less well understood, and could be important sources of acidity within coastal NETN parks such as Acadia. The group was undecided as to whether occult deposition should be monitored at Acadia; this is an issue for further consideration. The group recognized that acid stress response should be monitored in addition to inputs, and advocated sampling of streamwater ANC, but was less sure whether soil chemistry and nutrient cycling should also be monitored. The former would also provide a useful measure of terrestrial system nitrogen saturation as well as water quality. Heavy metal deposition is also monitored by the NADP and CASTNET networks, that data should also be acquired and compiled by the I&M program.

7. Heavy Metal Contamination

The group considered heavy metal contamination to be a significant emerging ecological problem with both research value and management significance. Heavy metals such as mercury, zinc, lead and cadmium are toxic and can accumulate in biota. Thresholds of toxicity are not yet well established, though they are perhaps better established in aquatic than terrestrial systems. The group recommended acquiring data on atmospheric inputs from existing sources (the NADP and CASTNET networks, discussed above) but did not have time to fully consider whether measures of biotic accumulation and response were mandatory or optional.

8. Invasive Exotic Species

Invasive exotic species are a significant and growing stressor with clear ecological relevance to terrestrial systems within NETN. This Vital Sign has relatively strong management implications via exotic species control programs. Numerous groups of invasive exotic species are of concern, including terrestrial plants, insect pests and pathogens, and earthworms; it might be wise to develop separate Vital Signs focusing on these groups. The group questioned whether feral animals would/should be included within invasive exotic species monitoring and management programs. Appropriate monitoring strategies will depend upon the group of organisms in question and might include surveillance, perhaps in conjunction with the field vegetation surveys, followed by monitoring after initial detection. The literature and support information available on invasive exotic species is extensive.

9. Ozone

Atmospheric ozone pollution is an important stressor of terrestrial vegetation with clear ecological relevance. This Vital Sign has management significance at higher level than NPS via air quality legislation. Standard methods for monitoring are available. Bob Kohut recommends that both atmospheric ozone concentrations and ozone stress on indicator species be monitored as mandatory indicators. Ozone concentration data is available from CASTNET network and other sources, and need only be acquired by NETN. Ozone stress on specific indicator species should be monitored within NETN parks.

10. Roads

The Roads Vital Sign originally contained three components: the road network, road chemical use, and roadkill. The terrestrial workgroup considered only the first to have strong ecological relevance in terrestrial systems, as an important source of landscape fragmentation and an entry point for invasive species. The group thought perhaps the aquatic and wetland workgroups were better suited to considering the impacts of road chemical use and roadkill. This Vital Sign has some management significance in terms of changes to the road network within parks. The group wondered if the road network could best be monitored via remote sensing together with Landcover/landuse.

11. White-tailed Deer Herbivory

This was a controversial Vital Sign for the terrestrial workgroup. While some in the group felt deer herbivory has high ecological relevance for regeneration and substantial management significance, others considered it inappropriate for NPS to consider a native species to be a "Stressor." This also stimulated discussion of how the historic and/or natural range of variability of a particular measure might contribute to evaluating ecological integrity. Some questioned whether this Vital Sign should include additional herbivores. Most of the group advocated monitoring browse impacts rather than herbivore populations.

Other Potential Vital Signs or Issues

Several important issues relating to medium- and low-priority Vital Signs were raised during discussion within the terrestrial workgroup.

During discussion of **Natural disturbance regime**, the group recognized that large/infrequent disturbances might best be monitored from remote sensing together with Landcover/landuse, while small/frequent disturbances might best be monitored from field surveys together with Vegetation community structure & demography.

The group considered **Productivity** to be a useful indicator of the state of terrestrial systems, but ranked it medium priority rather than high because they questioned whether it was useful for identifying specific problems.

The group was unsure if and how **Feral animals/pets** should be monitored. Some felt feral animals should be considered part of the Invasive exotic species Vital Sign. The group was unsure of the ecological impact of pets within NETN parks, and wondered whether this problem was already sufficiently managed by park personnel.

In discussion of **Herbicide/pesticide use**, the group questioned whether it was useful to quantify amounts used within and surrounding the parks, or whether it was better to measure specific impacts within NETN parks.

Though it ranked low priority, the group spent considerable time discussing **Land management**. The land management activities that occur in all the NETN national historical parks and historic sites have considerable ecological relevance, but are tied to the parks' cultural mandate. For this reason, the group questioned the utility of monitoring those activities within the I&M program. However, some in the group thought fire management activities should be monitored.

One member of the group noted that it might be more useful to monitor ant-dispersed herbaceous species than spring ephemerals as a **Focal taxa** for terrestrial systems, because they persist longer and may be more useful as an indicator of ecological condition. Spring ephemerals can be hard to define as a guild.

Finally, the discussion of **Vegetation/canopy condition** noted that this Vital Sign might be hard to quantify. Two possibilities for doing so would be to monitor canopy crown condition using field surveys, or to assess vegetation stress from remote sensing.

Several important general issues were raised during discussion in the terrestrial workgroup. First, the group discussed whether some potential Vital Signs were more appropriate as issues for inventory, surveillance, research or management, than for monitoring. The distinction between inventory and monitoring is an important one that has been specifically addressed by the I&M program – the program recognizes that an initial inventory of park resources is essential to the development of an effective monitoring program. While potential Vital Signs such as landcover/landuse are already being assessed in NETN parks in an initial inventory, landcover/landuse change over time is an important element to monitor, though probably at longer return intervals than some other Vital Signs.

The distinction between monitoring and surveillance is less clear. The group discussed the need for surveillance to detect the presence of certain invasive exotic species – which might then be monitored or eradicated. More generally, one member advocated a policy of surveillance for several Vital Signs in order to determine whether certain thresholds of response had occurred, which might then trigger monitoring. This issue should be clarified during Phase 3 protocol development.

Likewise, the distinction between research and monitoring is important – scientific research is hypothesis-driven, while monitoring seeks to elucidate changes in resources over time, and/or to determine the effects of management action on resources. During discussions of deer herbivory, the group briefly debated whether the impacts of deer herbivory on terrestrial ecosystems were an issue for research or monitoring. Most, though not all, felt that deer impacts were important stressors on terrestrial regeneration that should be monitored over time.

The group debated whether some potential Vital Signs, such as some invasive exotic species and feral animals/pets, were management issues that would be addressed and assessed by NPS programs other than the I&M program. While it is clear that monitoring is an important component of adaptive management which allows assessment and fine-

tuning of management strategies, it is an NPS administrative decision whether to monitor known management issues as part of the I&M program, or separately within management programs.

Second, the group debated whether some proposed Vital Signs were appropriate issues for NPS to monitor from an ideological standpoint. Specifically, one group member questioned whether it was appropriate for NPS to consider the concept of "health," "condition" or "integrity" of natural vegetation and systems, or to assess the impacts of current, historically-high populations of native herbivores on vegetation. The underlying philosophy seemed to be that native systems and species should be free to exist without human intervention and/or management. Most of the group disagreed with this philosophy because anthropogenic change so pervasively affects these native systems and species. Indeed, it is a stated goal of the I&M Program to identify vital signs that "represent the overall health or condition" of park resources.

Third, a related and important issue discussed in this workgroup was how to apply the concept of resource "condition" or ecological integrity to highly modified systems. These concepts are more easily applied to natural systems, but substantial land within the national historic parks and sites is maintained as open fields for cultural reasons. The group struggled with the concept of choosing Vital Signs that represent the health or condition of these modified semi-natural or cultural systems. This is an issue that will require further consideration.

Fourth, the group debated the utility and cost-effectiveness of biogeochemical approaches to monitoring. In general, this group considered biogeochemical approaches to be prohibitively expensive and of lower priority, though there was some discussion of perhaps perpetuating ongoing watershed analyses within Acadia in conjunction with the I&M program. The assembled group did not include specific expertise within the field of biogeochemistry. For this reason, it might be useful to seek additional review and input from a small group of scientists with expertise in biogeochemistry – a discipline developed in part to provide indicators of ecosystem status and functioning. This additional review might also provide needed input on the related issue of the best measures for monitoring acidic stress on terrestrial systems, and the question of monitoring occult deposition inputs at Acadia.

Fifth, the group discussed the existence of adequate baseline data. Good baseline data exists for some proposed Vital Signs but not all. The group noted that a long-term monitoring dataset can detect trends despite the lack of baseline data for comparison.

Sixth, one group member strongly advocated a GIS approach to data management for monitoring in general. He felt that data collected for many of the high priority Vital Signs should be maintained in a spatial database to allow spatial analysis.

Finally, the group recognized that climate change was a key stressor for terrestrial systems over the long-term, but struggled to identify useful Vital Signs associated with this stressor. The group discussed two relevant Vital Signs, Phenology and Species migration – climate change, in some depth, but ranked both only medium priority. In part, this was because NPS has less ability to manage this stressor than some of the others. The medium priority rating for phenology was also partly due to the inherent variability of this response. However, the group recommended further consideration of

how species migration in response to climate change could be monitored along the altitudinal and latitudinal gradients of the Appalachian Trail.

Table 3. Summary of Terrestrial Workgroup vital signs, rankings, and workgroup justification

Category	***Original Vital Sign***	***Workgroup Vital Sign***	***Justification***	***Initial Rank***	***Workgroup Rank***
Climate	Basic climate	Climate	Widely applicable. Few specific management applications, but useful to rule out other causes. Already measured, data widely available.	M	H
Disturbance	Natural disturbance regime, Beaver engineering	Natural disturbance regime	Important background information. Limited management significance. Currently not measured. High response variability.	L	M
Biotic condition	Species of concern	At-risk biota	Not a useful indicator, rare plants have specific requirements.	L	L
	Bats	Bats	Low ecological relevance and management significance.	L	L
	Demography - dominant vegetation, Stand structure retention - legacy features, Stand structure	Vegetation community structure and demography	Anticipatory measure of future cover, function, habitat quality & stressors. Indicator of disturbance. Could be bundled with multiple VS. Standard methods available. Variability understood. Legacy features can be created in young stands	M	H
	Focal taxa - additional	Focal taxa - additional	Relevance depends upon taxa considered. Consider lichens, pollinator groups, arctic/alpine plants.	M	M
	Focal taxa - Forest interior breeding birds	Focal taxa - Forest interior breeding birds	Biotic indicator of fragmentation effects. Can coordinate with other organizations, use volunteers. Many reference datasets and standard methods available. Response variability understood.	M	H

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
	Focal taxa - Obligate lepidopterans/odonates	Focal taxa - Lepidopterans/odonates	Narrow ecological significance. Low management significance. Applicable to additional wetland, upland habitat than specified.	L	L
	Focal taxa - Red backed salamander	Focal taxa - Red backed salamander	Indicator of acid deposition, microclimate. Can use volunteers. Response perhaps not well known.	M	M
	Focal taxa - Soil biota	Focal taxa - Soil biota	Group considers our understanding of soil biota insufficient to use herein.	L	L
	Focal taxa - spring ephemerals	Focal taxa - spring ephemerals	Linked to earthworm populations, herbivory. Some management significance. Consider changing to ant-dispersed herbaceous species.	M	M
	Focal taxa -Grassland birds	Focal taxa -Grassland birds	Does not clearly relate to ecological integrity, but does have clear land management implications. How to consider ecological integrity of highly modified systems?	M	L
	Rare plant community	Rare plant community	Might provide a coarse filter for rare species, but irrelevant to "health." Species will respond individually to climate change. Perhaps harder to monitor than individual rare species. Consider as focal park resource.	M	M
	Species composition - fauna	Species composition – fauna	Difficult to consider in general - perhaps consider large predators specifically.	H	L
	Species composition - flora	Species composition - flora	Broader than dominant vegetation. Non-clonal herbs may provide early warning. Some	H	M

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
			management implications. Can bundle with other vegetation inventory.		
	Species migration - climate change	Species migration - climate change	Good long-term dataset to document clear response to critical stressor. Could bundle with vegetation inventory. Consider transects upslope on AT. Consider latitudinal change also.	L	M
	Vegetation condition	Vegetation/ canopy condition	Can provide important early warning. May be difficult to quantify. Bundle with vegetation inventory. Consider defining as canopy condition, and/or remotely sensed stress	H	M
Ecological process	Nutrient cycling	Nutrient cycling	High ecological relevance, some management significance. Group considers this expensive, but perhaps warranted in specific cases such as Ca depletion, N saturation. Perhaps consider with atmospheric deposition	M	M
	Phenology	Phenology	High ecological relevance, indicator of climate change. Other groups are measuring this - should NPS too? Some phenology easily measured using volunteers. Response variability may be high.	M	M
	Productivity	Productivity	Indicator of system state. Can be monitored using remote sensing using standard protocol. Has NPP been useful in identifying specific problems?	M	M

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
	Soil respiration	Soil respiration	Ecological relevance and management significance are vague.	L	L
	Trophic dynamics	Trophic dynamics	Feasibility is low. Perhaps consider monitoring coyotes.	M	L
Focal park resource	Amphibians	Amphibians	Wetlands workgroup should consider this in more detail.	M	M
	Breeding birds	Breeding birds	Duplicative. See comments under Biotic Condition.	M	M
	Mandated Species	At-risk biota	Duplicative. See comments under Biotic condition.	M	L
	Viewshed	Viewshed	Very limited ecological relevance.	L	L
Landscape context	Landcover. Landscape buffer, Landuse, Park boundary	Landcover/ landuse	High ecological relevance and management significance. Easily monitored using remote sensing.	H	H
Manage-ment	Land management	Land management	A controversial VS. Some felt activities necessary for park's cultural mandate should not be monitored. Group thought fire management might require monitoring.	H	L
	Park infrastructure	Park infrastructure	Localized ecological impacts, clear management significance. NPS maintenance produces this information. Consider lumping with landcover/landuse.	M	M
	Visitor use	Visitor impacts	Localized ecological impacts. Clear and useful management significance. Trail impacts particularly important to AT. Monitor visitor impacts such as trampling.	M	H
Stressor	Acidic deposition &	Atmospheric	High ecological	H	H

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
	stress	deposition & stress	relevance. High management significance at higher level than NPS. Standard methods available, wet deposition data available. Response varies across landscape, some aspects of variation are understood. Consider occult deposition at Acadia? Best measure of response?		
	Contamination	Contamination	Low ecological relevance for terrestrial systems.	M	L
	Dark night sky	Dark night sky	Some limited ecological relevance, but less than other VS herein. High management significance. Could be monitored by volunteers.	L	L
	Feral animals/free-ranging pets	Feral animals/free-ranging pets	Group suggests feral animals should be considered exotic species. Group questions if pets should be monitored or just managed. Monitoring or management issue?	M	L
	Heavy metal contamination	Heavy metal contamination	Significant emerging ecological problem with research value and management significance. Thresholds of toxicity not well established, perhaps better established in aquatic systems. Bundle inputs with atmospheric deposition.	H	H
	Herbicide/ pesticide use	Herbicide/ pesticide use	Perhaps better considered by aquatic workgroup. Measured via impacts within park or easier to measure	M	M

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
			amounts used?		
	Hunting	Hunting	Measured by state, NPS has little influence.	M	L
	Invasive exotic species	Invasive exotic species	Clear ecological relevance. High management significance. Consider invasive plants, herbivores (insect pests), earthworms, pathogens, etc. Group suggests surveillance is needed. Clarify distinction between monitoring, management, surveillance. Split VS? Feral animals included?	H	H
	Noise	Noise	Relatively low ecological relevance. Should know background levels, perhaps measured by others.	L	L
	Ozone	Ozone	Clear ecological relevance. Clear management significance at higher level than NPS. Standard methods available and atmospheric concentrations are available.	M	H
	Roads	Roads	Group considered road network important ecologically and to management within terrestrial systems, but not road chemical use. Roadkill considered an amphibian/wetland issue. Consider within landcover/landuse?	H	H
	Soil erosion	Soil erosion	Localized ecological impacts. Erosion on AT is important with management	H	L

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
			implications.		
	UVB	UVB	Ecologically relevant most strongly to amphibians - thus more relevant to wetland group. Is funding ending for current Acadia monitoring?	M	L
	White tailed deer herbivory	White tailed deer herbivory	A controversial VS. Some felt this has high ecological and management significance, others found it is inappropriate to consider a native species a "stressor." Group wants to monitor impacts, not deer population. Should NPS consider "overpopulation" of native species? Are additional herbivore species of interest?	H	H

Table 4. Mandatory and optional measures for high priority Vital Signs recommended by the terrestrial workgroup.

