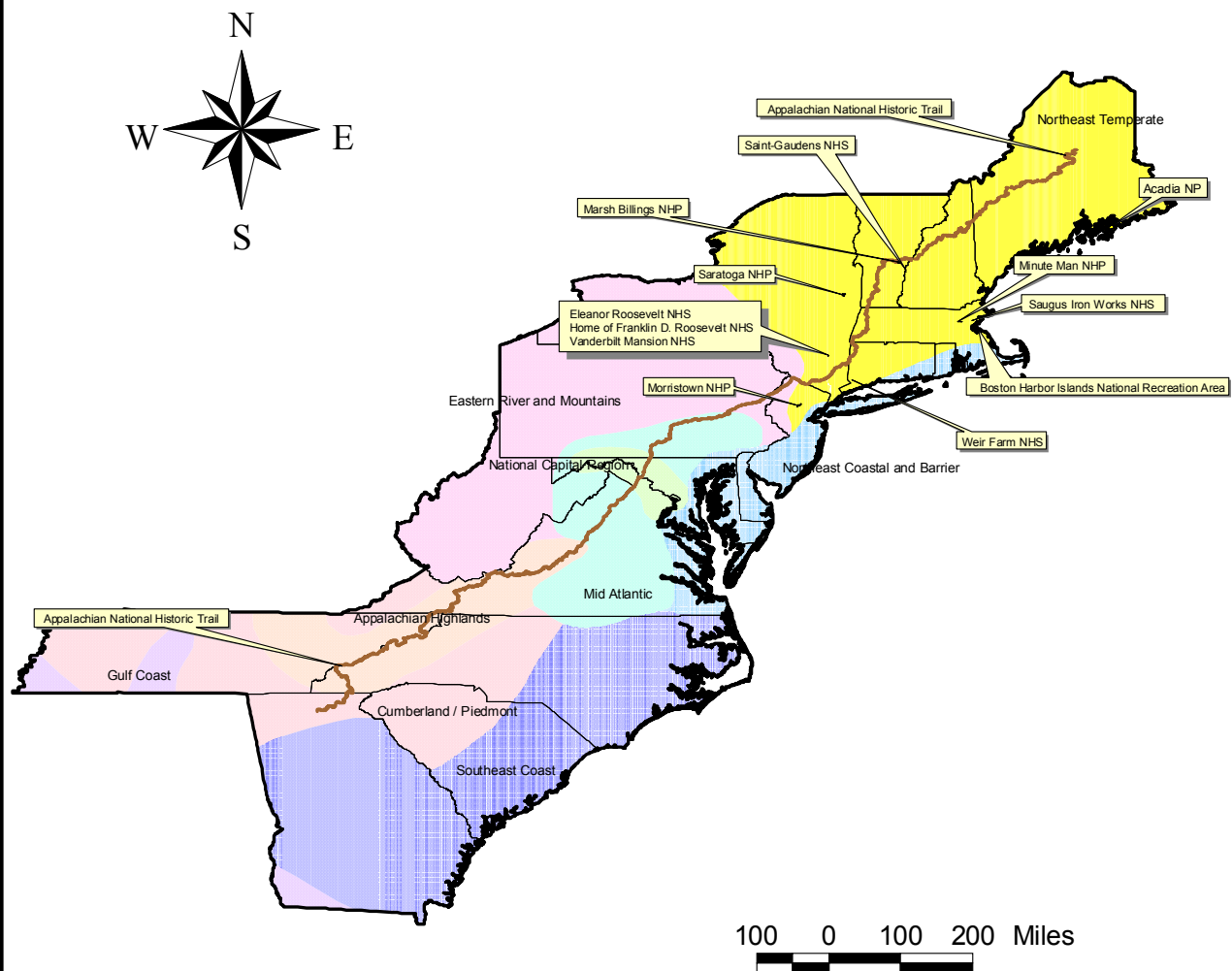


Phase I Vital Signs Monitoring Plan for the Northeast Temperate Network

National Park Service
U.S. Department of the Interior



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Chapter 1 Introduction and Background

1.1 Purpose

1.1.1 Justification for Integrated Natural Resource Monitoring

Knowing the condition of natural resources in national parks is fundamental to the Service'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 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 threats such as air and water pollution, or invasive species, originating outside of park boundaries. An ecosystem approach is further 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 be at the population, species, community, or landscape level, and in some cases may require a regional, national or international effort 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 understand and identify change in complex, variable, and imperfectly understood natural systems and to determine whether observed changes are within natural levels of variability or may be indicators of unwanted human influences. Thus, monitoring provides a basis for understanding and identifying *meaningful change* in natural systems characterized by complexity, variability, and surprises. Monitoring data help to define the normal limits of natural variation in park resources and provide a basis for understanding observed changes. Monitoring results may be used to identify 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 aimed 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 (“vital signs”), or significant indicators of ecological condition. This subset of resources and processes is part 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. 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.

1.1.2 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".

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).*

Additional statutes 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, including:

- ◆ 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;
- ◆ Clean Air Act, amended 1990.

1.2 *Monitoring Goals and Strategies*

1.2.1 Role of Inventory, Monitoring, and Research in Resource Management

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 (Fig. 1.1). The NPS strategy to institutionalize inventory and monitoring throughout the agency is based on a framework consisting of three major components; (1) completion of 12 basic resource inventories upon which monitoring efforts can be based, (2) a network of 11 experimental or “prototype” long-term ecological monitoring (LTEM) programs initiated in 1992 to evaluate alternative monitoring designs and strategies, and (3) 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.

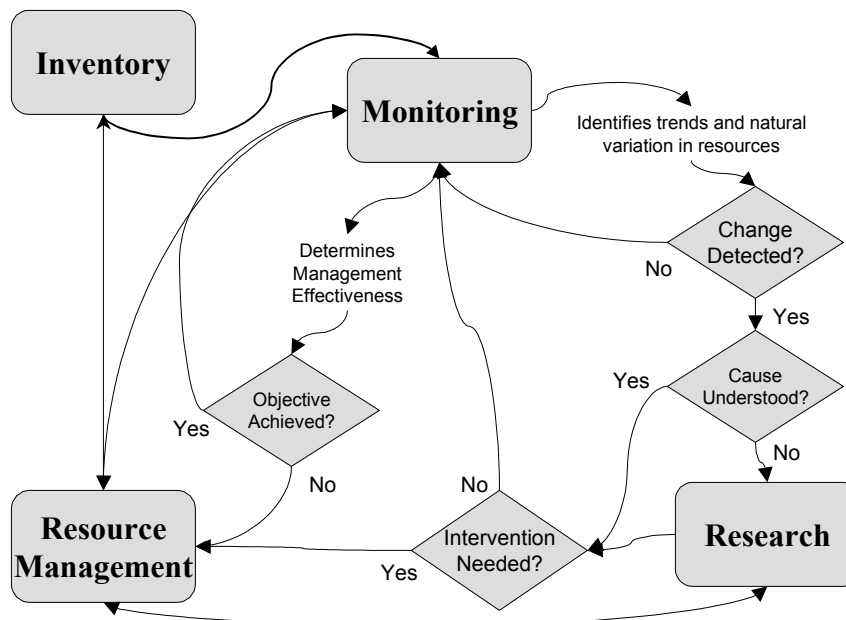


Figure 1.1. Relationships between monitoring, inventories, research, and natural resource management activities in national parks (modified from Jenkins et al. 2002).

1.2.2 Vital Signs Monitoring Goals

Service-wide 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.

1.2.3 Strategic Approaches to Monitoring

1.2.3.1 Scope and Process for Developing an Integrated Monitoring Program

During the development of the vision for park vital signs monitoring, it was clear that a “one size fits all” approach to monitoring design would not be effective in the NPS considering the tremendous variability among parks in ecological conditions, sizes, and management capabilities. To develop an effective and cost-efficient monitoring program that addresses the most critical information needs of each park and integrates with other park operations such as interpretation and maintenance activities, parks need considerable flexibility to allow existing programs, funding and staffing to be combined with new funding and staffing available through the Natural Resource Challenge and the various divisions of the Natural Resource Program Center. Partnerships with federal and state agencies and adjacent landowners are necessary to effectively understand and manage resources and threats that extend beyond park boundaries, but these partnerships (and the appropriate ecological indicators and methodologies involved) differ for parks throughout the national park system. For example, parks in the Pacific Northwest need to select

certain indicators and methodologies that are consistent with their National Forest neighbors and the Northwest Forest Plan, whereas parks in South Florida, in conjunction 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.