Category	*Workgroup Vital Sign*	*Mandatory Measures*	*Optional Measures*
Climate	Climate	precipitation by type, temperature	snow water equivalent, relative humidity, snow depth, wind speed and direction, solar radiation
Biotic condition	Vegetation community structure and demography	mortality, regeneration, stand structural stage, basal area by species, composition, canopy condition, snags, coarse woody debris,	earthworm presence
	Focal taxa - Forest breeding birds	Species richness, population trend	
Landscape context	Landcover/landuse	landcover/ecological system map, ecological system change, road network	patch fragmentation, patch connectivity, patch size distribution, disturbance extent, regeneration, proximity indices, , , type of

			road & road network change, % impervious surface in watershed, nearby human population density, land ownership in park boundary
Management	Visitor impacts	Number of visitors by location and activity, trampling disturbance, soil erosion	wildlife disturbance,number snowmobiles, social trail development, trail network change
Stressor	Atmospheric deposition & stress	Wet & dry deposition from NADP and CASTNET, stream alkalinity/ANC, streamwater nitrate	soil base saturation, occult acidic deposition, soil Ca:Al ratio
	Heavy metal contamination	Atmospheric deposition	bioaccumulation in indicator species, metal contaminants in water
	Invasive exotic species	surveillance	extent, abundance
	Ozone	foliar injury to indicator species, atmospheric ozone concentration	
	White tailed deer herbivory	vegetation browse intensity, regeneration impacts	Deer population size

Wetland Breakout Session

Overview of Vital Signs

The workgroup began by reviewing the categories of Vital Signs and deciding that the group would transcend discussions about Vital Sign categories and focus on the tasks of determining if the proposed list was complete and the ranking the list and identifying measures. The group decided to change the "septic/wastewater discharge" and "fertilizer use" Vital Signs to "Nutrient Enrichment" (Table 5). The group added the "Heavy Metal Contamination" to the "Contaminants" Vital Sign to create more general and comprehensive Vital Sign. The group also added a new Vital Sign "Emerging Wildlife Diseases" and then ranked it as a low priority due to the difficulty in tracking these over time.

High priority Vital Signs

1. Climate

The workgroup thought that acquiring basic climate data was important for any long-term monitoring program because these variables provide background explanation that is important in the interpretation of changes to wetland condition. All the parks in the network identified global climate change as a pervasive stressor to all park resources, not just wetlands. Therefore, monitoring basic climate data is a necessary component of a Vital Signs program.

The workgroup recommended that it was more efficient to access existing weather and climate resource systems and make that information available to park managers than to install new park based weather stations. This provision was qualified with the understanding that if an existing climate data source is not available within an acceptable

distance, or necessary data is not collected by existing sources, then the network should consider installation and maintenance of an appropriate weather station.

The workgroup also recommended that network parks should cooperate with existing snow cover monitoring programs to obtain annual snow cover trends. These measures should minimally include snow depth and snow cover duration. The workgroup recommended these measures because of the relationship between winter precipitation and seasonal wetland hydrology.

2. Hydrology

Hydrologic conditions are extremely important for wetland structure and function. Hydrology affects most abiotic factors, which in turn affect the biotic condition of the wetland. Without basic hydrologic information, it is not possible to interpret the condition of any wetland resources and this is therefore, a high priority for any wetland monitoring.

The workgroup recommended that surface and sub-surface water level, and water level duration form the primary measures for monitoring wetland hydrology. Establishing sources and quantity of inflow and outflows was not considered to be a primary measure due to cost and site selection difficulties.

3. Water Chemistry

The workgroup considered this to be the only high priority abiotic condition vital sign. Information from basic water chemistry measures can be directly related to the condition of a wetland and may be correlated with other wetland vital signs. In order for causal relationships between physical and biological processes to be fully understood, the workgroup thought it was necessary to obtain basic water chemistry measures in wetlands.

The workgroup recommended three mandatory measures: temperature, pH, and conductivity. These were selected because their response variability is understood, they are cost effective, provide meaningful management directed information, and are good indicators of wetland condition. This vital sign generated a discussion that centered on the effectiveness of a measure to produce meaningful information. Data from some traditional water quality measures are difficult, if not impossible to interpret in a monitoring setting when the measures are taken on regular, but infrequent intervals. For example, Dissolved Oxygen (DO) was suggested as a potential measure because it is easy to accomplish and commonly obtained. The work group decided against DO because it is too easily affected by other factors that occur on a daily or seasonal basis which would make comparison of data obtained from different sampling cycles difficult or impossible to compare.

4. Species Composition – Fauna

This was one of two biotic condition vital signs identified by the wetland workgroup as high priority. The workgroup thought that faunal composition was highly relevant and applicable to wetland condition. Monitoring specific measures of indicator groups was considered to be high priority vital sign because it integrates stressor, condition, and response vital signs.

The workgroup discussed the difficulty of identifying indicator faunal groups for specific wetland types and parks. For example, a different faunal community would be expected in a vernal pool than would be found in an emergent marsh. Similarly, the faunal community in an Acadia National park vernal pool may be different that the community found in a Saratoga National Historic Park vernal pool.

The workgroup recommended that wetland indicator fauna be specified for each wetland type and each park and should be a primary component of protocol development. The principal metric for this vital sign is abundance by indicator species.

5. Species Composition – Flora

This was one of two biotic condition vital signs identified by the wetland workgroup as high priority. The workgroup thought that floral composition was highly relevant and applicable to wetland condition. Knowing the relative abundance and species composition of the floral community provides basic biological information that can be related to stressor and abiotic vital signs. Monitoring the vegetation community is also a good early detection strategy for management of invasive species.

Wetland vegetation monitoring provides a good indicator of wetland condition because plant species vary in their response to stress. Monitoring wetland flora is relatively low cost, sampling is efficient, and changes in plant species composition and abundance can be accurately measured.

The principal metric for this vital sign is abundance by species.

6. Landuse/Landcover

Landcover is an important vital sign because it integrates across multiple spatial scales; from the buffer around an individual wetland, to the wetland complex within a park's boundary, to the distribution of wetlands within the region. Landcover change was identified as a high priority issue for all network parks due to concerns arising from the negative effects of habitat conversion adjacent to park boundaries. By implementing a basic landcover change monitoring program inferences can be drawn between measurable changes in park wetland integrity and anticipated negative effects. For example, increased development around parks increases the likelihood of invasive species introduction, feral animals, and water quality changes resulting from increased impervious surfaces.

Landcover change detection has been identified by most other networks within the Inventory and Monitoring Program, especially those in the eastern United States where human populations have increase dramatically during the last century.

The recommended measures proposed by the workgroup exist in two different spatial scales. Broad scale measures would be used to provide basic landcover change within and around parks. Finer scale measures (wetland level) included the abundance of plant species within 100-meters and 500- meters from the wetland edge. The workgroup recommended that for vernal pools and some forested wetlands, canopy cover should be included as a measure.

7. Atmospheric Deposition

The workgroup thought that compiling acidic deposition data was important for any long-term monitoring program because this stressor has demonstrated negative affects on water chemistry and can alter wetland function and biogeochemical processes. All the parks in the network identified acid deposition as a pervasive stressor to all park resources, not just wetlands. Therefore, acquiring and synthesizing data from existing sources, including the National Atmospheric Deposition Program (NADP), is a necessary component of a vital signs program.

The workgroup recommended that it was more efficient and cost effective to acquire existing acid deposition information and make that information available to park managers than to install new park based monitoring stations.

8. Contamination

The workgroup recognized that monitoring contaminant concentrations in the wetland environment and biota is a high priority. However, the workgroup recommended that contaminant experts be solicited for recommendations for specific compounds and biota to monitor. The workgroup also recommended that potential sources of contamination be identified (i.e., gas stations, landfills, industrial sites, shipping channels, power plants, etc.).

9. Nutrient Enrichment

The negative effect of nutrient enrichment in wetlands, and other waters, is well documented. Habitat quality can be adversely impacted from increased nutrient inputs, anoxic conditions can arise, and changes to the biotic community can occur.

The workgroup decided that randomly monitoring nutrient concentrations in wetlands is not an effective design. Sampling is costly, nutrient concentrations are variable, dependent upon vegetation uptake, and may not provide a direct measure of nutrient loading. However, because nutrient enrichment is considered a high priority for wetland systems, inventorying existing potential sources of nutrient enrichment as well as proposed additional sources (i.e., building permits, road development, etc.) is considered necessary.

Potential measures for this vital sign include fertilizer use within parks and residential density within buffer adjacent to park.

10. Invasive Exotic Species

The negative effects of invasive species are second to direct habitat loss in the reduction of biodiversity. The national I&M program and all the parks in the Northeast Temperate Network have identified invasive species as a high priority vital sign and management issue. The workgroup emphasized the importance of developing a monitoring program that a) will identify potential wetland invasive species before they become established in a park; and, b) is sensitive enough to detect any new invasions at a point when management can be most effective.

The workgroup recommended that the role of the vital signs program is early detection of invasive wetland species, not monitoring the effectiveness of invasive wetland species control programs.

Potential measures for this vital sign include presence/absence of any invasive wetland species.

Table 5. Summary of Wetland Workgroup vital signs, rankings, and workgroup justification

Category	***Original Vital Sign***	***Workgroup Vital Sign***	***Justification***	***Initial Rank***	***Workgroup Rank***
Climate	Basic climate	Basic climate	Management Significance - good baseline information that integrates across multiple systems including wetlands, easy to obtain and may help explain observed patterns in wetland condition over time; Feasibility - Look for adjacent meteorological stations in immediate vicinity of each NETN park. Initial costs may be high if stations need to be established within parks	M	H
Disturbance	Natural disturbance regime	Natural disturbance regime	Ecological Relevance - Weather related disturbance events are priorities for ACAD, other may be for other NETN parks; Insect outbreaks may be a component of a remotely sensed landcover change monitoring program or could be integrated from other ongoing programs.	L	L
Hydrology/ Geomorphology	Hydrology	Hydrology	Management Significance - Driving parameter in wetland ecology; Feasibility - Some easy measures that can explain much of the variation in wetland condition; Ecological Relevance - driving parameter in wetlands, can not explain much without knowing the basic hydrology of each wetland	M	H
Abiotic condition	Core water chemistry	Water Chemistry	Response Variability – variability is measure specific; Management Significance - Provides useful management directed information; Feasibility - Easy, relatively cheap; Ecological Relevance – provides the necessary physical parameters to assess basic wetland condition.	H	H
	Sediment characteristics	Sediment characteristics	Response Variability - highly variable; Management Significance - hard to interpret, no clear linkage to management; Feasibility - Highly variable; Ecological Relevance – Confusing to interpret	L	L

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
Biotic condition	Focal taxa - Amphibians	Focal taxa - Amphibians	Response Variability – Amphibians are taxa sensitive to wetland condition (both physical and biological parameters); Management Significance – can be a component of Phenology monitoring; Feasibility – park monitoring can integrate with other existing programs; Ecological Relevance – some taxa are good indicators of wetland condition. This Vital Sign will likely be a component of the "Species Composition – fauna" Vital Sign.	H	M
	Rare plant community	Rare plant community	Management Significance – Distribution can be incorporated as a landscape measure;	M	L
	Species composition - fauna	Species composition - fauna	Ecological Relevance – high, knowing the status of wetland obligate fauna important to tracking wetland condition over time. Must identify indicator taxa for wetland types and NETN regions.	H	H
	Species composition - flora	Species composition - flora	May be good indicator of stress; Different vegetation respond to stress at different rates that can be easily observed and quantified; relatively low cost and provides information that can be used in management.	H	H
	Species of concern	Species of concern	Management Significance - Park focused study; Feasibility - Not an I&M level concern;	L	L
		Emerging Diseases	Response Variability - Uncertain; Feasibility - May be hard to develop a means to study; Ecological Relevance - Very interesting question, not easy to implement.		L
	Vegetation condition	Vegetation condition	This will be integrated into Species Composition – Flora metrics	H	L
	Water quality - algal biomass	Water quality - algal biomass	Response Variability - sensitive; Management Significance - Gives potentially good feedback for wetlands that have open water; Feasibility – Chlorophyll-a feasible for suspended phytoplankton, periphyton measures may not be	H	M

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
			readily available; Ecological Relevance - Look into available science -- does it support monitoring objectives? May be a Vital Sign that is implemented later in program development.		
	Water quality – macro-invertebrates	Water quality – macro-invertebrates	Feasibility - requires technological expertise; Ecological Relevance - Science may not support predicted patterns; Could be integrated into program over time and within specific parks but may not be the highest priority for initial program development.	M	M
	Water quality - nutrient loading	Water quality - nutrient loading	Response Variability – Measuring nutrient concentrations produces highly variable results; Management Significance - Not sensitive to management concerns -- may be caused by natural as well as anthropogenic sources; Feasibility - Too costly; Ecological Relevance - Not sensitive to management concerns -- may be caused by natural as well as anthropogenic sources;	H	L
Ecological process	Nutrient cycling	Nutrient cycling	Response Variability - hard to interpret; Management Significance - may not give useful answers to management questions; Feasibility - too costly; Ecological Relevance - important, would be useful bit does not outweigh the variability and indirect relationship to management decision making.	M	L
	Phenology	Phenology	Feasibility - Link into other programs and utilize relatively simple measures; Ecological Relevance – good indicator of the biological response to climate change	M	M
	Productivity	Productivity	Feasibility - too much financial investment, too complicated	M	L
	Trophic dynamics	Trophic dynamics	Feasibility - Huge investment more research than monitoring;	M	L
Focal park resource	Amphibians	Amphibians	Management Significance – Important park resources;	M	M

Appendix N: NETN Vital Signs Selection Workshop Summary

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
			Ecological Significance – may be appropriate indicator taxa; Feasibility – can integrate with regional and national protocols		
	Breeding birds	Breeding birds	Response Variability - variable; Management Significance - difficult to interpret because trends may not be due to changes in park resources; Ecological Relevance - cause and effect difficult to interpret; Feasibility – easy to implement and integrate with ongoing programs, strong public interest.	M	M
	Mandated Species	Mandated Species	Management Significance - Important, but not emphasis of I&M program. Should be responsibility of individual parks	M	L
	Viewshed	Viewshed	Management Significance - Park issue. Deals with aesthetics, Adjacent land use; Feasibility – may be incorporated into landcover change detection monitoring.	L	L
Landscape context	Landcover, Landscape buffer, Landuse, Park boundary	Landuse/ Landcover	Response Variability - Good indicator of changing conditions for all park resources, integrates across multiple spatial scales; Management Significance - Measures that are Park focused, Acquire many remotely sensed measures simultaneously that can be applied to multiple systems and park stressors. Important measure for wetland management includes buffer quality around each wetland. Roads metrics should be included in this Vital Sign.	H	H
Management	Land management	Land management	Management Significance - Irrelevant to wetlands in NETN parks except restoration work at SAIR.	H	L
	Park infrastructure	Park infrastructure	Management Significance - Park driven management, not a monitoring issue;	M	L
	Trail network	Trail network	Management Significance - Not a monitoring issues;	M	L

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
	Visitor use	Visitor use	Management Significance - Major park concern, but on a park-by-park basis. May not be a reasonable VS to measure on a network basis; Feasibility - Can be done.;	M	M
	Wetland restoration	Wetland restoration	Management Significance - Aside from SAGA, few wetland restoration activities occur. Necessary measures will be captured under VS's.;	M	L
Stressor	Acidic deposition & stress	Acidic deposition & stress	Feasibility - Utilize existing data and make it available to parks.;	H	
	Beaver engineering	Beaver engineering	Assess extent of beaver activity with remote sensing Management Significance - Question whether beaver activity is true stress, or just inconsistent with ongoing park management; Beaver activity should be a measure included in landscape monitoring.	H	L
	Contamination, Heavy metal contamination, Herbicide/ pesticide use	Contamination	Management Significance - Lot's of potential measures. Network must work with experts to identify priority contaminants and biologic responses that should be monitored. Feasibility - This Vital Sign comes with a range of measures and a range of costs and could quickly become too expensive.	M	H
	Dark night sky	Dark night sky	Management Significance - Park centered issue	L	L
	Feral animals/free-ranging pets	Feral animals/free-ranging pets	Feasibility - May be serious logistical problem; Ecological Relevance - Significant question that may be best administered on a park level.	M	L
	Fertilizer use, Septic systems/Wastewater Discharge	Nutrient Enrichment	Measuring nutrient concentrations in wetlands is too variable, may not be directly related to sources, and is expensive. However, because nutrient enrichment is a major stressor to park wetlands the network should monitor changes in the potential sources of inputs (i.e.	M	H

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
			septic systems, fertilizer use, residential density in park buffer)		
	Hunting	Hunting	Ecological Relevance - Few if any game fish. Hunting is not permitted in parks, not relevant to wetland systems.	M	L
	Hydrologic alteration	Hydrologic alteration	Ecological Relevance - captured by other Vital Signs elements	M	L
	Invasive exotic species	Invasive exotic species	Management Significance - Serious management, and ecological concern, high priority for all network parks; Network should focus on early detection of new invasives in wetlands.	H	H
	Noise	Noise	Management Significance - Not an I&M monitoring issue, though a potentially significant ecological issue because high noise levels can disrupt wildlife communication systems; may be appropriate to consider establishing baseline sound levels in wetlands.	L	L
	Ozone	Ozone	defer to experts in terrestrial and aquatic workgroups for guidance on future monitoring	M	M
	Roads	Roads	Captured in landuse/landcover Vital Sign measures. Does not need to be its own Vital Sign.	H	L
	UVB	UVB	Management Significance and Ecological Relevance- Some uncertainty and lack of understanding specific to wetland impacts. Also being measured regionally	M	M
	White tailed deer herbivory	White tailed deer herbivory	Not a major stressor specific to wetland condition.	H	L

Table 6. Mandatory and optional measures for high priority Vital Signs recommended by the wetland workgroup

Category	***Workgroup Vital Sign***	***Mandatory Measures***	***Optional Measures***
Climate	Basic climate	relative humidity, precipitation by type, snow water equivalent, snow depth, temperature, wind speed and direction, solar radiation	
Hydrology/ Geomorphology	Hydrology	Water duration, water depth	
Abiotic condition	Water Chemistry	conductivity, pH, Temperature	
Biotic condition	Species composition - fauna	abundance by indicator species	
	Species composition - flora	Presence/absence, Percent cover by species, Stem Density	
Landscape context	Landuse/ Landcover	basic change detection metrics, wetland buffer condition (100 and 500 m), canopy cover for vernal pools, local permitting, road network changes, beaver activity	
Stressor	Acidic deposition & stress	Obtain and synthesize NADP data from existing ongoing monitoring programs	
	Contamination	concentration of relevant compounds in the environment and appropriate indicator taxa. Network must work with contaminants experts to determine what compounds and what taxa to monitor.	
	Nutrient Enrichment	Residential Density within buffer, nearby septic permits, amount fertilizer used within and nearby park	
	Invasive exotic species	conduct walk-through inspections for early detection, monitor regional invasive species network	

Intertidal Breakout Session

Overview of Vital Signs

High priority Vital Signs

1. Climate

The workgroup thought that acquiring basic climate data was important for any long-term monitoring program because these data provide are critical to understanding and interpreting intertidal zone species changes. Typical climate measures, such as air temperature, wind speed and direction, and precipitation (measured for rain and snow) are important. Snow/ice depth within the intertidal zone would be a particularly valuable measure as there is evidence that this may have a significant effect of controlling the species composition and abundance in the intertidal zone.

The workgroup noted that many well-documented data sources exist and that it would be desirable to make that information available to park managers, though these data may not directly drive management actions.

2. Natural Disturbance Regime

Storms and important natural events that shape the intertidal zone through physical movement/transport of intertidal substrate and associated biota. Measures of the frequency and duration of storm events is required. These data are readily available from the above-mentioned climate measures. Wave energy or wave climate is directly coupled to storms and is a good natural disturbance regime measure for the intertidal zone. The location of offshore wave gages (usually deployed by NOAA) in relation to ACAD and BOHA should be investigated.

Measuring the duration of ice cover within the intertidal zone, as well as depth of ice cover, represent important signs of natural disturbance. See above comments on climate.

3. Substrate Composition

This vital sign is an important indicator of biotic change. Bedrock substrates and very large boulder substrates are not likely to change significantly over-time, but cobble, gravel, sand and mud substrates of the intertidal zone are subject to change seasonally, especially in response to storm events. Substrate composition may shift gradually over time, or episodically from one composition to another. Removal of smooth rocks from cobble beaches by visitors is a frequent occurrence, but the impact on substrate composition is unkown.

4. Water Chemistry

Information from basic water chemistry measures can be directly related to changes in distribution of flora and fauna, and may be correlated with other intertidal vital signs. Having basic water quality information helps to establish relationships between physical and biological processes, and gives support to management actions. For these reasons, the workgroup thought it was necessary to obtain basic water chemistry measures in the intertidal zone and nearshore subtidal zone, including water temperature, conductivity/salinity, water clarity. Water clarity can be simply measured by the secchi

disk method or by using a submersible light meter. The workgroup indicated that water quality measures are well documented and useful for long-term measurements.

5. Community Type

Having a well-documented map of intertidal substrate types and biotic assemblages is critical to understanding current conditions, monitoring long-term changes, and may be an important resource for the formulation of an intertidal zone quantitative (e.g., quadrat or transect) monitoring program. Recent substrate and biotic assemblage maps are available for 21 of the 34 BOHA islands.

6. Species Composition – Fauna

Knowledge of faunal species richness, species abundance, and distribution is critical to an intertidal monitoring program. Such assessements must be done for the diversity of intertidal habitats (e.g., rock substrate, cobble beaches, mudflats, others). The workgroup expressed concern about the high spatial and temporal variability associated with sampling intertidal fauna. Some baseline data exists for Boston Harbor Islands which may help in assessing variability and in selecting indicator species, but little exists for Acadia National Park. The workgroup discussed the difficulty of identifying indicator faunal groups for specific intertidal types. There was disagreement over the most appropriate method, though no methods were considered "rapid." Despite these concerns, this is a high priority vital sign. The concept of seasonality may also be important to consider and incorporate into the monitoring design for intertidal fauna (e.g., time of larval set for blue mussel or barnacle). Monitoring of select faunal species may be particularly useful in documenting the impact of visitor trampling (e.g., stature of barnacles).

7. Species Composition – Flora

Knowledge of macro-algal species richness, abundance, and distribution is critical to an intertidal monitoring program. This may be an especially important indicator of trampling by park visitors. Determining and monitoring the algal species composition within the intertidal zone is not a simple task, but should prove easier than for intertidal fauna.

8. Harvesting

Resource harvesting is often focused on intertidal zone habitats. Shellfish and bait worms are harvested from soft-bottom mud and sand flats throughout the both ACAD and BOHA. Rockweed and knotted wrack (Fucus and Ascophyllum) are harvested primarily for lobster packing. Commercial harvest of sea cucumbers, lobsters, sea urchins, and others are harvested from subtidal zones, often immediately adjacent to the intertidal. As part of an intertidal monitoring program, ACAD and BOHA should access existing data from regulatory agencies (e.g., state agencies, town shellfish wardens, fishing permits issued, etc.) on harvesting activity and intensity.

9. Visitor Use

The intertidal zone, especially the rocky intertidal, is a frequently visited habitat and often the focus of park-led interpretive tours at both ACAD and BOHA. Trampling and removal of resources can be significant. In order to understand why the biotic

components of the intertidal zone are changing, it is important to monitor visitor use, and more specifically, intensity of visitors, location of visitor use, and activities of visitors (e.g., walking, resource removal). Trampling and other visitor use impacts are likely localized to areas with available parking (e.g., at ACAD) or ferry access (at BOHA). In the soft-bottom intertidal habitats, recreational or non-commercial shellfishing occurs. The parks may have existing visitor monitoring data available.

10. Invasive Exotic Species

Non-native and invasive species have assumed dominant roles in defining the species composition and structure of intertidal habitats throughout New England. A recent inventory of the BOHA intertidal zone found that over 20% of the species (animals and plants) present are classified as non-native. Monitoring of faunal and floral species composition and abundance (see above) will serve to evaluate the status and change in the status of non-native species.

11. Shoreline Erosion / Sea Level Rise

Sea level is an important physical process that controls the distribution and spatial pattern of intertidal habitats. As sea level rises, the boundary of intertidal habitat types will shift. Sea level is presently rising at a rate of about 2-4 mm/yr along the New England coastline and is predicted to accelerate in response to global warming. Sea level is presently measured by NOAA tide gauges in Boston and Bar Harbor.

Shoreline erosion results in the movement of intertidal sediments and change in biotic communities. Storm wave energy is an important factor inducing shoreline erosion. Boat wakes can reportedly be a significant human-induced process that can increase shoreline erosion. A study to evaluate the impact of boat wakes on shoreline geomorphological processes at BOHA is presently underway.

Shoreline types should be monitored. This may be best accomplished by the substrate-type mapping identified in the "substrate type" high priority vital sign.

Table 7. Summary of Intertidal Workgroup vital signs, rankings, and workgroup justification

Category	***Original Vital Sign***	***Workgroup Vital Sign***	***Justification***	***Initial Rank***	***Workgroup Rank***
Climate	Basic climate	Climate	Response Variability - All criteria apply; Management Significance - These core parameters not directly linked to management actions; Feasibility - Many well-documented baseline data sources available; Ecological Relevance - Useful information to interpret species responses.	M	H

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
Disturbance	Natural disturbance regime	Natural disturbance regime	Response Variability - All criteria apply; Management Significance - No direct relationship to management; Feasibility - Documented in literature/by other VS monitoring. Analysis needed; Ecological Relevance - Useful information to interpret species responses.	L	H
Hydrology/ Geomorphology	Tidal Patterns	Tidal Patterns	Management Significance - Not directly related to management issues but important to understanding biotic changes; Feasibility - Data may be available from other sources;	M	M
	Substrate composition	Substrate composition	Management Significance - Not directly related to management issues but important to understanding biotic changes. Cobble beaches subject to change due to theft/storms; Ecological Relevance - Mud flats substrate can change seasonally and long-term.	M	H
Abiotic condition	Core water chemistry	Water chemistry	Response Variability - Well documented methods. Useful for long-term measurements; Management Significance - These core parameters not directly linked to management actions; Feasibility - Inexpensive, easy to implement. Low impact to resources; Ecological Relevance - Useful for understanding changes in distribution of flora & fauna.	M	H

Appendix N: NETN Vital Signs Selection Workshop Summary

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
Biotic condition	Focal Taxa - Additional		Response Variability - Temp & spatial variability less than multiple taxa studies; Management Significance - All criteria apply; Feasibility - Can decrease the variability in sampling design, less costly, easy to find specialists to conduct studies. May need to identify multiple focal taxa.; Ecological Relevance - All criteria apply.;	M	M
		Community Type	Ecological Relevance - Important for tracking long-term, large scale changes.;		H
	Species composition - fauna	Species composition - fauna	Response Variability - High spatial and temporal variability; Management Significance - All ranking criteria; Feasibility - Numerous well-documented methods and considerable disagreement! No methods considered "rapid". Good baseline data for BOHA, very little for ACAD; Ecological Relevance - All ranking criteria;	H	H
	Species composition - flora	Species composition - flora	Response Variability - High temporal & spatial variability; Management Significance - Same as "fauna". Also indicator of trampling; Feasibility - Easier to assess species composition of macroalgae & other higher plants since they are sessile; Ecological Relevance - Same as "fauna".	H	H