Each network is required to design an integrated monitoring program that addresses the monitoring goals listed above and is tailored to the high-priority monitoring needs and partnership opportunities for the parks in that network. Although there will be considerable variability among networks in the final design, the basic approach to designing a monitoring program should follow five basic steps:

1. Define the purpose and scope of the monitoring program;
2. Compile and summarize existing data and understanding of park ecosystems and resource management issues;
3. Develop conceptual models of relevant ecosystem components;
4. Select indicators and specific monitoring objectives for each and,
5. Determine the appropriate sampling design and sampling protocols.

These steps are incorporated into a 3-phase planning and design process that has been established for the monitoring program. Phase 1 of the process involves defining goals and objectives; beginning the process of identifying, evaluating and synthesizing existing data; developing draft conceptual models; and completing other background work that must be done before the initial selection of ecological indicators. Each network is required to document these tasks in a Phase 1 report, which is then peer reviewed and approved at the regional level before the network proceeds to the next phase. Phase 2 of the planning and design effort involves prioritizing and selecting vital signs and developing specific monitoring objectives for each that will be included in the network's initial integrated monitoring program. Phase 3 entails the detailed design work needed to implement monitoring, including the development of sampling protocols, a statistical sampling design, a plan for data management and analysis, and details on the type and content of various products of the monitoring effort such as reports and websites. The timeline the Northeast Temperate Network (NETN) is following for this process is presented in Table 1.1.

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, internal scoping										
Inventories to Support Monitoring										
Scoping Workshops										
Conceptual Modeling										
Indicator Selection and Prioritization										
Protocol Development, Monitoring										
Monitoring Plan Due Dates Phase 1, 2, 3						Phase 1 Oct. 03		Phase 2 Oct. 04		Phase 3 Dec. 05

1.2.3.2 Water Resources Monitoring

The implementation plan for the water quality monitoring component funded by the NPS Water Resources Division is fully integrated with the network-based vital signs monitoring program. Networks incorporate the 3-phase approach and follow the same implementation schedule for their water quality monitoring planning. The NETN has decided to produce a single, integrated monitoring plan that incorporates the “core vital signs” and water quality monitoring components. The NETN is working with USGS to determine water quality monitoring priorities, develop freshwater ecosystem conceptual models, select monitoring indicators, and implement a pilot water quality monitoring program. Presently, a summary of the water resources, issues, and conceptual models for water quality/quantity monitoring is presented in [Appendix A](#). We will work over time to integrate the water quality conceptual modeling and monitoring development with the terrestrial component presented in Chapter 2.

We used a standard process to begin the development of long-term ecological monitoring in the NETN (Fig. 1.2). We began with a series of brainstorming sessions, questionnaires, meetings and workshops (Table 1.2) to scope out: (1) focal resources (including ecological processes) important to each park, (2) agents of change or stressors that are known or suspected to cause changes in the focal resources over time; and (3) some basic key properties and processes of ecosystem health. Conceptual models were then developed to help organize and communicate the information compiled during scoping, and to identify where cause-effect is known between some of the stressors and response variables (see Chapter 2).

1.2.3.3 Strategies for Determining What to Monitor

Monitoring is an on-going effort to better understand how to sustain or restore ecosystems, and serves as an "early warning system" to detect declines in ecosystem integrity and species viability before irreversible loss has occurred. The goals of the vital signs monitoring program recognize the dynamic nature and condition of park ecosystems and the need to identify and separate ‘natural’ variation from undesirable anthropogenic sources of change to park resources.

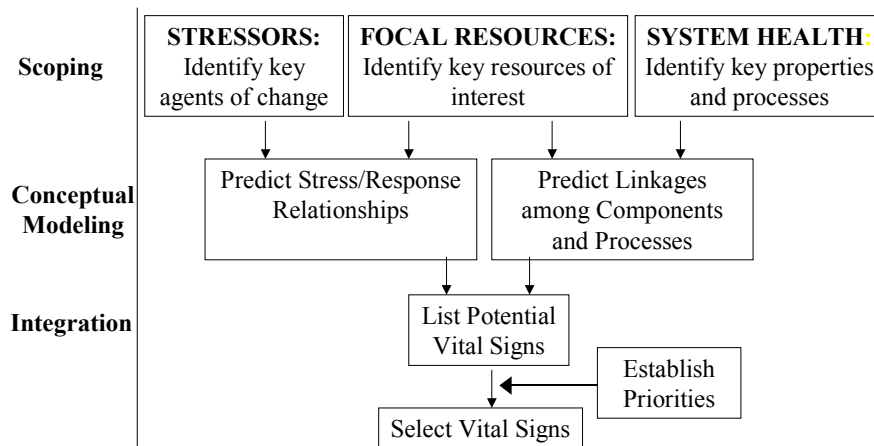


Figure 1.2. Basic approach to identifying and selecting vital signs for integrated monitoring of park resources (source: Kurt Jenkins, USGS Olympic Field Station).

A key initial decision in designing a monitoring program is deciding how much relative weight should be given to tracking changes in focal resources and stressors that address current management issues, versus measures that are thought to be important to long-term understanding of park ecosystems and may provide early-warning of presently unforeseen issues and threats to the sustainability or resilience of park ecosystems. Ultimately, an indicator is useful only if it can provide information to support a management decision or to quantify the success of past decisions. Useful ecological indicators must produce results that are clearly understood and accepted by managers, scientists, policy makers, and the public. However, our

current understanding of ecological systems and consequently, our ability to predict how park resources might respond to changes in various system drivers and stressors is often poor. A monitoring program that focuses only on current threat/response relationships and current issues may not provide the long-term data and understanding needed to address high-priority issues that will arise in the future.

Should vital signs monitoring focus on the effects of known threats to park resources or on general properties of ecosystem status? Woodley et al. 1993, Woodward et al. (1999), Jenkins et al. (2002) and others have described some of the advantages and disadvantages of various monitoring approaches, including a strictly threats-based monitoring program, or alternate taxonomic, integrative, reductionist, or hypothesis-testing monitoring designs (Woodley et al. 1993, Woodward et al. 1999). The approach adopted by our network agrees with the assertion that the best way to meet the challenges of monitoring in national parks and other protected areas is to achieve a balance among different monitoring approaches, while recognizing that the program will not succeed without also considering political issues. We have adopted a multi-faceted approach for monitoring park resources, based on both integrated and threat-specific monitoring approaches and building upon concepts presented originally for the Canadian national parks (Fig. 1.3, Woodley 1993).

Table 1.2. Workshops/meetings held to identify significant resources, management and scientific issues, and monitoring needs for parks in the Northeast Temperate Network.

DATE/PLACE	PARKS	PARTICIPANTS	PURPOSE
22 May 2000 Roosevelt- Vanderbilt NHS	BOHA, SARA, MABI, SAGA, MIMA, WEFA, MORR, ROVA, SAIR	Park Staff, NER-IM Staff	Identify priorities for inventory needs
25 May 2000	ACAD	Park Staff, NER-IM Staff	Identify inventory priorities
1-2 May 2001 Marsh-Billings- Rockefeller NHP	ACAD, BOHA, MABI, MIMA, MORR, SAIR, SAGA, SARA, ROVA, WEFA	Park Staff, NER I&M Staff	Identify Significant Resources, Prioritize Management Issues, Identify Monitoring Needs
17 December 2002 Marsh-Billings- Rockefeller NHP/conf. call	ACAD, APPA, BOHA, MABI, MIMA, MORR, SAIR, SAGA, SARA, ROVA, WEFA	Park Staff/superintendents, NER Chief of Science, and I&M staff	First NETN Board of directors meeting to review program and charter
13 January 2003 Marsh-Billings- Rockefeller NHP	MABI	Park Staff/superintendent, NETN Coord. and data mgr.	Identify Sig. Resources, Mgt. Issues, Monitoring Needs
14 January 2003 Saint Gaudens NHS	SAGA	Park Staff/superintendent, NETN Coord. and data mgr.	Identify Significant Resources, Prioritize Management Issues, Identify Monitoring Needs
30 January 2003 Marsh-Billings- Rockefeller NHP	APPA	Park Staff/superintendent, NETN Coord. and data mgr. Appalachian Trail Conference regional director	Discuss integration of ATC monitoring initiative with NPS Vital Signs program
12 February 2003 Saratoga NHP	SARA	Park Staff/superintendent, NETN Coord. and data mgr.	Identify Significant Resources, Prioritize Management Issues, Identify Monitoring Needs
19 February 2003 Minute Man NHP	MIMA	Park Staff/superintendent, NETN Coord. and data mgr.	Identify Significant Resources, Prioritize Management Issues, Identify Monitoring Needs
3 March 2003 Appalachian NST conference call	APPA	Park Staff/superintendent, NER I&M Coord., NETN Coord. and data mgr.	Status of APPA resource mgt. plan, biological inventory needs, and selecting priority Trail segments for Network Projects