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
	Species of concern	Species of concern	Response Variability - Same as Focal Taxa.; Management Significance - Some species (harlequin, black ducks, wading birds, purple sandpipers) of management concern; Feasibility - Same as Focal Taxa. No species of concerns obvious indicators in these areas; Ecological Relevance - Some species (harlequin, black ducks, wading birds, purple sandpipers) of ecological concern.	L	L
	Vegetation Condition	Vegetation Condition	Feasibility - Can be accomplished concurrently with other qualitative monitoring (redundant with species composition).	H	L
Ecological process	Nutrient cycling	Nutrient cycling	Response Variability - High spatial variability; Management Significance - Tightly coupled to the nutrient enrichment issue, esp.in mudflats. May increase in significance in future; Feasibility - Difficult to quantify in this environment. BOHA has extensive water quality data - other existing programs may supply additional info; Ecological Relevance - Not highly important in rocky intertidal, perhaps more in mudflat sediments. More applicable in basins with low flushing rates. Are better indicators.	M	M

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
	Phenology	Phenology	Response Variability - Medum variability. May not be able to predict "health of park; Management Significance - Very important with respect to climate change issues. Perhaps not valuable sign for NPS local management issues. May affect national policy; Ecological Relevance - Patterns do exist related to species life history as related seasonal changes.	M	M
	Productivity	Productivity	Response Variability - High spatial & temporability; Management Significance - Not redundant; Feasibility - Determining density of grazers could be accomplished by either focal taxa or species composition monitorng. Analysis if this information needed; Ecological Relevance - Larger issue than just "predator compostion". Grazers and predators such as sea stars have high impacts on intertidal species.	M	M
	Trophic dynamics	Trophic dynamics	Response Variability - High spatial & temporability; Management Significance - Not redundant; Feasibility - Determining density of grazers could be accomplished by either focal taxa or species composition monitorng. Analysis if this information needed.; Ecological Relevance - Larger issue than just "predator compostion". Grazers and predators such as sea stars have high impacts on intertidal species.;	M	M

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
Focal park resource	Breeding Birds	Breeding Birds	Feasibility - Information will hopefully be captured by other workgroup monitoring efforts; Ecological Relevance - Resting and feeding migratory birds more important than breeding birds as indicators.;	M	L
		Migratory Birds	Response Variability - High variability; Management Significance - Areas can be managed to reduce human disturbance. Strong constituency among park visitors.; Feasibility - All criteria apply; Ecological Relevance - All criteria apply;		M
	Harbor Seals	Harbor Seals	Management Significance - Could limit human impacts if visitor use increases in future; Ecological Relevance - Not that many, only around in winter.;	L	L
	Mandated Species	Mandated Species	Management Significance - Parks usually have management plan (including monitoring component) for mandated species; Ecological Relevance - No known mandated species exclusive to intertidal. Bald eagle utilize intertidal, Common tern at BOHA.;	M	L
	Viewshed	Viewshed	Management Significance - In ACAD enabling legislation;	L	L
Landscape context	Landcover	Landcover	Ecological Relevance - Movement between systems and recruitment patterns occur differently than in terrestrial systems.;	M	L
	Landscape buffer	Landscape buffer	Ecological Relevance - Landscape buffer issues related to human development are important t mudflats. Most not relevant to rocky shores,;	H	M
	Landuse	Landuse	Management Significance - Tightly coupled to nutrient enrichment issues, which are important to mudflats.;	H	M

Appendix N: NETN Vital Signs Selection Workshop Summary

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
	Park boundary	Park boundary		M	L
Management	Park infrastructure	Park infrastructure	Management Significance - Increasing visitor use and new/rebuilt facilities at BOHA. Charley says: this is stupid- this is not a Vital Sign.; Feasibility - Sin;	M	L
		Harvesting	Management Significance - Highly relevant due to commercial and recreational in both rocky intertidal & mudflats. Want to understand what harvest levels are; Feasibility - Data may be available from external sources; Ecological Relevance - Major disturbance issue relative to trophic dynamics.;		H
	Trail network	Trail network	Management Significance - This is related to visitor use.	M	M
	Visitor use	Visitor use	Management Significance - This is related to trampling, and resource taking/damage. Usually localized to designated visitor use areas and should be able to be controlled by education, etc.; Feasibility - Visitor use should be monitored in the intertidal zone. Fishing/shellfishing permits should be quantified. VS should analyze, not collect this information;	M	H
Stressor	Acidic deposition & stress	Atmospheric deposition	Ecological Relevance - N/A Seawater is well buffered!	H	L

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
	Contamination	Inventory-Contamination	Management Significance - Oil and contaminant spills are a major concern,; Feasibility - Other prescribed monitoring activities will provide baseline information in the event of resource damage. Should be high priority for INVENTORY; Ecological Relevance - Baseline inventory of sediment hydrocarbon levels useful for damage assessment.	M	L
	Dark Night Sky	Dark Night Sky	Management Significance - N/A for this system;	L	L
	Fertilizer use	Fertilizer use	Feasibility - Easy way of quantifying nutrient enrichment. More useful if linked to aquatic or other workgroups; Ecological Relevance - Amount of fertilizer use may be relevant for mudflats.	M	M
	Heavy metal contamination	Heavy metal contamination	Ecological Relevance - Same issues as CONTAMINATION	M	L
	Herbicide/pesticide use	Herbicide/pesticide use	Feasibility - May want to inventory in tidal mudflats; Ecological Relevance - Watershed issues that tie into mudflats. Dilution too great in intertidal.;	M	L
	Hydrologic alteration	Hydrologic alteration	Management Significance - Site specific management concern.	M	L
	Invasive exotic species	Invasive exotic species	Ecological Relevance - Large potential for alteration of species distribution and abundance.	H	H
	Noise	Noise		L	L
	Roads	Roads	Ecological Relevance - Low-priority research issue to investigate the effects of deicing material on intertidal.	H	L
	Septic systems/Waste water Discharge	Septic systems/ Wastewater Discharge	Management Significance - Should be aware of discharge issues; Feasibility - Most information obtained from associated monitoring efforts.	M	M

Category	*Original Vital Sign*	*Workgroup Vital Sign*	*Justification*	*Initial Rank*	*Workgroup Rank*
	Shoreline erosion/sea level rise	Shoreline erosion/sea level rise	Management Significance - High issue with boat wakes in BOHA.; Feasibility - Info on sea level rise available from other sources.; Ecological Relevance - More prevalent in BOHA due to softer sediments.	H	H
	UVB	UVB	Ecological Relevance - N/A to intertidal;	M	L

Table 8. Mandatory and optional measures for high priority Vital Signs recommended by the intertidal workgroup

Category	*Workgroup Vital Sign*	*Mandatory Measures*	*Optional Measures*
Climate	Climate	Temperature, precipitation by type, wind speed and direction	relative humidity, snow depth
Disturbance	Natural disturbance regime		
Hydrology/ Geomorphology	Substrate composition	Substrate composition	redox potential
Abiotic condition	Water chemistry	Temperature, conductivity, secchi disk	pH
Biotic condition	Community Type	Substrate and biotic assemblage mapping	
	Species composition - fauna	Species richness, species abundance, and species distribution	seasonality
	Species composition - flora	Species richness, species abundance, and species distribution	seasonality
Management	Harvesting	Analysis of other data sources	
	Visitor use	Number of visitors by location & activity, number fishing/shellfishing permits, trampling disturbance impacts	number boats, wildlife disturbance impacts??
Stressor	Invasive exotic species	Species richness, species abundance, and species distribution	
	Shoreline erosion/sea level rise	Relative surface elevation, shoreline change	

Overall Workshop Summary

Northeast Temperate Network High Priority Vital Signs

The core planning team identified and ranked seventy-six potential Vital Signs in 8 categories and 4 workgroups prior to the workshop. After the workshop participants reviewed and revised the proposed list of Vital Signs, twenty-seven (27) were identified by at least one (1) workgroup as high priority for NETN (Table 9). These Vital Signs represent an integrated list of ecological processes, biotic and abiotic conditions, and stressors to park ecosystems, and are directly relevant to the natural resource management issues of a majority of NETN parks (Table 9). Nineteen of the twenty-seven Vital Signs (70%) apply to nine (9) or more network parks, creating a framework to design a standardized, comprehensive monitoring program where protocols can be designed and implemented within the majority of network parks. The exceptions to a comprehensive, network-wide monitoring program occur with the intertidal and lake ecological systems where these resources add system specific Vital Signs that are not readily transferable to parks without lakes and intertidal communities (i.e. intertidal substrate composition, sea-level rise, lake morphometry, and zooplankton community).

All four workgroups identified climate, species composition flora/fauna, and invasive exotic species as high priority Vital Signs, but 59% (16/27) of high priority Vital Signs were identified by 1 workgroup (Table 9). Three workgroups identified water chemistry, landcover/landuse, atmospheric deposition, and contamination as high priority Vital Signs and two workgroups identified hydrology, visitor impacts, and nutrient enrichment.

Using the list of twenty-seven Vital Signs, NETN staff and the core planning team, will begin to build a comprehensive ecological monitoring plan intended to provide an integrated program that addresses significant issues to NETN park natural resources. The results of this workshop and recommendations solicited from biogeochemists and contaminants experts, will be presented to the NETN Board of Directors, park staff, and the Technical Steering Committee at a meeting this August. A draft of the NETN Phase 2 report, including a chapter describing the prioritization and justification of selected Vital Signs, will be submitted to the National I&M program and available for review 1 October 2004.

Acknowledgements

The NETN core planning team warmly acknowledges all workshop participants for taking the time out of already over committed schedules to assist the National Park Service with this important effort. The results of this workshop provide the foundation, direction, and justification for the development and implementation of a long-term ecological monitoring program throughout NETN parks and will provide the necessary information to better manage park natural resources. We would also like to thank the Acadia NP and Schoodic Education Research Center staff for their participation, logistical support, and assistance with workshop preparation.

Table 9. High priority Vital Signs for Northeast Temperate Network Parks based on the prioritization by Vital Signs Selection Workshop, the number of workgroups (#WG's) that rated each Vital Sign as a high priority, and the parks where each Vital Sign applies to natural resource management decision making.

Category	High Priority Vital Signs	# WG's	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
Climate	Climate	4	X	X	X	X	X	X	X	X	X	X	X
Disturbance	Natural Disturbance Regime	1	X	X	X	X	X	X	X	X	X	X	X
Hydrology/ Geomorphology	Hydrology	2	X	X	X	X	X	X	X	X	X	X	X
	Intertidal Substrate Composition	1	X		X								
Abiotic condition	Stream morphology	1	X	X		X	X	X	X	X	X	X	
	Lake morphometry	1	X			X							X
	Spring/seep distribution	1	X	X	X	X	X	X	X	X	X	X	X
	Water chemistry	3	X	X	X	X	X	X	X	X	X	X	
Biotic condition	Fish community composition	1	X	X		X	X	X	X	X	X	X	X
	Intertidal Community Type	1	X		X								
	Zooplankton community – Lakes	1	X			X							X
	Species Composition – fauna	4	X	X	X	X	X	X	X	X	X	X	X
	Species Composition – flora	4	X	X	X	X	X	X	X	X	X	X	X
	Water quality - trophic status	1	X			X							X
	Macroinvertebrate community comp.	1	X	X	X	X	X	X	X	X	X	X	X
	Vegetation Community Structure and demography	1	X	X	X	X	X	X	X	X	X	X	X
	Focal Taxa – Forest Breeding Birds	1	X	X		X	X	X	X	X		X	X
Landscape context	Landcover/ Landuse	3	X	X	X	X	X	X	X	X	X	X	X
Management	Visitor Impacts	2	X	X	X	X	X	X	X	X	X	X	X
	Harvesting	1	X		X	X							
Stressor	Atmospheric deposition	3	X	X	X	X	X	X	X	X	X	X	X
	Contamination	3	X	X	X	X	X	X	X	X	X	X	X
	Invasive exotic species	4	X	X	X	X	X	X	X	X	X	X	X
	Shoreline Erosion/sea level rise	1	X		X								
	Ozone	1	X	X	X	X	X	X	X	X	X	X	X
	White-tailed Deer Herbivory	1	X	X		X	X	X	X	X	X	X	X
	Nutrient Enrichment	2	X	X	X	X	X	X	X	X	X	X	X

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Freshwater Issues for National Parks of the Northeastern United States

PHASE II: Selection of Water Quality Monitoring Variables for NETN Parks

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LIST OF ACRONYMS

ACAD	Acadia National Park
ANC	Acid neutralizing capacity
BMP	Best management practices
BOHA	Boston Harbor Island National Recreation Area
CASTNET	Clean Air Status and Trends Network
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
IBI	Index Biotic Integrity
MABI	Marsh-Billings-Rockefeller National Historical Park
MIMA	Minute Man National Historical Park
MORR	Morristown National Historical Park
MWRA	Massachusetts Water Resources Authority
NADP	National Atmospheric Deposition Project
NAWQA	National Water-Quality Assessment Program
NHP	National Historical Park
NHS	National Historic Site
NOAA	National Oceanic and Atmospheric Agency
NP	National Park
NPS	National Park Service
NRA	National Recreation Area
NETN	Northeast Temperate Network
QA/QC	Quality assurance/quality control

ROVA	Roosevelt-Vanderbilt National Historic Site
SAGA	Saint-Gaudens National Historic Site
SAIR	Saugus Iron Works National Historic Site
SARA	Saratoga National Historical Park
USGS	U.S. Geological Survey
WEFA	Weir Farm National Historic Site

Introduction

The Northeast Temperate Network (NETN) is made up of the following 10 National Parks (NP), National Historical Parks (NHP), National Recreation Areas (NRA), and National Historic Sites (NHS):

1. Acadia NP, Maine (ACAD)
2. Boston Harbor Island NRA, Massachusetts (BOHA)
3. Marsh-Billings-Rockefeller NHP, Vermont (MABI)
4. Minute Man NHP, Massachusetts (MIMA)
5. Morristown NHP, New Jersey (MORR)
6. Roosevelt-Vanderbilt NHS, New York (ROVA)
7. Saint-Gaudens NHS, New Hampshire (SAGA)
8. Saugus Iron Works NHS, Massachusetts (SAIR)
9. Saratoga NHP, New York (SARA)
10. Weir Farm NHS, Connecticut (WEFA)

In all NETN parks, freshwater resources are subjected to natural and anthropogenic impacts and alterations, which, in some cases, have imposed stress on these resources for many years. Current and historic threats facing aquatic ecosystems in National Park Service (NPS) units throughout the northeastern U.S. have led to specific physical, biological, or chemical stressors to the freshwater ecosystems.