<i>DATE/PLACE</i>	<i>PARKS</i>	<i>PARTICIPANTS</i>	<i>PURPOSE</i>
6 March 2003 Marsh-Billings-Rockefeller NHP	APPA	MABI/APPA superintendent, NETN Coord. and data mgr.	Reviewed upcoming network projects to aid in identifying priority Trail segments
25 April 2003 Boston Harbor Islands NPA	BOHA	Park Staff, NETN Coord. and data mgr.	Identify Significant Resources, Prioritize Management Issues, Identify Monitoring Needs
8 May 2003 Acadia NP	ACAD	Park Staff/acting superintendent, NETN Coord. and data mgr., NER staff	Identify Significant Resources, Prioritize Management Issues, Identify Monitoring Needs
6 June 2003 NY Academy of Sciences	APPA	Academic cooperators, Park superintendent, ATC staff, NETN coordinator	Roundtable to discuss the Appalachian Trail environmental monitoring initiative
13 August 2003 Saratoga NHP	SARA	Park Staff, NETN staff, Les Mehroff	Identify invasive plant and fire management issues
9 September 2003 Weir Farm NHP	WEFA	Park Staff/superintendent, NETN Coord. and data mgr.	Identify Significant Resources, Prioritize Management Issues, Identify Monitoring Needs
18/20 August 2003 Meeting of the Networks, VA	APPA	Park Staff/superintendent, NETN, NCRN, ERMN, CUPN, APHN, Coords. NETN data mgr., SHEN&GRSM res. Mgrs., I&M monitoring coord.	Discuss how APPA will work within the I&M network system to develop ecological monitoring
10 September 2003	ROVA	NETN Coord. and data mgr.	Identify Significant Resources, Prioritize Management Issues, Identify Monitoring Needs
11 September 2003	MORR	Park Staff, NETN Coord. and data mgr.	Identify Significant Resources, Prioritize Management Issues, Identify Monitoring Needs

Specifically, we recommend choosing indicators in each of the following broad categories (see Glossary for definitions):

- (1) **ecosystem drivers** that fundamentally affect park ecosystems,
- (2) **stressors and their ecological effects**,
- (3) **focal resources** of parks, and
- (4) **key properties and processes of ecosystem integrity**.

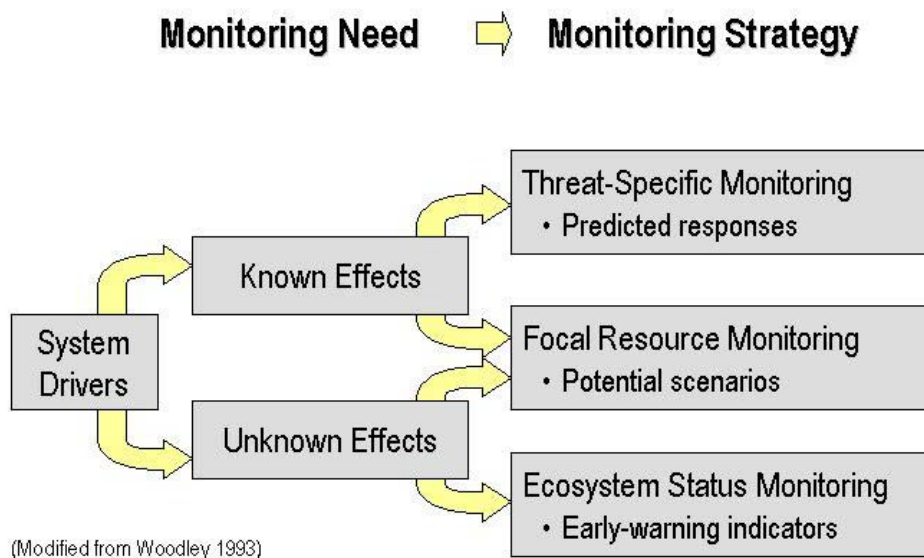


Figure 1.3. Conceptual approach for selecting monitoring indicators.

In certain cases where good understanding exists between potential effects and responses by park resources (Known Effects), monitoring of system drivers, stressors, and effected park resources is conducted. A set of focal resources (including ecological processes) will be monitored to address both known and unknown effects of system drivers and stressors on park resources. Key properties and processes of ecosystem status and integrity will be monitored to improve long-term understanding and potential early warning of undesirable changes in park resources.

Monitoring of key properties and processes of ecosystem integrity will provide the long-term baseline needed to judge what constitutes unnatural variation in park resources and provide early warning of unacceptable change. Biological integrity has been 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 and Dudley 1981). Ecological integrity is the summation of physical, chemical, and biological integrity, and it implies that ecosystem structures and functions are unimpaired by human-caused stresses. Indicators of ecosystem integrity are aimed at early-warning detection of presently unforeseeable detriments to the sustainability or resilience of ecosystems.

1.2.3.4 Integration: Ecological, Spatial, Temporal and Programmatic

A successful comprehensive monitoring program must provide for holistic integration of all the monitoring components such that interpretation yields information at multiple spatial and temporal scales and across major disciplines. Integration involves ecological, spatial, temporal and programmatic aspects:

- ◆ **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 within a park or network of parks, or between individual park programs and broader regional programs (i.e., National Park Service or other national and regional programs). 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 data. At the park or network level, for example, the involvement of a park's law enforcement, maintenance, and interpretative staff in routine monitoring activities and reporting results in a well-informed park staff, wider support for monitoring, improved potential for informing the public, and greater acceptance of monitoring results in the decision-making process. 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.

1.2.3.5 Limitations of the Monitoring Program

Managers and scientists need to acknowledge limitations of the monitoring program that are a result of the inherent complexity and variability of park ecosystems, coupled with limited time, funding, and staffing available for monitoring. Ecosystems are loosely-defined assemblages that exhibit characteristic patterns on a range of scales of time, space, and organization complexity (De Leo and Levin 1997). Definitions of ecological integrity are problematic, partly because key terms such as "natural" remain vague (Noon 2003). 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. These complexities demand then, that we both not be overly prescriptive in our definitions of systems, but neither ignore the differences that occur along a continuum of change.

The monitoring program is also challenging in that it simply cannot address all resource management interests because of limitations of funding, staffing, and logistical constraints. Rather, the intent of vital signs monitoring is to monitor a select set of ecosystem components and processes that reflect the condition of the park ecosystem and are relevant to management issues. Cause and effect relationships usually cannot be demonstrated with monitoring data, but monitoring data might suggest a cause and effect relationship that can then be investigated with 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.