The amount of available water-quality and water-quantity data is variable for the NETN parks. Although limited water-quality monitoring has been done in each of the parks, no systematic water-quality and water-quantity data have been collected with adequate quality assurance over a period of record sufficient to characterize baseline conditions and evaluate spatial and temporal changes in freshwater resources throughout a park. The documentation of baseline water-quality and water-quantity conditions is

critical to the long-term maintenance of freshwater resources in the parks. Changes in baseline conditions will assist natural resource managers to identify and manage stressors in park freshwater ecosystems.

A project to design freshwater-resources monitoring will be conducted in three phases.

PHASE I: Produce a scoping report for the NETN parks.

PHASE II: Design prototype guidance for monitoring freshwater resources in the NETN parks. This includes prioritizing the list of candidate monitoring variables into a final list of variables (vital signs) that will be measured in all NETN parks.

PHASE III: Conduct feasibility (pilot) testing of recommended freshwater-quality/aquatic-resource vital signs at select NETN parks in order to finalize the freshwater-resource-monitoring design for the network.

This report is a product of Phase II, in which the list of vital signs developed in Phase I, is reviewed and ranked, and specific measures of high-priority vital signs are proposed. The report includes a summary of a workshop in which professionals in the field of freshwater-quality monitoring discussed the potential list of vital signs and made recommendations as to their ecological relevance, management significance and utility, feasibility, and response variability.

The report also includes a comparison of the recommended list of high-priority vital signs and the water-quality monitoring that is currently taking place in the parks. This includes a preliminary evaluation of the availability of protocols, the identification of quality-assurance and quality-control measures, and/or data storage practices.

Summary of the FreshwaterAquatic Session at the Vital Signs Selection Workshop

The objective of the aquatic workgroup was to review and make changes to the preliminary list of freshwater aquatic vital signs. In the initial review, workgroup participants added, removed, renamed, and regrouped vital signs. The second part of the review process was to rank the new list. A summary of appreciable changes to vital signs follows. A list of changes in names or groupings is provided in table 1.

Table 1. Summary of vital signs, rankings, and aquatic workgroup justifications.
[H, high; M, medium; L, low; NA, not applicable]

Category	***Original vital sign***	***Workgroup vital sign***	***Justification***	***Initial rank***	***Workgroup rank***
Climate	Basic climate	Climate	Measures such as temperature & precipitation critical to understanding ecological condition of aquatic resources. Provides background explanation for changes or variations in other vital signs. Available from other agencies- we can compile & regionalize.	M	H
Disturbance	Natural disturbance regime	Natural disturbance regime	High ecological relevance. Low management relevance.	L	L
Hydrology/ Geomorphology	Morphology - channel	Stream morphology	Necessary to compile/collect this information in order to better design monitoring program. Could be monitored on a periodic/infrequent basis.	M	H
	Morphometry - lake	Lake morpho-metry	Necessary to compile/collect this information in order to better design monitoring program.	M	H

Category	*Original vital sign*	*Workgroup vital sign*	*Justification*	*Initial rank*	*Workgroup rank*
	Water quantity	Water quantity	Important information, but optional because of cost/feasibility. Lake levels may be feasible, whereas streamflow could be prohibitively expensive. Important to map distribution of springs and seeps.	H	H
	Substrate composition	Substrate composition	Used on an optional/site-specific basis at some parks. Too difficult to apply parkwide at all parks. May be reasonable at smaller parks.	M	M
Abiotic condition	Core water chemistry, Water quality - total dissolved ions, Water quality - total organic carbon	Water chemistry	Essential indicator for any long-term aquatic monitoring program. Critical for interpreting biotic condition & ecological processes. Easily collected--readily available protocols	M	H
Biotic condition	Focal taxa - Fish	Focal taxa-fish	By definition, not an indicator of ecological condition. May be more appropriately covered by other programs.	L	L
	Species composition - fauna	Fish community composition	Fish integrate physical, chemical & biological environment over long term-- esp. in streams	H	H
Biotic Condition (cont.)	Species composition - fauna	Zooplankton community composition in lakes	Indicative of trophic status of lakes- respond to changes in water chemistry, nutrients, and predation by fish and other invertebrates. Has not been applied as widely as fish or macroinverts in streams.	NA	H
	Species composition - flora	Phyto-plankton community composition	Medium priority in lakes, but not as important as other indicators	NA	M
	Species composition - flora	Macrophyte community composition	Medium priority in lakes, but not as important as other indicators	NA	M
	Species composition - flora	Periphyton community composition	Medium priority in streams, but not as important as other indicators	NA	M

Category	*Original vital sign*	*Workgroup vital sign*	*Justification*	*Initial rank*	*Workgroup rank*
	Species of concern	Species of concern	Not necessarily a good indicator of ecological condition.	L	L
	Water quality - algal biomass, Water quality – clarity, Water quality - Lake trophic status, Water quality - nutrient loading	Trophic status	Indicative of stress-- widely understood by land managers and often linked to management actions. Standard protocols can be rapid, cost effective & easily tracked.	H	H
	Water quality-macro-invertebrates	Macro-invertebrate community composition in streams	Macroinvertebrates integrate physical, chemical & biological environment over short term-especially in streams. Numerous protocols available.	M	H
	Water quality-micro-organisms	Water quality – micro-organisms	More a public health concern than indicator of ecological condition.	H	L
Ecological process	Nutrient cycling	Nutrient cycling	Low management relevance inititally. Could be useful to interpret other monitoring variables later in program	M	L
	Phenology	Phenology	Low management relevance inititally. Could be useful to interpret other monitoring variables later in program	M	L
	Trophic dynamics	Trophic dynamics	Low management relevance inititally. Could be useful to interpret other monitoring variables later in program	M	L
Focal park resource	Mandated Species	Mandated Species	By definition, not an indicator of ecological condition. May be more appropriately covered by other programs.	M	L
Landscape context	Landcover, Landscape buffer, Landuse, Park boundary	Landcover/ Landuse	Important as an inventory variable-- may need to update on a periodic basis as needed.	H	H

Category	*Original vital sign*	*Workgroup vital sign*	*Justification*	*Initial rank*	*Workgroup rank*
Management	Land management, Park infrastructure, Trail network	Park management	Minimal ecological relevance if already being tracked/evaluated by park staff.	M	L
	Visitor use	Visitor use	Fish stocking/fish harvesting the primary concern- only at some parks.	M	M
Stressor	Acidic deposition & stress	Atmospheric deposition	High ecological relevance. Best strategy may be to collect this information from other sources because of high cost/complexity	H	H
	Beaver engineering	Hydrologic alteration	Will be tracked with water quantity.	H	L
	Contamin-ation, Heavy metal contamination	Contamin-ation	Important to map sources of contamination and compile this information in a database before the feasibility/necessity of a monitoring program can be assessed. Important at some parks, but expensive.	M	H
	Fertilizer use	Fertilizer use	Will be covered by landcover/landuse	M	L
	Herbicide/ pesticide use	Herbicide/pe sticide use	Will be covered by landcover/landuse	M	L
	Invasive exotic species	Invasive exotic species	Important management concern at all parks. Presence/absence surveys & early intervention critical for health/viability of native species.	H	H
	Roads	Roads	Top management concern, but could be picked up by other vital signs such as landuse & water chemistry. May guide site selection.	H	M
	Septic systems/Wast ewater Discharge	Septic systems/ Wastewater Discharge	Important for understanding trends in water quality. Trophic status may give an indication of the extent of this problem, but worth collecting number of septic systems/discharges explicitly.	M	H
	Shoreline erosion/sea level rise	Shoreline erosion/sea level rise	Not a big concern for freshwater aquatics	H	L

Category	*Original vital sign*	*Workgroup vital sign*	*Justification*	*Initial rank*	*Workgroup rank*
Stressor (cont.)	Soil erosion	Soil erosion	Site specific issue- not a widespread concern at most parks	H	L
	UVB	UVB	Low management relevance.	M	L

Review and Ranking of Vital Signs

The vital sign "Core water chemistry" was changed to "Water chemistry" and now includes total dissolved ions, and total organic carbon as mandatory measures in addition to the previous mandatory measures of pH, temperature, dissolved oxygen, and specific conductance. The high priority remained. The vital sign "Water quality-lake trophic status" was changed to the more general "Water quality-trophic status" in order to include streams. The water quality vital signs of "algal biomass," "water clarity," and "nutrient loading" or "nutrients" were incorporated into trophic status. Although lake trophic status was originally ranked as medium, the addition of the other components to this new vital sign caused the workgroup to upgrade the rank to high.

One of the more significant changes the workgroup made was a splitting of "species composition-flora" and "species composition-fauna" into the more specific taxonomic groups: community compositions of fish, macroinvertebrates, and zooplankton for fauna; and phytoplankton, periphyton, and macrophytes for flora. Each community composition vital sign was ranked individually for lakes versus streams, and

the highest ranking for each vital sign was chosen for the appropriate target resource. The workgroup ranked fish and macroinvertebrates in streams and zooplankton in lakes as high, while phytoplankton and macrophytes in lakes and periphyton in streams were ranked medium.

"Focal taxa fish," "species of concern," and "mandated species" all remained low priorities. Although the importance of these potential vital signs was recognized, the group felt that by definition, they are not necessarily good indicators of ecological integrity and would perhaps more appropriately be monitored by park specific programs. "Water quality-microorganisms," was recognized as important for human health, but was a low priority in terms of its usefulness to assess ecological integrity.

The vital signs "basic climate" and "acidic deposition and stress" were renamed "climate" and "atmospheric deposition," respectively. The importance of these vital signs was not questioned, but the ability of this program to improve greatly on the information that is already being collected by other networks was questioned. They remained high-priority vital signs with the recognition that the inventory and monitoring program may not be collecting data, but rather compiling this information from other sources.

"Natural disturbance regime," "trophic dynamics," "phenology," and "nutrient cycling" were all considered beyond the scope of the inventory and monitoring program, although some of the measures and components of "trophic dynamics" and "nutrient cycling" were incorporated into "trophic status." There was a recognition that these vital signs may be important to understand and interpret data in the future, but would be ranked as low priority for assessment for the present.

The group felt strongly that a distinction should be made between inventory vital signs and monitoring vital signs. Inventory vital-sign information would be collected or compiled at the start of the monitoring program, could potentially guide the design of the monitoring program, and would be critical for interpreting monitoring data by providing context. Inventory vital signs included "lake morphometry," "channel morphology," "landcover/landuse" and "contamination." "Landcover/landuse" included the original vital signs of "landcover," "landuse," "landscape buffer" and "park boundary," while "contamination" included "heavy metal contamination." The frequency of collection/compilation of these inventory variables could range from biannually to once every decade, and would be guided by changes in the watershed including operational changes at a park.

"Water quantity" remained a high priority. The workgroup recognized that lake levels would perhaps be easy and relatively inexpensive to measure, whereas continuous stream gaging might be prohibitively expensive. The mapping of springs and seeps in the parks was moved from its own category to now be included in water quantity.

The group did not reach consensus regarding "substrate composition." Some workgroup members felt it would be more appropriately named "benthic habitat." This received a rank of medium recognizing that in some parks it may be possible and (or) critical while in other parks it may be not as important and difficult to characterize across the entire park.

The vital sign called "park management" includes "land management," "park infrastructure," and "trail network." This vital sign was ranked low because workgroup participants felt that these features were probably already well monitored by the parks

and (or) documented information that was available or could be accessed as necessary. "Visitor use" remained its own vital sign, ranked medium, with the primary concern relating to fish stocking/harvesting. This has a big impact at some parks such as Acadia, and is not currently being monitored. At other parks it is not a significant issue.

There was a fair amount of discussion regarding the category of stressors and how they should fit into a monitoring program of ecological integrity. The conclusions of the workgroup were that "invasive exotic species" and "septic/waste water discharge" were ranked high, "roads" was ranked medium, and the rest were ranked low. The group felt that "fertilizer use" and "herbicide/pesticide" use would be captured in "landcover/landuse"; "soil erosion" was not a serious networkwide issue, but could become important on a case-by-case basis; "hydrologic alterations" (now including "beaver engineering") would be captured by "water quantity"; "UVB" was beyond the scope of this program; and "shoreline erosion/sea-level rise" was more of an intertidal issue than one of freshwater aquatics.

Justifications, Measures, and Concerns for High Priority Vital Signs

The vital signs presented below are all high-priority vital signs as assessed by the aquatic workgroup. These vital signs address the ecological integrity of the parks and were selected to address the physical, chemical, and biological aspects of the ecosystem. In most cases, the workgroup recommended at least one mandatory measure; in several cases, they recommended multiple mandatory measures and additional optional measures (table 2). The workgroup also discussed and concluded that vital signs may be high priority for specific targets (lakes, streams, or springs/seeps) or may be high priority for all targets. Ground water is only considered as a target where specifically addressed.

Table 2. Mandatory and optional measures for high-priority vital signs recommended by the aquatic workgroup.

Category	**Workgroup vital sign**	**Mandatory measures**	**Optional measures**
Climate	Climate	Air temperature, precipitation by type	Relative humidity, total solar radiation, wind speed, wind direction, snow water equivalent, snow depth
Hydrology/ Geomorphology	Water quantity	None	Ground-water inputs, ground-water levels, lake water levels, spring/seep volume, streamflow
	Stream morphology	Gradient, drainage area, stream order	Run/riffle/pool survey, stream sinuousity, bankful lcross-sectional geometry
	Lake morphometry	Surface area, drainage area, elevation, lake type/origin, maximum and mean depth, bathymetry	Flushing rate
Abiotic condition	Water chemistry	Specific conductance, percent DO saturation, temperature, pH, color, turbidity	Iron, cations, anions, alkalinity/ANC, aluminum, dissolved organic carbon
Biotic condition	Fish community composition	Species abundance, species richness	None
	Zooplankton community composition	Species abundance, species richness	None

Category	Workgroup vital sign	Mandatory measures	Optional measures
	Water quality -- trophic status	Algal biomass, measures of water clarity such as secchi disk, and total and dissolved phosphorus	Macrophyte distribution, diel oxygen curves, periphyton abundance, and dissolved oxygen profiles
	Macroinvertebrate community composition	Species abundance, species richness	None
Landscape context	Land cover/ land use	Land cover/ecological system map	Buffer width, buffer vegetation, percent impervious surface in buffer or watershed, percent canopy shading for streams, patch connectivity, patch fragmentation, patch size distribution
Stressor	Atmospheric deposition	None	Inorganic toxics, dry deposition, mercury, wet deposition
	Contamination	None	Toxic boat paint use and concentrations in water, sediment contamination, MTBE/chloroforms/ trichloroethylene in water, contaminant spills, air toxic concentrations, bioaccumulation in indicator species
	Invasive exotic species	Presence/absence	Relative abundance
	Septic systems/ wastewater discharge	Track number of septic systems in the park	Track nearby septic permits and the location, quantity, and quality of wastewater discharges

Climate

Climate data provide background explanations for changes or variation in other vital signs. Measures of climate such as precipitation and temperature are critical to understanding the ecological condition of aquatic resources and biota (Hynes, 1975; Poff, 1997). Climate data are available so the parks probably will not have to collect them, but rather compile these data from other sources such as the National Oceanic and Atmospheric Administration (monthly reports) or the National Climatic Data Center (Sorenson and others, 1999). The short-term response variability for climate is clear; however the long-term response variability of changing climate is still under investigation.