1.3 *Ecological Context*

All the parks in the NETN are located within the temperate deciduous forest biome. Temperate deciduous forests are located in the mid-latitude areas between the polar regions and the tropics (Fig. 1.4). Deciduous forest regions are exposed to warm and cold air masses, which cause this area to have four distinct seasons. Temperature varies widely from season to season with cold winters and hot, wet

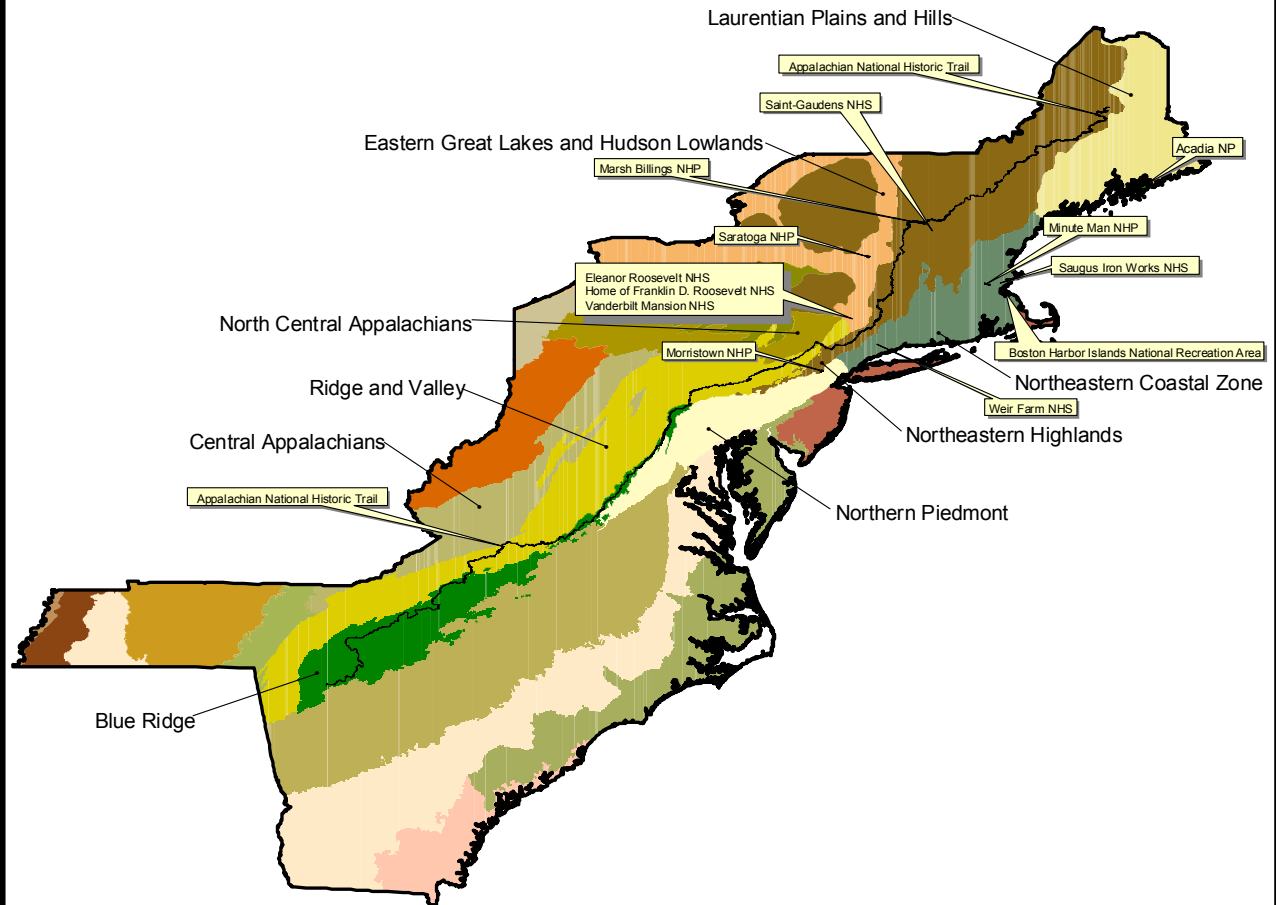
summers. The average yearly temperature is about 10°C. The areas in which deciduous forests are located get about 750 to 1,500 mm of precipitation spread fairly evenly throughout the year. The temperate deciduous forest biome in North America occupies most of the eastern part of the United States and a small strip of southern Ontario (Fig. 1.4). Dominant trees are broadleaf trees such as oak, maple, beech, hickory and chestnut.



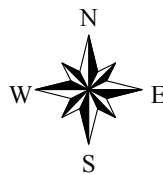
Figure 1.4. Global distribution of broadleaf deciduous forest.

Ecoregions of the Eastern U.S.

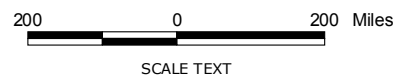
National Park Service
U.S. Department of the Interior



Ecoregions of the
United States obtained
from the U.S. Environmental
Protection Agency



Northeast
Temperate
Network



PROJECT

DATE

Figure 1.5. Location of NETN parks with respect to the ecoregions of the eastern US.

1.3.1 Overview of Network Parks and Selected Natural Resources

The Northeast Temperate Network (NETN) contains 11 parks (including for planning purposes a section of the Appalachian NST from Maine to the MD boarder, Table 1.3) with diverse cultural and natural resources in eight states (ME, NH, VT, MA, CT, NY, NJ, and PA) and 2 ecological divisions (Laurentian / Acadian and Central Interior and Appalachian, NatureServe 2003). Parks in the Network range from Acadia NP in coastal Maine to Morristown NHP in central New Jersey, an area where 61 ecological systems have been identified (NatureServe 2003). Based on a side meeting held at the “Meeting of the Networks 2003” (see Table 1.2 for attendees) the Appalachian Trail preferred to coordinate inventory and monitoring activities with the NETN and have the NETN coordinate monitoring efforts with APPA networks (here APPA networks are defined as any I&M network crossed by the Appalachian Trail). This framework reduces the burden of coordination for APPA staff with the 5 I&M networks traversed by the Appalachian Trail, and provides a point of contact for I&M related activities as it applies to the Trail.

NETN parks range in size from ≈ 9 acres at Saugus Iron Works to $\approx 85,000$ 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 NHP and Weir Farm NHP), and Roosevelt-Vanderbilt NHP celebrates the lives of the “Guilded 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 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 NP is the only National Park in the NETN and host 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. The 11 NETN parks will work together, to prepare a monitoring program that will accomplish the five goals of vital signs monitoring and provide the broad-based scientific information needed to protect and manage park resources ([Appendix B](#)).

Park Name	Code	Size (acre)	% Total Area	Annual Visits	% Total Visits
Acadia NP (ME)	ACAD	47,498	0.34	2,504,708	0.35
Appalachian NST (ME-PA)	APPA	85,036	0.60	NA	NA
Boston Harbor Islands NPA (MA)	BOHA	1,465	0.01	NA	NA
Marsh-Billings-Rockefeller NHP (VT)	MABI	643	<0.01	28,699	<0.01
Minute Man NHP (MA)	MIMA	967	0.01	1,064,389	0.15
Morristown NHP (NJ)	MORR	1,707	0.01	422,758	0.06
Roosevelt-Vanderbilt NHP (NY)	ROVA	401	<0.01	2,841,220	0.40
Saint-Gaudens NHP (NH)	SAGA	150	<0.01	47,801	0.01
Saratoga NHP (NY)	SARA	3,392	0.02	152,854	0.02
Saugus Iron Works NHP (MA)	SAIR	9	<0.01	17,050	<0.01
Weir Farm NHP (CT)	WEFA	74	<0.01	16,820	<0.01

Table 1.3. Parks included in the Northeast Temperate Network indicating park name, code, size, percent of park area in total Network area, annual visits (FY02), and percent of total Network visits. Visitation estimates were not available for APPA or BOHA at the time of this report. APPA lands had the highest proportion of land within the Network and ROVA had the highest visitation rates. Park area and visitation were not closely associated indicating that some small parks in the Network have proportionally higher visitation rates than some larger parks.

Table 1.4. Ecological communities present in NETN parks. General ecological systems were identified within parks and cross walked to Nature Serve ecological community classification system (see [Appendix C](#) for community definitions). Park resource management and I&M staff ranked each ecological community type within each park as follow; 0 = not present in park, 1 = present in park, 2 = management priority in park.