Mandatory measures include air temperature and precipitation. Optional measures to compile include relative humidity, total solar radiation, wind speed, wind direction, snow water equivalent, and snow depth . Project managers would need to account for spatial variability to extrapolate regional information to parks.

Stream geomorphology

Baseline stream geomorphology will be important to collect and (or) compile from other sources because it is a major physical component of aquatic ecosystems. This information falls into the category of inventory because it will involve infrequent/periodic measurements rather than annual sampling. Channel geomorphologic units change due to both natural and anthropogenic factors (Leopold, 1994). Bankfull discharge, which has a recurrence interval from 1.5 to 2 years, also has been called the "channel forming discharge" and/or effective flow (Andrews, 1980; Leopold, 1994). Overbank flow, or floods, occur at less frequent intervals and can affect riparian zones

and land use as well as have significant effects on erosion, bed-load transport, sediment accretion and deposition in the channel, and modification of geomorphic structure of the channel (Leopold and others, 1964; Hill and others, 1991). Anthropogenic developments in the basin can alter the recharge and runoff to the stream and affect runoff by increasing the amount of peak runoff and reducing the duration of runoff.

Mandatory measures include stream order, drainage area, and gradient. In most cases, this will involve compiling available variables in a database. Optional measures could include run/riffle/pool geometry, bankfull cross-sectional geometry, and stream sinuosity from aerial photos or topographic maps. Delineation and measurement of channel geomorphologic units can be accomplished with existing protocols from the U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) program or the U.S. Environmental Protection Agency's (USEPA) Environmental Monitoring and Assessment Program (EMAP)(Fitzpatrick and others, 1998; Lazorchak and others, 1998). Representative reaches (20 times the mean channel width from NAWQA or 40 times the mean channel width from EMAP) can be assessed by two people in 2 to 3 hours.

Optional more frequent measurements would include surveys of channel geomorphologic units to quantify habitat types for aquatic biota. Each geomorphologic channel unit provides unique combinations of depth, velocity, and substrate composition. Substrate composition was its own vital sign and is discussed below.

Lake morphometry

Morphometric mapping of lakes provides baseline data for future reference, and may be available from existing sources. Mapping that includes substrate types and extent of macrophyte growth could be used to interpret macrophyte growth patterns, which

respond to changes in light penetration, substrates, nutrients, and water depth (Goldstein, 2000).

Mandatory measures include surface area, drainage area, elevation, lake type/origin, maximum and mean depth, and bathymetry. An optional measure would be flushing rate. Lake morphometry can be easily mapped with depth finders (fish finders) and GPS. This baseline information will be compiled initially and could guide monitoring site selection.

Water quantity

Information about water quantity is necessary to interpret other vital signs such as eutrophication, sediment processes, or contaminants because stream discharge is used to calculate annual loads and annual watershed yields. Furthermore, water quantity determines the physical extent and volume of aquatic habitat at the parks. Numerous factors affect water quantity including precipitation, evapotranspiration, water withdrawals, and ground-water recharge.

All measures are optional including ground-water inputs, ground-water levels, lake water levels, spring/seep volume, and streamflow, but measures such as lake water levels are considerably more easily obtained than streamflow, and thus are highly recommended. Existing stream gages with long historical records may be used to extend and interpret incidental measurements and (or) stage gages within parks if a relationship between the two sites is established. Although only two NETN parks have streamflow gages within or adjacent to park boundaries, the closest long-term streamflow gages have been identified in all cases.

Springs and seeps create unique aquatic resources. They are an integral component of ground-water-fed streams and can be critical for understanding the thermal regime and biodiversity of aquatic habitats because they indicate the quantity and quality of water in surficial aquifers as well as the interaction of surface and ground water. Furthermore, they are a good indicator of ecological integrity because they can indicate which contaminants that have been applied in the watershed are reaching surficial ground water and subsequently other aquatic resources (e.g., Cowdery, 1997).

Baseline inventory data should include the location and possibly the seasonality of springs and seeps in the park. Frequent monitoring water quality and quantity of springs and seeps may be beyond the scope of this program, but springs and seeps should be considered as a target for water quantity and water quality on a site specific basis. The relative importance of this information will depend on the size of the park/drainage basin. At smaller parks, the locations may be known; at the larger parks, aerial photography with thermal mapping can be used to locate springs and seeps after/during snowmelt. The size of the springs and seeps will change with climatic conditions and groundwater withdrawals. Water quality will depend on surrounding geology and land use in the watershed.

Water chemistry

Water chemistry directly addresses one of the inventory and monitoring objectives: to detect changes in the status of physical, chemical, or biological attributes or vital signs of the ecosystem. It is an essential indicator to any long-term aquatic monitoring program (Gilliom and others, 1995). It is widely applicable and is critical for interpreting the biotic condition and ecological processes of a resource. Water chemistry

affects the bioavailability of contaminants and the metabolism of aquatic species. For example, ionic conditions affect osmo-regulation (Hoar and Randall 1969) and contaminant uptake (Sinley and others, 1974; Luoma, 1989; Spry and Weiner, 1991); dissolved oxygen and temperature affect metabolic rate (Hoar and Randall, 1969). Successful reproduction requires the appropriate chemical conditions for fertilization and development of eggs and larvae (Holtze and Hutchinson, 1989).

Water-quality parameters are sufficiently well known that abnormal conditions and trends can be recognized or determined statistically. Mandatory measures include specific conductance, percent DO saturation, temperature, pH, color, turbidity. Targets include lakes, streams, springs and seeps unless specified. Ground-water chemistry could be considered where monitoring wells are in place.

Optional measures include iron, cations, anions, alkalinity/ANC, aluminum, dissolved organic carbon. Protocols for collection of water samples and standard methods of chemical analysis are widely available (e.g., Shelton 1994). Most of the mandatory water-chemistry measures can be obtained in the field or with relatively inexpensive laboratory analyses. Optional measures will vary depending on the needs of individual parks.

Fish community composition in streams

Richness and composition of fish species is a highly relevant and applicable vital sign because fish communities integrate their physical, chemical, and biological environment through time (Tonn and others, 1983; Gurtz, 1993). Species richness and composition in small streams can be obtained easily with the proper equipment (electro-fishing or small seine) (Meador and others, 1993; Moulton and others, 2002a). An

alternative, non-evasive method is direct observation and counts by divers with mask and snorkel (Goldstein, 1978). On average, a site can be sampled in about 2 hours. The size of the stream dictates the number of individuals needed, which will range from two to five (Moulton and others, 2002a). Although a representative sample of a fish community can be obtained from small- to moderate-sized streams, such a sample is not readily obtainable from larger rivers (Moulton and others, 2002a). Fish species composition can be evaluated with multimetric indices of biological integrity such as an index of biotic integrity (IBI) or by examination of species traits (Karr and others, 1986) (Goldstein and Meador, in press). These indices evaluate the quality of the resource by rating the ecological structure and functional composition of the community. Although a reference site normally is used for comparison, the initial sample for the monitoring program will constitute the baseline condition for comparison. Certain metrics can be diagnostic of specific environmental changes (Karr and others, 1986).

Mandatory measures include relative abundance and species richness in a representative sample, i.e., the numbers and identity of all species collected. Fish community composition in streams was ranked high priority wheareas fish community composition in lakes was ranked medium priority.

Zooplankton community composition in lakes

Zooplankton community composition and abundance is indicative of the trophic status of the lakes, reflects primary and secondary production (Porter, 1977), and also implies year class strength of most lotic fish species because early fish life history stages feed primarily on zooplankton. Therefore, community composition and abundance of the zooplankton not only reflect the abundance and composition of the phytoplankton, but

also provide a basis for predicting certain aspects of the fish community and fishery. If the timing of zooplankton blooms of the larger sized taxa is concurrent with the hatching of salmonid and centrarchid eggs, then zooplankton provide an abundant food source for these early fish life history stages (Goldstein and Simon, 1998); this implies greater survival, year class strength, and recruitment to the fishery. Like other biotic communities, zooplankton respond to changes in water chemistry, nutrients, and predation by fish and other invertebrates. Changes in zooplankton taxa composition and abundance in lakes has not been applied as an environmental indicator to the same degree as fish or invertebrates in streams.

The mandatory measures of zooplankton species richness and abundance are collected by either horizontal or vertical tows with a plankton net. Abundance (density) is based on the volume of water filtered. Identification and subsampling require special training. Zooplankton collection in lakes was ranked high priority whereas zooplankton collection in streams was ranked low priority.

Trophic status

Eutrophication causes degradation of park aquatic resources. Nutrient inputs cause nuisance algal blooms, unwanted macrophyte growth, odors, and even fish kills (Clady, 1977; Porcella, 1978; Porter and others, 1993). As land use changes from forest to agriculture or urban, the potential sources of nutrients increase. Trophic status is indicative of nutrient stress (Wetzel, 1983). It is widely understood by resource managers that when status levels change, management actions such as application of best management practices (BMPs) may be necessary to reduce inputs. Sufficient information

exists in the literature to quantify the trophic status of park lakes based on the measures listed below (Carlson, 1977).

Mandatory measures include algal biomass, measures of water clarity such as secchi disk, and total and dissolved phosphorus. Optional measures include macrophyte distribution, diel oxygen curves, periphyton abundance, and dissolved oxygen profiles. Many of these measures are seasonal. Standard protocols (e.g., Sorenson and others, 1999) can be rapid, cost effective, and easily tracked over time. Secchi disc readings, plankton tows for algal biomass (density) or chlorophyll a, and water samples for nitrogen and phosphorus can all be collected in a short period of time.

Macroinvertebrate community composition in streams

Invertebrate community taxa richness and composition is a highly relevant vital sign in streams because macroinvertebrates integrate their physical, chemical, and biological environment like fish, however, they do so in a shorter temporal period than fish (most invertebrate life cycles are accomplished in a single year compared to multiple years for fish). Therefore invertebrates may provide a "first response" vital sign**.** The integration is manifest in the taxa richness and composition. Macroinvertebrate community composition has been used to evaluate water quality and aquatic resources (Hilsenhof, 1987; Lenat, 1993). Collection of invertebrate samples is relatively easy. Numerous protocols exist (Lazorchak and others, 1998; Moulton and others, 2002a). For direct collections from natural stream substrates, two people can collect a sample in about an hour using standard equipment, nets with a 595/600-micron mesh (USEPA uses this mesh size for EMAP (Lazorchak and others, 1998). For indirect collections of artificial substrates or natural substrates placed in the stream for colonization, the collection time is

less, but an initial site visit is necessary to insert the sampler. The analysis, counting and identification, is not a trivial matter and can take up to 1 day per sample. The identification of invertebrate taxa requires specialized training or a specialty laboratory (Moulton and others, 2002b). Several invertebrate multimetric environmental indices are available for invertebrate data. The USGS has an Invertebrate Data Analysis System that contains more than 130 metrics available for use (Cuffney, 2003).

Mandatory measures include invertebrate taxa richness (measured to the lowest practicable taxa) and taxa abundance from a randomly selected subsample of 100 or 300 individuals from direct collections, but fewer individuals from indirect collections. Taxa abundance is the proportion of each taxa in the subsample. Macroinvertebrate collection in streams was ranked high priority whereas macroinvertebrate collection in lakes was ranked low priority.

Land use/land cover

This land use/land cover vital sign includes "landcover," "landscape buffer," "land use," and "park boundary." At a watershed level, land use and land cover affect the quality of aquatic environments (Stauffer and others, 2000; Meador and Goldstein, 2003). An initial inventory of land use and land cover will provide context for the observed ecological conditions. If changes occur in this condition, they can be interpreted in the context of land use or land cover at the watershed scale. Aquatic ecosystems respond to changes in landuse, and this response has been documented in urban, agricultural, and forested environmental settings (Meador and Goldstein, 2003).

This is a high-priority vital sign, but the measures can be collected or compiled as part of an initial inventory and updated only as changes in the watershed become

apparent. Most measures are optional depending on the park and need to reflect the varying scales and specific requirements of the parks. The only mandatory measure is a landcover/ecological system map. For most parks, these data already exist, are straight forward to interpret, and will help in site selection/prioritization.

Optional measures include buffer width, buffer vegetation, percent impervious surface in buffer or watershed, percent canopy shading for streams, patch connectivity, patch fragmentation, patch size distribution. The park boundary already exists for all parks, and can be updated as necessary.

Atmospheric deposition

Atmospheric deposition includes acid rain, inorganic compounds, and mercury. This vital sign was modified to include all atmospheric deposition (as opposed to just acidic deposition), and now includes only the deposition, rather than the response/stress to the aquatic resource. Measures of atmospheric deposition are critical for understanding water chemistry and stress (Likens and Bormann, 1974). Swain and others (1992) estimated that 90 percent of the mercury entering remote lakes in Voyageurs National Park (Minnesota) is derived from atmospheric deposition. However, these measures are expensive and may be covered sufficiently by other programs. Deposition at coarse resolutions is already measured as part of National Atmospheric Deposition Project (NADP) and the Clean Air Status and Trends Network (CASTNET). Information about deposition should drive site selection for measurements of water chemistry.

Optional measures include inorganic compounds, dry deposition, mercury, wet deposition. Although mercury deposition is an issue throughout the Northeast, other

types of atmospheric deposition may be an issue primarily in ACAD and along the Appalachian Trail.

Contamination

All members of the workgroup agreed that contamination (including heavy metal contamination) is ecologically relevant. The accumulation of trace elements and organic compounds in aquatic organisms can cause physiological problems and even death of aquatic organisms. Accumulated contaminants move upward through the food chain.

Initially there is a need for a better assessment of existing data to determine the sources and pathways of contamination. This vital sign may need to be added as a continuous monitoring variable at some parks after the initial inventory and assessment is complete. Some contaminants such as metals may be occurring at high levels "naturally." Responses may be difficult to interpret without long-term data.