Ecosystem Category	Park Habitat Resource	Ecological System Types	Nature Serve code	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
TERRESTRIAL (upland, wetland)	Forested Wetlands	softwood/hardwood swamp	Laurentian-Acadian Acidic Swamp	2	1	0	1	2	2	1	0	0	1	2
			Laurentian-Acadian Alkaline Swamp											
			North-Central Appalachian Acidic Swamp											
			North-Central Interior and Appalachian Rich Swamp											
		floodplain forest	Laurentian-Acadian Floodplain Forest	0	1	2	0	2	2	1	0	2	1	0
			Central Appalachian Floodplain											
			Central Appalachian Riparian											
	Open/Shrub Wetlands-peatlands	peatland	Acadian Maritime Bog	2	1	0	0	1	0	0	0	0	0	0
			Laurentian-Acadian Acidic Basin Fen											

Ecosystem Category	Park Habitat Resource	Ecological System Types	Nature Serve code	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
		Laurentian-Acadian Alkaline Fen	CES201.585											
		North-Central Interior and Appalachian Acid Peatland	CES202.606											
Open / Shrub Wetlands - mineral-muck soils	marshes, sedge meadows, wet shores, shrub swamps			2	2	0	1	2	1	2	2	2	1	2
Tidal Wetlands		Laurentian-Acadian Wet Meadow-Shrub Swamp and Marsh	CES201.577											
	rocky shore													
		Acadian-North Atlantic Rocky Coast	CES201.573											
		North Atlantic Rocky Intertidal	CES201.048											
	salt marsh													
		Acadian Coastal Salt Marsh	CES201.578											
		Acadian Estuary Marsh	CES201.579											
	cobble beach	North Atlantic Cobble Shore	CES201.051											
	mudflat	North Atlantic Intertidal	CES201.050	2	0	2	0	0	0	0	0	2	0	0

Ecosystem Category	Park Habitat Resource	Ecological System Types	Nature Serve code	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
Upland Forests	deciduous forest	Mudflat												
		North Atlantic Tidal Sand Flat	CES201.049											
		Boreal Aspen-Birch Forest	CES103.020	2	1	1	2	2	2	2	2	1	2	2
		Laurentian-Acadian Northern Hardwoods Forest	CES201.564	2										
		Northeastern Interior Dry Oak Forest	CES202.592											
	mixed forest			2	1	1	2	2	2	2	2	1	2	2
		Acadian Lowland Spruce-Fir-Hardwood Forest	CES201.565	2										
		Laurentian-Acadian White Pine-Red Pine Forest	CES201.719	2										
		Central Appalachian Oak and Pine Forest	CES202.591											
		Central Appalachian Pine- Oak Rocky Woodland	CES202.600											
	hemlock, mixed forest	Acadian Montane Spruce-Fir-Hardwood Forest	CES201.566	2	1	0	2	2	0	2	2	0	1	1
		Laurentian-Acadian Pine-Hemlock-Hardwood Forest	CES201.563	2			2			2				
		Appalachian Hemlock-Hardwood Forest	CES202.593	-				2	-	2	-	-		2

Ecosystem Category	Park Habitat Resource	Ecological System Types	Nature Serve code	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
Open Uplands - Rocky	rocky summit	Laurentian-Acadian Acidic	CES201.571	2	2	0	0	0	0	0	0	0	0	0
	ridgetop shrubland	Rocky Outcrop												
	cliffs and talus, rock cliffs			2	2	0	0	0	0	0	0	0	0	0
		Laurentian-Acadian Acidic Cliff and Talus	CES201.569	2										
		North-Central Appalachian Acidic Cliff and Talus	CES202.601	-										
		North-Central Appalachian Circumneutral Cliff and Talus	CES202.603	-										
Open Uplands - Alpine		Acadian Alpine Barrens	CES201.567		2									
		Acadian Subalpine Woodland and Barrens	CES201.568		2									
PLANTED/ MODIFIED	Conifer Plantation			0	0	0	2	0	0	2	0	0	1	0
	Hardwood Plantation			0	0	0	2	0	0	2	0	0	0	0
	Grassland (pasture)			2	0	1	2	2	0	2	1	0	2	2
	Old field			1	1	1	0	2	0	1	0	0	2	2
	Cultural/natural landscape interface			1	1	2	2	2	2	2	2	2	2	2

Ecosystem Category	Park Habitat Resource	Ecological System Types	Nature Serve code	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
AQUATIC	Vernal Pools/Seeps			2	2	0	2	2	2	1	2	1	2	2
	open water / lakes			2				-			2			
	riverine			2				2			2			
	tidal river										2			
	fresh water springs										1			
	eelgrass beds													

A diverse array of ecological communities occur in the NETN parks (Table 1.4). Resource managers were asked to identify general ecological systems located within the parks and indicate the relative management priority for each system (Table 1.4). Tidal wetland and other coastal ecological communities occur only at Acadia and Boston Harbor Islands, many of which are considered management priorities and are potentially stressed by global climate change and visitor impacts. Freshwater wetlands and vernal pools were identified as management priorities for 9 of the 11 parks on which they occur. Deciduous, mixed, and hemlock forests were also listed as high management priorities by park staff and all parks have some type of forest ecosystem within park boundaries (Table 1.4).

1.3.2 Classification of Community And Ecosystem Types

As part of the inventory of park resources, a method is needed to establish the ecological types or landscapes to be monitored. We use the classification and mapping tools that are based on existing park inventory and monitoring program guidelines. Specifically, we will use the U.S. Geological Survey - National Park Service (USGS - NPS) Vegetation Mapping Program classification and maps (<http://biology.usgs.gov/npsveg/>). That program, which is mapping a large percentage of the NPS land base, relies on the U.S. National Vegetation Classification (USNVC), a federal standard for classification of terrestrial ecological communities using vegetation. The program has also begun to use NatureServe's Ecological Systems classification (Comer et al. 2003, NatureServe 2003b) as an additional classification and mapping tool. These classifications and maps are tailored to address park-specific needs.

Ecological Systems are defined as a group of plant community types that tend to co-occur within landscapes with similar ecological processes, substrates, and/or environmental gradients (Comer et al. 2003). These systems have been defined across the coterminous United States, and are linked to the USNVC at the alliance and association levels.

Communities are defined using the USNVC, which is used by many federal and state agencies (FGDC 1997, Grossman et al. 1998, Jennings et al. 2002, NatureServe 2003a). State Natural Heritage Programs in the northeast have all helped to develop this classification, and state community classifications are explicitly linked to the USNVC (e.g., in Vermont, see Thompson and Sorenson 2000, Appendix C), allowing information to be easily shared between jurisdictions.

Global and state conservation status (relative rarity) of each USNVC or state community type are available using this system, allowing parks to prioritize monitoring needs. In addition, because states track these community types across the state, parks are able to compare status of occurrences (stands). These ranks are now also in use by the forest industry for purposes of forest certification (Sustainable Forestry Board 2002).

The USGS-NPS vegetation maps for each park also provide polygon information on the occurrences of all types across the park. In essence, they provide a systematic inventory of all of the locations of communities and systems found in the parks. However, not every polygon may define a meaningful stand – clusters of polygons may be the more meaningful unit, depending on how far apart they are and what separates them. We propose to convert these polygons to stands/occurrences, that is, areas that have practical conservation value for the community or ecosystem type. Having assigned the polygons to stands/occurrences, we are then in a position to develop criteria to evaluate their current ecological condition or integrity.

1.3.3 Identification of Key Factors of Ecological Integrity and Viability

Ecological integrity is 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). Ecological integrity is not an either/or measure. Rather it exhibits a range of variability. Population viability is the assessment of the likelihood that if current conditions prevail a species

occurrence will persist for a defined period of time, typically 20-100 years (within the bounds of natural disturbance regimes) (NatureServe 2002).

To assign a meaningful rank of ecological integrity or population viability to stands/occurrences or populations within parks, the various factors or indicators that comprise ecological integrity or viability need to be specified – that is, the indicators need to be measurable in some way.

We propose to use a methodology for measuring of ecological integrity and population viability that has been developed by NatureServe and its network of natural heritage programs (Stein and Davis 2000, NatureServe 2002b, Groves 2003). That methodology uses three main categories (condition, size, landscape context) and a set of key factors or indicators within those categories to assess ecological integrity or population viability (Table 1.5). The methodology is in wide use throughout the network, and offers the opportunity to integrate evaluations of ecological integrity on national park land with those of surrounding lands.

Table 1.5. Rank Factor Categories and Key Factors used to assess Ecological Integrity and Population Viability (from NatureServe 2002b).

CATEGORY	GENERALIZED KEY FACTORS	Species	Communities and Systems
Biotic Condition	reproduction and health (evidence of regular, successful reproduction; age distribution for long-lived species; persistence of clones; vigor, evidence of disease affecting reproduction/survival)	√	
	development/maturity (stability, old-growth)		√
	species composition and biological structure (richness, evenness of species distribution, presence of exotics)	√	√
	ecological processes (degree of disturbance by logging, grazing; changes in hydrology or natural fire regime)	√	√
	abiotic physical/chemical factors (stability of substrate, physical structure, water quality) [excluding processes]	√	√
Size	area of occupancy	√	√
	population abundance	√	
	population density	√	
	population fluctuation (average population and minimum population in worst foreseeable year)	√	
Landscape Context	landscape structure and extent (pattern, connectivity, <i>e.g.</i> , measure of fragmentation/patchiness, measure of genetic connectivity)	√	√
	condition of the surrounding landscape (<i>i.e.</i> , development/maturity, species composition and biological structure, ecological processes, abiotic physical/chemical factors)	√	√

For communities and ecosystems, a subrank is assigned to each of the categories, based on fairly qualitative or semi-quantitative evaluation of the factors or indicators within each category. Thus the key factors or indicators within a category are used as guides for assessing the status of a category, but each

indicator itself may not be explicitly measured or ranked. The three categories are then integrated into an overall rank value of ecological integrity (Table 1.6), details of which are provided in NatureServe (2002b). For species, emphasis is usually given to population size (at least for vertebrate species), with some consideration for factors or indicators from the other categories, to produce a single overall rank.

Table 1.6. Assessing the Range of Variability of Ecological Integrity using rank values from NatureServe methodology (NatureServe 2002b).

Rank	Description of Ecological Integrity
A	excellent
B	good
C	Fair
D	poor
E	verified extant (viability or integrity not assessed)
H	Historical
X	extirpated

Examples of the ranking system for communities and species are provided in Tables 1.7 and 1.8. For communities then, separate indicators are developed for each category. A separate step, not shown here, is then needed to integrate the three category ranks into the overall rank shown in Table 1.6. For species the indicators are developed together, and the overall rank is assigned in a single step.

Table 1.7. Example of factors/indicators used by NatureServe methodology to assign subranks for the three main categories of ecological integrity (condition, size, and landscape context) (NatureServe 2002b, Appendix D). The example uses the *Tsuga canadensis* – (*Betula alleghaniensis*) Mesic Forest (Eastern Hemlock – (Yellow Birch) Mesic Forest).

***Tsuga canadensis* – (*Betula alleghaniensis*) Mesic Forest,
Eastern Hemlock – (Yellow Birch) Mesic Forest**

SPECS GROUP

Tsuga canadensis Forest Alliance Group

CONDITION CATEGORY

A SPECS

- a) overstory structure intact (*i.e.*, old-growth has not been cut), generally 150 years old or more;
- b) understory vegetation composed of native species;
- c) stands may have been thinned with minimal disruption of understory (>20 years ago), but little or no exotics are present.

B SPECS

- a) Overstory structure intact, with perhaps some selective logging. Stand age may range from 80-150 years;
- b) if thinning of small diameter trees has occurred, there is little evidence of disruption of understory vegetation;
- c) some light grazing by livestock may have occurred;
- d) exotic species may be present at low densities.

C SPECS

- a) Heavily logged with only small diameter trees remaining and disturbance to understory vegetation (due to logging activities or grazing); stand age may range from 50-80 years;
- b) heavy grazing by livestock or by deer has severely altered ground layer composition;
- c) some exotic species present.

D SPECS

- a) Heavily logged and thinned, perhaps to the point of a clear-cut; stand age less than 50 years;
- b) ground very disturbed with major disruptions to vegetation;
- c) large proportion of exotic species.

RANK SPECS JUSTIFICATION

“A” rating threshold: Hemlock forest systems begin to take on old-growth characteristics only after 150 years, and may even go through a series of old-growth changes between 180 and 400 years (Tyrrell and Crow 1994). Forest stands of this type experience relatively low disturbance rates, so under natural disturbance regimes most of the stands should be in old-growth.

“C”/“D” threshold: Native ground layer composition is severely altered and unlikely to replace exotics. Recovery of hemlock old-growth structure would take greater than 100 years. Overgrazing by deer could prevent hemlock regeneration (Mladenoff and Stearns 1993).

SIZE CATEGORY

A SPECS

Very large (≥ 400 ha)

B SPECS

Large (40-399 ha)

C SPECS

Moderate (4-39 ha)

D SPECS

Small (< 4 ha)

RANK SPECS JUSTIFICATION

“A” rating threshold: Stands this size would be able to support natural disturbance processes such as wind blowdowns, and would contain sufficient internal variability to be representative of the type. Studies of old-growth landscapes in the Great Lakes region show that stands can attain this size (Mladenoff *et al.* 1993).

“C”/“D” threshold: Studies by Mladenoff *et al.* (1993) found that in one old-growth landscape, patches of hemlock stands ranged in size from 2 ha to over 1,000 ha, and that the average stand was 21 ha. Stands much below this average (*i.e.*, less than 4 ha) will be dominated by edge effects throughout the stand.

The minimum size, even for “D”-ranked occurrences, will rarely fall below 2 ha. Stands below 2 ha become difficult to judge in terms of stand homogeneity, and become heavily influenced by edge effects. Note, however, that size can be naturally quite variable in this type (Mladenoff *et al.* 1993).

LANDSCAPE CONTEXT CATEGORY

A SPECS

Highly connected – area around the EO is largely intact natural vegetation, with species interactions and natural processes occurring across communities (> 5000 ha).

B SPECS

Moderately connected – area around the EO is moderately intact natural vegetation, with species interactions and natural processes occurring across many communities; landscape includes partially disturbed natural or semi-natural communities, some of it not high quality due to overgrazing or recent logging (> 5000 ha).

C SPECS

Moderately fragmented – area around the EO is largely a combination of cultural and natural vegetation, with barriers between species interactions and natural processes across natural communities; EO is surrounded by a mix of intensive agriculture and adjacent forest lots.

D SPECS

Highly fragmented – area around the EO is entirely, or almost entirely, surrounded by agricultural or urban land use; EO is at best buffered on one side by natural communities.

RANK SPECS JUSTIFICATION

“A” rating threshold: Landscapes could sustain natural disturbance regimes. Definitions for minimum dynamic area (*i.e.*, the area of land necessary so that the proportion of the landscape in early, middle and late successional stages will remain constant over time, given the occurrence of windstorms and fires) proposed by Shugart (1984) – fifty times the average disturbance size, or Johnson and Van Wagner (1985) – two times the maximum disturbance size (see also Frelich 1995), can be used as a rough guide to landscape size. Frelich and Lorimer (1991) showed that the average disturbance size in these hemlock-hardwood forests was about 100 ha, so that landscapes of over 5,000 ha would be needed to sustain old-growth characteristics.

“C”/“D” threshold: Processes such as natural disturbances are essentially irretrievable.

*Table 1.8. Demonstration example of factors/indicators used by NatureServe methodology to assign viability ranks for species (NatureServe 2002b). The example uses *Ambystoma cingulatum* (flatwoods salamander) as a model for the *Ambystomatid* salamanders as a group. Specs were written by John Palis and Geoff Hammerson, are in draft form and should not be cited.*

Viability Rank specs for *Ambystoma cingulatum* (J. Palis):

A SPECS: Breeding pond(s) relatively open and graminaceous, free of deleterious anthropogenic threats (including long-term fire exclusion and hydrological alteration), and surrounded by at least 300 hectares (roughly equivalent to one-kilometer radius around pond) of relatively natural habitat, including groundcover. A-ranked principal EOs may include several breeding ponds in relatively close proximity. Adult breeding population in peak years consisting of at least 100 individuals. Larvae repeatedly obtainable during appropriate season in most years with suitable hydrological conditions.

B SPECS: Breeding pond(s) not dominated by a closed canopy, free of significant hydrological disturbance, and with at least 80 hectares (roughly equivalent to 0.5-kilometer radius) of adjacent uplands, most of which retain relatively natural characteristics, including groundcover. Adult breeding population estimated to include at least 50 individuals. Larvae repeatedly obtainable during appropriate season in most years with suitable hydrological conditions.