All measures are optional and site specific, and include measures of toxic boat paint use and concentrations in water, sediment contamination, MTBE/chloroforms/ trichloroethylene in water, contaminant spills, air toxic concentrations, bioaccumulation in indicator species. Initially it is recommended that an inventory of contaminant sources and historical sites of contamination be compiled in a database if this is not already done. This vital sign would, however, require very expensive laboratory analyses, and may be beyond the scope of this program financially. Composite sampling may help to keep costs down (Correll, 2001).

Invasive exotic species

The presence and extent of invasive exotic species is a critical management concern at all parks in the network. Parks would benefit from quick identification and

removal of new invasive species, and monitoring and removal of already established invasive exotic species. Catastrophic consequences to native species, including loss of biodiversity and replacement of native flora and fauna, can result if this vital sign is not addressed.

Routine surveys for the presence/absence of particular invasive species are mandatory at all parks. Lists of non-native species with the potential to invade individual parks already exist in most states**.** These lists will identify the types of habitats to examine for invasive species. The relative abundance of established invasive species is optional.

Septic systems/wastewater discharge

It is important to collect the number of septic systems/wastewater discharges explicitly to understand trends in water quality related to measures of trophic status. Parks may not be able to affect change in nutrient inputs from wastewater sources outside the park, but this information still helps to interpret trends in water quality.

Tracking the number of septic systems in the park is mandatory and is information that is readily available. Tracking nearby septic permits and the location, quantity, and quality of wastewater discharges are optional measures.

Justifications, measures and concerns for medium-priority vital signs

Although the workgroup is not recommending the following vital signs for immediate inclusion in a monitoring program, information regarding the vital signs is included below because either a minority of workgroup members felt that they should be high-priority vital signs, or there was a general consensus that these medium-priority vital signs should have their priority reassessed as potential high-priority vital signs further

into the program as additional funding and (or) partnering with other agencies becomes available. Potential measures are included in some cases.

Phytoplankton community composition

Species richness and species abundance are optional measures. This vital sign was ranked medium priority for lakes and ranked low priority for streams. Phytoplankton respond to the physical and chemical conditions present at the time of collection; they reflect the water quality of the water mass they occupy (Clesceri and others, 1989; Porter and others, 1993).

Periphyton community composition

Species richness and species abundance are optional measures. Periphyton abundance (either cell volume or ash free dry mass) and chlorophyll a in streams can be a useful vital sign for nutrient enrichment, whereas species composition and abundance can be used in an Index of Biotic Integrity (Hill and others, 2000). This vital sign was ranked medium priority for streams and ranked low priority for lakes.

Macrophyte community composition

Species richness and species abundance are optional measures. Inherent in this vital sign are invasive aquatic plant species and a measure of lake eutrophication. Therefore, this sign was considered redundant. This vital sign was ranked medium priority for lakes and ranked low priority for streams.

Substrate composition

This vital sign is an important indicator of aquatic habitat (Stauffer and Goldstein, 1997; Goldstein and others, 2002), but may be reflected in invertebrate taxa composition and abundance. Sedimentation can be a major issue, so a rapid measure of embeddedness

could be used. Questions remain as to the frequency of monitoring because changes in substrate composition are related to the frequency of high-flow events (Andrews, 1980; Leopold, 1994). Detailed particle-size analysis is expensive, but visual evaluation techniques and indices could be applied.

Visitor use

Stocking/fishing issues are significant management issues in some parks, but not in others. The workgroup recommended that this be a park-specific vital sign to be monitored as needed. Parks generally do not know amounts of fish being harvested and (or) stocked where these activities are taking place.

Optional measures that the workgroup identified as higher priority include the number of fishing/shellfishing permits, and information regarding stocking (species stocked and location). Lower priority measures include the number of visitors by location and activity and the number of boats.

Roads

Roads were identified as a top management concern in most NETN parks. This vital sign was downgraded to medium because the aquatic workgroup felt that information surrounding roads as stressors could be picked up by other vital signs such as water chemistry, landcover/landuse, and contamination. Site selection/sampling design should, in some cases, be driven by road locations. Specific road-runoff studies are complex/expensive and may be beyond the scope of this monitoring program.

Optional measures include road network information, types of roads, measurements of quantity and quality of road runoff, amounts and types of de-icing

chemicals applied, and the presence/quality of nonpoint-source pollution control measures in place.

Conclusions

The workgroup was successful at meeting the objectives of reviewing and ranking the list of potential vital signs and providing initial justifications and measures for all of the vital signs ranked high and for most of the vital signs ranked medium. The goal of including vital signs for each of the three major components of ecosystems (physical, chemical, and biological) was accomplished and the list of high-priority vital signs is well balanced among the three components. Many potential vital signs were consolidated into other vital signs during the process, but in retrospect, it was useful to have all these potential vital signs considered independently. The workgroup found it easier to consider individual vital signs and then group them rather than to separate vital signs with multiple components. All participants provided valuable input.

Current Aquatic Monitoring Programs at NETN Parks

Five parks currently have water-quality and (or) water-quantity monitoring programs. The parks are ACAD, MORR, ROVA, SAGA, and SAIR. BOHA benefits from a monitoring program conducted by the Massachusetts Water Resources Authority (MWRA). The monitoring programs are summarized in the Phase I scoping report. The period of data collection varies; some monitoring programs were initiated as early as the 1970s and some as recently as 1998. The parks that do have monitoring programs primarily include the measures included in the high-priority vital sign water chemistry selected for the NETN monitoring program. Data collected as a part of this program will

provide historical comparisons and context for the data collected by the vital-signs program. In some cases, the NETN monitoring program will build on the program currently in place, especially where measures, sampling locations, and(or) sampling protocols are similar across programs. In other cases, however, because the monitoring programs at some of the parks are focused on specific aquatic resources or have different objectives than the vital-signs program, compatibility with the vital-signs program will vary. The remaining five parks (MABI, MIMA, SARA, WEFA, BOHA) have no known current freshwater-quality monitoring at present (2004) and will not be included in this part of the report.

Current Aquatic Monitoring Programs at NETN Parks Compared to High-Priority Vital Signs

The purpose of this section of the report is to determine the compatibility between data currently being collected (including protocols, quality assurance/quality control, and data-storage practices) and the measures associated with the high-priority vital signs selected for the NETN vital-signs monitoring program.

Direct comparisons or incorporation of the data from previous monitoring programs may be problematic for the following reasons. First, methods of analysis may have changed. For example, biological monitoring of stream macroinvertebrate communities has been conducted at four of the five parks, but the protocols or analyses are not consistent across the parks. For chemical analyses, there are different analyses used for certain constituents (e.g., pH) and so the results are not always comparable. Additionally, as chemical analytical methods advance and become more sensitive, detection limits decrease and accuracy and precision increase. As changes in

methodology progress, comparability decreases. For those parameters that are consistent with the high-priority vital signs, the number of samples or the frequency of sampling may not be the same. This introduces differences in estimates of variability (standard deviations and coefficients of variation) and affects measures of central tendency such as the mean or median values. At many of the parks, data from the vital signs such as climate and water quantity, which are important for interpreting water quality data, are intermittent or unavailable. Without this contextual information, including information about vital signs such as channel morphology or lake morphometry, historical trends in water quality will be difficult to interpret. Concentrations of chemical components change with dilution, and thus depend on water quantity. Standardization of concentration data by using water quantity data to calculate annual loads and yields can not be accomplished without water-quantity data, and so year-to-year comparisons become difficult.

A matrix shows where suggested measures and current measures intersect (table 3). The high-priority vital signs, and their mandatory and optional measures are listed down the vertical axis and the parks are listed along the top horizontal axis. In the corresponding box under each park are the components of the current monitoring programs.

Climate

None of the parks are collecting climate data. Meteorological measures such as precipitation, temperature, snowfall, snowpack conditions, and wind direction and speed are often available regionally from NOAA, National Weather Service, and the NADP. In

some cases, meteorological stations run by these agencies are within or very close to park boundaries.

Stream gemorphology

Only ACAD and MORR are regularly collecting stream geomorphology data. The Rapid Bioassessment protocol conducted at MORR does not, however, include many of the mandatory measures identified for this vital sign. The ACAD program includes many of the mandatory and optional measures. SAIR has limited stream morphology data at the USGS gage.

Lake morphometry

Several parks have had bathymetric surveys done at lakes within the parks. Most parks have estimates of surface area and mean depth of the lakes.

Water quantity

All the parks have access to local USGS stream-gaging data as part of their monitoring program. ACAD has 2 continuous-record streamflow gages within the park, and SAIR has a continuous-record streamflow gage just upstream from its northern boundary. Incidental streamflow measurements are collected at SAGA as part of the monitoring program. A USGS ground-water program at ACAD monitors water levels. None of the parks, except for SAIR, have mapped or consistently measured discharge at springs or seeps.

Water chemistry

All the parks have some type of water chemistry monitoring program. Many of the mandatory high-priority vital signs are collected as part of these programs, e.g., water

temperature, pH, dissolved oxygen, and conductivity. Differences then become park specific. Mandatory measures of NETN high-priority vital signs that are currently being measured by park personnel could be incorporated into the NETN monitoring program. The only park where this might pose some difficulty is at SAIR, where water chemistry (except for temperature and specific conductance) is sampled by volunteers.

Table 3. Comparison of current park aquatic monitoring program components with high-priority vital signs.

[Empty boxes indicate no program components for the vital sign at a specific park; USGS, U.S. Geological Survey; NADP, National Atmospheric Deposition Program; NOAA, National Oceanic and Atmospheric Agency; NWS, National Weather Service; NPS, National Park Service; DEP, Department of Environmental Protection].

Vital Sign	Proposed measures	Measures currently collected					
		Acadia National Park	**Boston Harbor Island National Recreation Area**	**Morristown National Historical Park**	**Roosevelt-Vanderilt National Historic Site**	**Saint-Gaudens National Historic Site**	**Saugus Iron Works National Historic Site**
Climate	Optional: Air temperature and precipitation Wind speed and direction, precipitation by type, snow depth, snow water equivalent, relative humidity, and solar radiation.	NADP collects precipitation and air temperature data. NOAA and NWS collect precipitation, temperature, snowfall, snowpack conditions, wind direction and speed data.					USGS collects precipitation, air temperature, wind speed and direction data just upstream from park (station does not conform to National Weather Service standards).
Stream geomorphology	Mandatory: Stream order, drainage area, gradient Optional: Run/riffle/pool geometry, bank full cross-sectional geometry, stream sinuosity a substrate map of the stream bottom, surveys of channel geomorphologic units	Stream physical habitat data is collected at six macroinvertebrate monitoring sites by NPS. Data include channel width, depth, substrate composition, and canopy cover. Data not yet analyzed.	Not applicable	Stream habitat is evaluated with the rapid bioassessement program (Plafkin and others, 1989).			USGS has drainage area and bankfull cross-sectional geometry data just upstream from park.

Lake morphometry	Mandatory: Surface area, maximum and mean depth, drainage area, lake type and origin, bathymetry, and elevation Optional: Flushing rate	Surface area, maximum and mean depth, lake type and flushing rates for many of Acadia's lakes including the five largest lakes from the 1982 resource management plan. Lake surface areas included in 2000 Water Resources Management Plan.	Not applicable	There is some monitoring of Cat Swamp Pond due to concern over dam integrity.	A bathymetric study of the impounded part of Fall-Kill Creek was conducted by Pandullo-Quirk Associates (1979).	Pond and wetland bathymetry mapped (Cronan and Associates, 1981) and Bureau of Reclamation survey of dams	Not applicable
Water quantity	Optional: Streamflow, spring seep volume ,and inventory, lake water levels, groundwater levels, groundwater inputs	Two USGS continuous-record, streamflow gaging-stations in park: (USGS stations 01022835 and 01022860). Period of record is 1999 to 2004 USGS monitors water levels and water quality at four ground-water wells on Mount Desert Island. (USGS well numbers 441516068194101, 441650068210801, 442238068154101, and 442450068175201). Three of these wells are within park boundaries. Period of record is 2003 to 2004.		Two USGS stage-gages in park (USGS station 01378775 and USGS station 01378778). Period of record is 2003 to 2004. There are several groundwater wells installed in the park-not currently in operation.		Incidental discharge measurements taken concurrently with water quality measurements by NPS. Locations of wells and seeps shown in 1992 report USGS WRIR 92-4013.	USGS continuous-record, streamflow gaging-stations on the Saugus River (USGS station 01102345) just upstream from the park. Two freshwater springs in park have been mapped and discharge measured.
Water chemistry	Mandatory: Water temperature, specific conductance, pH, dissolved oxygen, percent dissolved oxygen saturation, color and turbidity Optional: Anions, cations DOC, alkalinity, ANC, iron, aluminum	Lake monitoring by NPS in cooperation with the Maine Department of Environmental Protection in selected lakes on Mount Desert Island to monitor change due to eutrophication and atmospheric deposition. Monitoring started in the late 1970s includes secchi disk water-column transparency and surface temperature. The program continues today, with monitoring expanded to include the following: pH, Acid neutralizing capacity, Specific conductance, True color, Dissolved organic carbon, Dissolved inorganic carbon, Major ions,	The Massachusetts Water Resources Authority has monitored wastewater and effluent components, nutrients, and water chemistry (1992-2004). Parameters (not all collected at all stations) include surface and bottom water temperature, dissolved oxygen, salinity, secchi depth,	NPS monitors the following parameters on 11 sites since 1982: temperature, pH, conductivity, and salinity; and concentrations of dissolved oxygen, chloride, total dissolved solids, and fecal coliform on a monthly basis at 11 stations. Occasional samples for fecal coliforms and fecal	The park initiated a water-quality monitoring program in 1994. Temperature, pH, dissolved oxygen, salinity, and conductivity are being collected at all three units on a monthly basis. Data on additional parameters, including concentrations of chloride, phosphate, and nitrate, and	Water-quality parameters are measured at six permanent monitoring stations: water temperature, water depth, dissolved oxygen, conductivity, pH, and turbidity. NH_4 - ammonia, NO_3 – nitrate and phosphorus (PO_4 - orthophosphate) were measured in	Water- quality parameters collected monthly by the Saugus River Watershed Council include pH, dissolved oxygen, temperature, and bacteria – fecal coliform (1998-2000) and e. coli (2001-2002) Water temperature and specific conductance determined at USGS gage