C SPECS: Breeding pond(s) and/or surrounding uplands somewhat degraded by anthropogenic disturbance, although habitat remains suitable for population survival. This may include fire-deprived basins characterized by a relatively closed canopy and abundant leaf litter. Upland habitat may represent a mosaic of disturbed and somewhat natural communities, the latter having at least some natural groundcover and encompassing at least 10 hectares (roughly equivalent to 180-meter radius). Breeding population estimated to include at least 25 individuals; larvae obtainable in at least 40 per cent of years sampled.

D SPECS: Upland and/or wetland breeding habitat substantially disturbed by anthropogenic factors. Fire exclusion may have resulted in a closed canopy and abundant leaf litter. Although extant, few individual salamanders (less than 25 adults) utilize site, and reproduction may be sporadic to virtually nonexistent.

Justification for "A" rank: In a detailed study of one breeding population in western Florida, Palis (1997a) recorded 67 and 53 nonyearling adults in two consecutive years. However, he suspected that, based on data for this and congeneric species from other states, the number of breeding adults would have been much greater had the site been completely surrounded by extensive suitable habitat or had no other breeding sites been nearby (Palis, in litt.). Palis (1997b) obtained larvae in at least three of five years at 79 per cent of 24 sites surveyed annually. Although Ashton's limited data documented post-breeding adult migration as far as 1.6 km from breeding ponds, Semlitsch's (1998) analysis suggested that a terrestrial buffer of 164 meters around ponds should be ample to protect most local AMBYSTOMA populations, though perhaps not of more vagile species like A.CINGULATUM. Such a limited buffer also does not allow for interdemec movements and recolonization following local extirpation, criteria that are important to the assignment of an "excellent" EO rank. Ashton (1998) recommended an absolute minimal protection zone around breeding sites of one square mile (250 hectares) but stated that this could include some ecologically compatible human use of lands.

Justification for "D" rank: Although the full effects of anthropogenic disturbances on this species are not well understood, it appears that local population extirpations may result from deleterious silvicultural practices in uplands surrounding breeding ponds (Means et al. 1996), as well as a variety of forms of hydrological disturbance.

Although the methodology has been fairly well developed (NatureServe 2002), specific indicators for most species, communities and systems have not yet been developed. Further, the methodology as it applies to communities and systems may lack indicators that are easily measured or amendable to monitoring purposes. In general, the methodology resembles other biodiversity assessment approaches, such as the key factors approach of Larsson (2001), or that of EPA using "essential ecological attribute categories and subcategories" (Harwell et al. 1999, Young and Sanzone 2002), though the EPA approach extends the NatureServe methodology by identifying measurable indicators for each category and subcategory (key factors). The Nature Conservancy has also proposed an "ecological attributes" approach for use in site conservation planning based on the NatureServe methodology, but more fully extended along the lines of the EPA approach (TNC 2000, Parrish et al. 2003). These more rigorous approaches allow these assessments to be more explicit and measurable, facilitating monitoring designs. They also draw on the growing expertise within the conservation biology and wildlife biology community on how best to monitor biodiversity. Thus, the NatureServe methodology falls within a cluster of recently proposed methodologies that, with suitable evaluation, could play a key role in the development of vital signs for measuring ecological integrity. The assessment of ecological integrity or viability at the stands/ occurrences or populations level during the process of inventory provides the parks with a critical set of information on where the exemplary stands or populations of focal ecological communities, systems or

species may be, or where stands or populations may be that are most in need of restoration. The information, in combination with the vegetation and systems maps, can then help inform decisions on where monitoring priorities lie.

Although we propose applying the NatureServe integrity and viability ranks to stands/occurrences or populations as part of the process of inventory, we also propose to develop the ranking process to include its potential use for ecological monitoring. In essence, the NatureServe ranking information that is completed during the inventory process uses a set of indicators that measure the current ecological integrity or condition of the system or community. This is a key component of a monitoring program (Young and Sanzone 2002, Noon 2003). In a subsequent step, we use these and other indicators to assess the effects of stressors and management activities related to those stressors. The way in which these two sets of indicators are developed is outlined in Chapter 2, which discusses the conceptual ecological models that form the bases for the methodology.

1.3.2 Management and Scientific Issues for Network Parks

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, 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 (Trombulak 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 (Broody and Pelton 1989), spread of exotic species (Greenberg et al. 1997), and changes in soil and water chemistry (see Trombulak and Frissell 2000 for review). Parks and reserves in the northeast exist as islands of habitat in a landscape matrix of developed or agricultural lands with some of the highest road densities in the US. 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 by external impacts, especially roads.

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 1.9). 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 D](#)). Nonindigenous species spread at the rate of $\approx 700,000$ hectares per year in the US with an impact on human economic systems estimated in the billions of dollars (Pimentel et al. 2000). 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 (Wilcove et al. 1998). Of the 958 species listed, about 400 (42%) are threatened by non-native species (Pimentel et al. 2000).

The NETN parks share some common resource management issues, but also have park specific issues and management priorities (Table 1.9). 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 (Table 1.9). Climate change was only identified as a natural resource issue for parks with coastal and high elevation habitats (Table 1.9).

Table 1.9. 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 Network Park Natural Resources	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
<i>Air Quality</i>											
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
<i>External Development</i>											
Cell 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					2	2	
Night Sky										1	
<i>Visitor Impacts</i>											
Boat Traffic	1	0	2	0	1	0	0	0	0	1	0

Potential Threats to Network Park Natural Resources	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
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	
<i>Contaminants/Toxics</i>											
PCB	1	1	1	0	1	1	1	1	1	2	0
Hg	2		1	0	1	0	1	1	1	2	0
Pb, Zn, Cd		2	1	0						2	
<i>Natural Disasters</i>											
Droughts	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	
Fire	1	1	1	0						1	
<i>Internal Park Development</i>											
	1	1	1	0	0	0	1	0	1	1	0
<i>Nuisance Wildlife</i>											
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	
Canada geese		0	0						2	0	
Woodchuck		0	0							0	2
Deer over browsing	0	1	0	2	1	2	2	1	0	2	2
<i>Pest Species (parasites/pathogens)</i>											
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

Potential Threats to Network Park Natural Resources	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
West Nile Virus	1	1	1	1	1	2	2	1	2	1	2
Chronic Wasting Disease			0					1		1	
Hanta Virus			0						1	1	
exotic ant	1		0							0	
exotic spider	1		0							0	
exotic fish	2		0							0	
<i>Water Quality</i>											
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
<i>Climate Change</i>											
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		0	2	0					1	0	0

1.4 *Summary of Existing Park and Adjacent Monitoring Programs*

We solicited park resource managers for information regarding current and historical monitoring efforts within the network parks to identify opportunities to continue, modify, or expand existing programs (Table 1.10). 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 E](#)). Acadia NP has an ongoing water quality monitoring program that includes stream invertebrates and is the only park in the network with this type of program. Morristown and Saratoga NHPs, 2 parks with ecological issues caused by over-abundance of deer, have ongoing deer population monitoring (Table 1.10). Acadia, Appalachian Trail, and Morristown have specific threatened and endangered species monitoring programs, and Marsh-Billings-Rockefeller and St. Gaudens are the only parks with ongoing forest monitoring programs (Table 1.10).

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 are summarized in [Appendix F](#).

Table 1.10. Summary of historical, recent, and ongoing monitoring programs within NETN 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.

	ACAD			APPA			BOHA			MABI			MIMA			MORR		
Monitoring Program	>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
Communities				X		X										X		X
Non-vascular																		
Monitoring Program	>5	<5	+	>5	<5	+	>5	<5	+	>5	<5	+	>5	<5	+	>5	<5	+

	ACAD		APPA	BOHA	MABI	MIMA	MORR
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					

Table 1.8. Summary of historical, recent, and ongoing monitoring programs within NETN parks (ROVA-WEIR). >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.