		Aluminum (total dissolved), Total phosphorus, Total nitrogen, Chlorophyll a, Lake stage, Dissolved oxygen/temperature profile. Stream Monitoring: Stream temperature, pH, dissolved oxygen, specific conductance, color, and flow rate measured since 1997 on Duck Brook, Stanley Brook, Canon Brook, and Hunters Brook, and since 1998 on Lurvey Spring Brook and Heath Brook (Breen and others, 2001).	total suspended solids, and pH.	streptococcus may be taken and forwarded to an independent laboratory for evaluation. Sites are monitored once a week during the summer and once a month the rest of the year.	measurements of turbidity, and alkalinity, are being collected quarterly. Starting in 1998, this work has been contracted to a private laboratory.	previous years This program will resume in 2003.	
Fish community composition in streams	Mandatory: Species composition and relative abundance		Not applicable	Fish community composition data available from surveys by US Fish and Wildlife Service for Great Swamp Refuge downstream of the park		Fish species list for park made in 1986	
Zooplankton community composition in lakes	Mandatory: Species composition and relative abundance		Not applicable				Not applicable
Trophic status	Mandatory: Algal biomass, measures of water clarity such as secchi disk, and total and dissolved phosphorus Optional: Macrophyte distribution,(diel oxygen curve and, periphyton in streams), dissolved oxygen profiles	See water chemistry, lake monitoring	Massachusetts Water Resources Authority monitors nutrients, phytoplankton composition, and productivity. Parameters are photosynthetically active radiation, transmissivity, particulate nitrogen, total dissolved nitrogen,	Dissolved phosphorus is monitored		Dissolved phosphorus is monitored	

			nitrate/nitrite, ammonium, total dissolved phosphorus, orthophosphate, particulate organic carbon, Chlorophyll *a*, Phaeophytin			
Macroinvertebrate community composition in streams	Mandatory: Taxa richness and relative abundance	Macroinvertebrates are monitored in six streams following Maine DEP protocols (Davies and Tsomides, 1997). It has been well documented, reviewed, and provides data and analyses comparable to other streams in the state. Protocols are comparable with USEPA and the USGS National Water Quality Assessment Program protocols. The resultant data are analyzed using accepted biological and taxa composition indices.	Massachusetts Water Resources Authority monitors benthic communities.	New Jersey DEP has recently initiated a Level II Rapid Bioassessment Program (Plafkin and others, 1989) throughout New Jersey including several sites along the Upper Passaic River, Indian Grave Brook, and Primrose Brook in park. New Jersey DEP conducts macroinvertebrate sampling on the West Branch of Primrose Brook.	Two macroinvertebrate studies have been conducted in the park by the Department of Environmental Conservation in Albany, New York.	The Izaak Walton League of America's Stream Quality Survey (SQS) was performed at 4 stations in the park to quantitatively evaluate the distribution and diversity of the benthic macroinvertebrates in park streams.
Landcover/land use inventories	Mandatory: landcover/ecological system map Optional: Patch size distribution, patch connectivity, patch fragmentation, % impervious surface in buffer or watershed, canopy shading, buffer vegetation and width					
	Optional: Wet deposition, dry deposition, inorganic toxics, mercury	Park Research and Intensive Monitoring of Ecosystems (PRIMENet)- cooperative program between the USEPA and the NPS. Includes mercury and nitrogen sampling in Hadlock and Cadillac				

Atmospheric deposition		Brooks from 1998 to 2000 and air-quality monitoring of ozone, wet and dry deposition, visibility, meteorology, and UV-B monitoring. NADP sites in park include collection of wet precipitation chemistry, ozone, particulates, sulfer dioxide and mercury wet deposition. University of Maine collects fog chemistry data				
Contamination	<u>Optional:</u> Air toxic concentrations, MTBE, chloroforms, trichloroethylene, contaminant spills, toxic boat point, sediment contaminants, metals, bioaccumulation in indicator species	See atmospheric deposition	Massachusetts Water Resources Authority monitors toxic contaminants, pathogens, and fish and shellfish pathology.			The wetland is contaminated with polyaromatic hydrocarbons and arsenic. The slag pile has arsenic levels above the Imminent Hazard threshold, (Goff-Chem, 1996). The USGS & Massachusetts DEP, are sampling sediments in the Saugus River for heavy metals. One site is just downstream from SAIR.
Invasive exotic species	<u>Mandatory</u>: Presence/ absence <u>Optional:</u> Abundance	Multiple level surveys conducted for aquatic invasive species				Proposed restoration of historic site includes removal of invasive plants.
Septic systems/ Wastewater Discharge	<u>Mandatory:</u> the number of septic systems <u>Optional:</u>	An estimate of number of houses in rural Bar Harbor was made from 1998 digital orthophotographs and field checks in 2001 (Glenn	Massachusetts Water Resources Authority	See water quality	Fecal coliform levels were assessed three times in 2002 at four	

	Nearby permits Waste water discharges	Guntenspergen, USGS, written commun., 2001). Bar Harbor Water Company tracks municipal water use	monitors wastewater and effluent components and sewage indicator bacteria, including fecal coliform bacteria and *Enterococcus spp.*	stations

Fish community composition

None of the parks are monitoring fish community composition in streams as part of their environmental monitoring programs.

Zooplankton community composition in lakes

None of the parks are monitoring zooplankton community composition in streams as part of their environmental monitor programs

Water quality – trophic status

Nutrient chemistry data and water clarity are collected as part of water chemistry monitoring at ACAD, ROVA, and SAGA. These programs are very close to the mandatory measures for this vital sign.

Macroinvertebrate community composition in streams

All the parks except SAIR have some form of invertebrate community composition monitoring for streams. The protocols vary among the parks so there is a lack of consistency. Modification of the existing protocols to a common methodology will provide consistency for the mandatory measures.

Land use/land cover inventory

None of the parks currently have a land-use/land-cover program, but these data should be available for all the parks as state or national GIS layers.

Atmospheric deposition

Only ACAD has an atmospheric deposition component in the current program as part of National Networks such as NADP and PRIMENet.

Contamination inventory

As part of the atmospheric deposition research at ACAD, mercury and nitrogen are monitored. States provide consumption advisories for fish, but none of the parks has

an active contaminants sampling program. SAIR has had sediment sampling for contaminants associated with several research projects.

Invasive exotic species

All the parks have lists of potential invaders, but monitoring is not performed on a standardized schedule.

Septic systems/wastewater discharge

This information is generally tracked by municipalities where available. In some cases it must be estimated from water use.

Protocols, Quality control, and Data Storage at NETN Parks

Each of the parks with a water quality monitoring program has components of the program that correspond to one or more vital signs; however the design of each of the programs however differs due to the objectives associated with it. Documented protocols, quality assurance/quality control, and data storage of the current monitoring programs are presented where available (table 4) in order to understand some of these differences.

Most of the monitoring programs do not have sufficiently documented protocols, quality-assurance/quality-control procedures, or data storage. Although each park has limited internal documents that provide some of this information, few published reports are available. For the data at these parks to be incorporated into the vital-signs programs and analyses, protocols will need to be standardized and documented, quality-assurance/quality-control procedures will need to be adopted and(or) documented, and data-storage practices will need to be updated. The exception is at Acadia where many of these protocols and documentation are already in place. The environmental monitoring

and research program at Acadia has written protocols, written quality control specifications, a database, and an annual reports program to publish the data and analyses. As such, very little modification to the current Acadia aquatic environmental monitoring program will be required to include all the necessary vital signs.

Table 4. Standardized protocols, quality control, and data storage at the five parks with current environmental monitoring programs.

Park	Protocols	Quality Assurance/Quality Control Procedures	Data Storage
ACAD	Gawley, 1996, Acadia National Park lake monitoring: field and laboratory methods.: Acadia National Park Natural Resources Report 96-01 Kahl, and Manski, 1997, Developing long-term monitoring protocols for freshwater resources at Acadia National Park: Interim report from a workshop, January 9-10, 1997.	Gawley, W. G. 1996, Acadia National Park lake monitoring: field and laboratory methods: Acadia National Park Natural Resources Report 96-01	Internal database, Annual report series, Year end reports for lake, water, and macroinvertebrates.
BOHA			
MORR	J. Runde, 2004, Draft Report: Synthesis, analysis, and interpretation of water resources at Morristown National Historical Park Technical Report NPS/NRWRD/NRTR-xx/xx Morristown National Historical Park Standard Operating Procedure SOP Number: 601 Subject: Water Quality Testing Effective Date: October 1992 Revision Dates: April 2001	J. Runde, 2004, Draft Report: Synthesis, analysis, and interpretation of water resources at Morristown National Historical Park Technical Report NPS/NRWRD/NRTR-xx/xx Morristown National Historical Park Standard Operating Procedure SOP Number: 601 Subject: Water Quality Testing Effective Date: October 1992 Revision Dates: April 2001	Results of water quality inventory studies in the park have been reported by Mele and Mele (1983), and Trama and Galloway (1988). Storet Excel spreadsheet
ROVA			
SAGA	Zubricki, B., 1995, Water resources monitoring plan, Saint-Gaudens National Historical Site Izaak Walton League of America, 1994, Save our streams, volunteer trainers handbook.	Instrumentation calibrated and checked for accuracy	Annual interpretive reports Water quality data in Storet
SAIR			Data collected by Saugus River Watershed Council Hard copy only

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APPENDIX P: Summary of Post-Workshop Scientific Input Solicited by NETN on Vital Sign Selection

Following the Vital Signs Selection Workshop in May 2004, NETN solicited additional scientific input from a select group of scientific experts in the fields of biogeochemistry and remote sensing to address lingering questions in those areas. The scientists contacted were: Dr. Tim Fahey of Cornell University, Dr. Scott Ollinger of the University of New Hampshire, Dr. Kathleen Weathers of the Institute for Ecosystem Studies, Dr. Marie-Louise Smith of USFS, and Dr. Lindsey Rustad of USFS. Their responses are summarized herein.

Biogeochemistry

Tim Fahey, Kathleen Weathers, and Lindsay Rustad all pointed out that a few, inexpensive measures of streamwater biochemistry would be very useful for interpretation of acid deposition and nitrogen saturation stresses. These measures include streamwater nitrate, pH and acid-neutralizing capacity (ANC). Dr. Rustad also advocated incorporating measures of streamwater phosphorus, base cations, DOC and metals, and noted that the seasonality of streamwater response is important. NETN has included streamwater measures within our Acid deposition and Water chemistry Vital Signs.

Tim Fahey suggested that additional biogeochemical measures may indeed by too expensive. However, Scott Ollinger and Lindsay Rustad suggested that a few additional measures of nutrient cycling would very helpful in better interpreting the impact of acidic deposition and nitrogen saturation. Both advocated monitoring of soil nitrogen mineralization. Dr. Rustad pointed out this measure could be done less frequently than annually – perhaps every 5 years. She also advocated monitoring pH, cations and Al:cation ratios in the soil. Dr. Ollinger further suggested monitoring soil C:N ratio and foliar N concentration, as these "would help to assess whether things like low base saturation and Ca:Al ratios are due to N deposition stress. Additional foliar nutrients would also be useful in that nutrient ratios (N:Ca) are often indicative of stress." NETN has attempted to include some of these measures into our Acid deposition Vital Sign.

Dr. Ollinger further noted that species composition of dominant forest vegetation is essential information because changes in ecosystem health can be manifested through shifts in species composition, and also because interpretation of other indices will vary according to species. "For instance, low base saturation in soils could be a cause for concern in a sugar maple stand, but is not necessarily a cause for concern in species such as beech or hemlock that tolerate more acidic soil conditions." He suggested we consider the work of Gary Lovett at IES for information on species interactions with nutrient cycles and differential responses to atmospheric deposition.

Occult deposition

Kathleen Weathers has studied occult deposition at Acadia and found it is an important component of total deposition at that site. She is currently developing a model of total deposition inputs (including occult) for Acadia, and will send us a preprint of this work when it is available. We may be able to use her model to assess total deposition from existing NADP and CASTNET monitoring. We are currently seeking input from NPS Air quality personnel

(Kristi Morris) on this possibility. Dr. Weathers also suggested that it would be useful to monitor throughfall flux and fog chemistry at some locations if funds permit.

Dr. Ollinger suggested we also explore the work on occult deposition of UNH's AIRMAP group.

Remote sensing

We are awaiting a written response from USFS hyperspectral remote sensing scientist Marie-Louise Smith. Verbal communication with her indicates that a Vegetation stress index from hyperspectral remote sensing could be a useful indicator of forest canopy vegetation condition. Drs. Smith and Ollinger point out that MODIS data would not be sufficient for this indicator because MODIS ecological data is calibrated for western forests and may be inappropriate for our systems, and also because the spatial resolution is too coarse. Dr. Smith suggests that hyperspectral remote sensing from sources such as the Hyperion sensor on EO-1 may become affordable soon, and may provide a useful data source for this indicator. Currently, a 7.5 km X 100 km Hyperion scene costs about $1500. However, some archived data may be available for only $250 per scene. NETN has included this indicator as a potential measure of our Forest vegetation Vital Sign. Depending upon the availability of archived data, it may be affordable to include this measure at some sites now or sometime in the future.

Dr. Ollinger also suggested a simpler alternative for "assessing changes in growth" of vegetation - "plot-level biomass measurements or analysis of tree cores. As with other variables, changes in growth would need to be interpreted with respect to natural variability caused by factors such as species and stand age before drawing conclusions about health and pollution effects." Tim Fahey suggests that NPP may be too expensive to monitor on a plot basis, but that plot-level measurement of tree/shrub mortality would be very useful. NETN has included a mortality measure within the Forest vegetation Vital Sign.

Dr. Ollinger further advocated a measure of forest crown condition as a high priority. He noted that there are many methods available, including subjective visual assessments. He suggested we consider using standardized measures of crown optical properties such as light penetration, gap fraction and leaf area index using digital canopy photos such as the "HemiView system" which includes software designed to calculate properties of vegetation canopies. He noted that this information could even more useful be combined with remote sensing data. NETN has included crown condition as a potential measure within the Forest vegetation Vital Sign.

Other comments

Tim Fahey highlighted the value of monitoring selected indicator species across parks, and advocated including a broad taxonomic range. He said, "I strongly believe indicator species populations from a slew of functional or taxonomic groups would be most useful and in line with NPS objectives." He further noted, "if some NPS funds could be used to monitor selected populations of indicator species in most of the parks, that would establish a valuable program. Choice of taxa probably would vary among parks and should include multiple functional groups, with selections based upon sensitivity to stresses most likely impacting each park." NETN recognizes the value of this approach, and has attempted to include the monitoring of select populations of plants, birds, amphibians, and insects within our list of Vital Signs.

Lindsay Rustad advocated elevating Phenology to a high priority Vital Sign. She noted that phenological measures are straightforwad to collect, and could serve as a valuable indicator of long-term climate change. NETN agrees with this assessment, and has elevated Phenology to high priority. Dr. Rustad further noted she did not find deer herbivory to be a top priority.

Finally, Tim Fahey noted that the Long-term Ecological Research (LTER) program could be a valuable partner to the NPS in this endeavor, and that we should consult available LTER protocols. NETN agrees and plans to do so.