	ROVA			SAGA			SAIR			SARA			WEIR		
Monitoring Program	>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															
Monitoring Program	>5	<5	+	>5	<5	+	>5	<5	+	>5	<5	+	>5	<5	+

	ROVA	SAGA	SAIR	SARA	WEIR
Exotic Plants		X			
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					

Chapter 2: Conceptual Ecological Models

2.1 Introduction

Development of conceptual models is an important step in the design of the Vital Signs Monitoring Program for each network. For that reason it is listed as one of the five steps that form the basic approach to designing a monitoring program (see Section 1.2.3.1 Scope and Process for Developing an Integrated Monitoring Program). The need for this key step is based on lessons learned about monitoring program designs from the NPS experience with its prototype parks program, and from many other monitoring programs. These lessons demonstrate that monitoring efforts are based on some underlying understanding of how the ecosystem in question works. To ensure a successful monitoring effort, these underlying models need to be explicit and available for discussion, evaluation, and refinement (Maddox et al. 1999). Conceptual models play several useful roles in monitoring program design, including:

- ◆ *Conceptualizing ecosystem function and structure (cumulative, holistic, multi-scale);*
- ◆ *Identifying major stressors, attributes affected, impacts, and indicators at a broad level;*
- ◆ *Aid in identifying “vital signs” to detect ecological health changes;*
- ◆ *Formalizing current understanding of the context and scope of the ecological processes important in the area of interest;*
- ◆ *Expanding our consideration across traditional discipline boundaries, fostering integration of biotic and abiotic information;*
- ◆ *Facilitating communication among scientists from different disciplines, between scientists and managers, and between managers and the public.*

The key point about conceptual models is their role in communication among people with different points of view (Abel et al. 1998). The models also help to clarify what is meant by ecological integrity. Herein, we developed draft conceptual models for terrestrial ecosystems important to NETN parks. We have also developed conceptual models for freshwater systems in NETN parks that identify park specific water bodies, issues, threats, and potential indicators ([Appendix A](#)). These models identify ecological processes, ecosystem threats and stressors, and suggest indicators that could be used to track ecological integrity over time. We are working to integrate the terrestrial and aquatic ecological monitoring programs by developing measures of ecological integrity for all systems in NETN parks. Given the complexity of natural systems and the huge variety of factors that influence natural processes, there is an obvious need for conceptual models that help organize information and make sense of system components and interactions. Failures in the development of major ecosystem monitoring programs have repeatedly been attributed to the absence of sound conceptual models that articulate key system components and their interactions (NRC 1995; Busch and Trexler 2002). Conceptual models can formalize current understanding of system processes and dynamics, identify linkages of processes across disciplinary boundaries, and identify the bounds and scope of the system of interest. Conceptual models also contribute to communication among scientists, program staff, managers, and the general public. Conceptual models express ideas about components and processes deemed important in a system, document assumptions about how components and processes are related, and identify gaps in our knowledge – they are working hypotheses about system form and function (Manley et al. 2000).

Conceptual models can take the form of any combination of narratives, tables, matrices of factors, or box-and-arrow diagrams. In the development of the NETN Vital Signs Monitoring Program, we have chosen to generally follow examples from Noon et al. (2002) to draft the diagrammatic conceptual models (Fig. 2.1), accompany these models with narratives that describe the details of the interactions among the components. These models identify ecosystem processes/functions that are integrated with structural/compositional attributes and predict biodiversity responses.

We are taking a hierarchical approach to model development starting with a general model for the key ecological systems located in the NETN (Fig. 2.2). The general model identifies the key ecological communities within parks and the natural and anthropogenic stressors that influence those systems. A model is then developed for each of the ecological systems (Fig. 2.3) that more specifically integrates the drivers, stressors, and attributes that may influence that specific system. Under each general ecosystem model a series of specific ecological models are then developed (Fig. 2.4) that focus the key disturbances and stressors, and identify specific attributes of the ecological system. Finally, sub-models of specific components of a system (Figs. 2.5 & 2.6) are modeled to identify the important interactions within a specific component of the larger system.

The goals of these conceptual models are to:

- ◆ Synthesize understanding of ecosystem dynamics;
- ◆ Provide a firm conceptual foundation for identifying monitoring indicators;
- ◆ Identify and illustrate relationships among indicators and key system processes;
- ◆ Provide a clear means of illustrating major subsystems and system components and their interactions;
- ◆ Facilitate communications on system dynamics and the vital signs monitoring program among network staff, managers, technical and non-technical audiences;
- ◆ Identify areas where knowledge is inadequate and further research is needed;
- ◆ Describe and illustrate alternative hypotheses about key processes or system dynamics;

2.2 *Framework and Definitions of Conceptual Model Components*

The NETN conceptual models use the Environmental Protection Agency (EPA) Framework of Essential Ecological Categories (Young and Sanzone 2002) adapted to fit into the NPS Vital Signs monitoring development program. We use the following terminology in developing conceptual models for the Northeast Temperate Network:

Ecosystem Drivers are major, naturally occurring forces of change such as climate, fire cycles, biological invasions, hydrologic cycles, and natural disturbance events (e.g., droughts, floods, lightning-caused fires) that have large scale influences on the attributes of natural systems” (Leibfreid 2003). We have divided ecosystem drivers into the following categories:

- ◆ Natural disturbance regimes (fires, floods, insect infestations, wind);
- ◆ Ecological processes (energy and material flows);
- ◆ Physical Processes (Hydrology and geomorphology surface and groundwater flows, channel characteristics, sediment and material transport);
- ◆ Climate (Temperature, precipitation).

Stressors are physical, chemical, or biological disturbance events that result in significant ecological effects and are considered proximate causes of adverse effects on the groups of organisms within the system (Noon et al. 2002). Stressors cause significant changes in the ecological components, patterns and processes in natural systems. Examples include air pollution, exotic pest invasions, water pollution, water withdrawal, pesticide use, timber harvesting, traffic emissions, stream acidification, trampling, poaching, and land-use change.

Ecological effects are the physical, chemical, biological, or functional responses of ecosystems to drivers and stressors.

Monitoring Attributes are any living or nonliving feature or process of the environment that can be measured or estimated and that provide insights into the state of the ecosystem. The term **Indicator** is reserved for a subset of attributes that is particularly information-rich in the sense that their values are somehow indicative of the quality, health, or integrity of the larger ecological system to which they

belong (Noon 2002). Indicators are a selected subset of the physical, chemical, and biological elements and processes of natural systems that are selected to represent the overall health or condition of the system, known or hypothesized effects of stressors, or elements that have important human values. We have identified the following general categories (again, following Young and Sanzone 2002) that establish a framework to identify indicators at multiple spatial and organizational scales.

- ◆ Landscape Condition (landscape pattern and composition);
- ◆ Biotic (stand) condition (structure, species composition, community diversity);
- ◆ Abiotic (stand) condition (chemical and physical characteristics; e.g., nutrient concentrations, trace chemicals, and soil and atmospheric characteristics).

2.3 *The basic components of NETN Conceptual Models*

Conceptual models can take the form of any combination of narratives, tables, matrices of factors, or box-and-arrow diagrams. In the development of the NETN Vital Signs Monitoring Program, we chose to generally follow the conceptual framework of Noon et al. (1999), Noon (2002), Hemstrom et al. (1998) and Hemstrom (2003). Their framework emphasizes the interactions between processes or functions and structure/composition, and how these in turn mediate biodiversity responses. The models therefore, identify tangible and measurable structural and compositional attributes of the system that reflect the state of underlying processes. These attributes in turn can be used to make predictions about the expected biological response (Noon 2003) (Fig. 2.1).

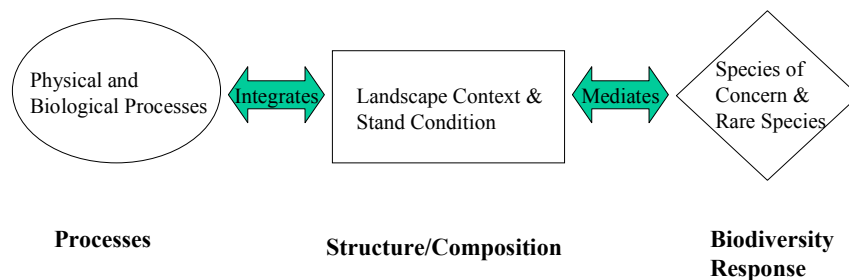


Figure 2.1. Basis for the conceptual models developed for the NETN. The model emphasizes how structural and compositional attributes integrate physical and biological processes/functions (drivers) and mediate the biodiversity response of focal and other species of interest. Adapted from Noon (2003).

General Model of System Groups for NETN

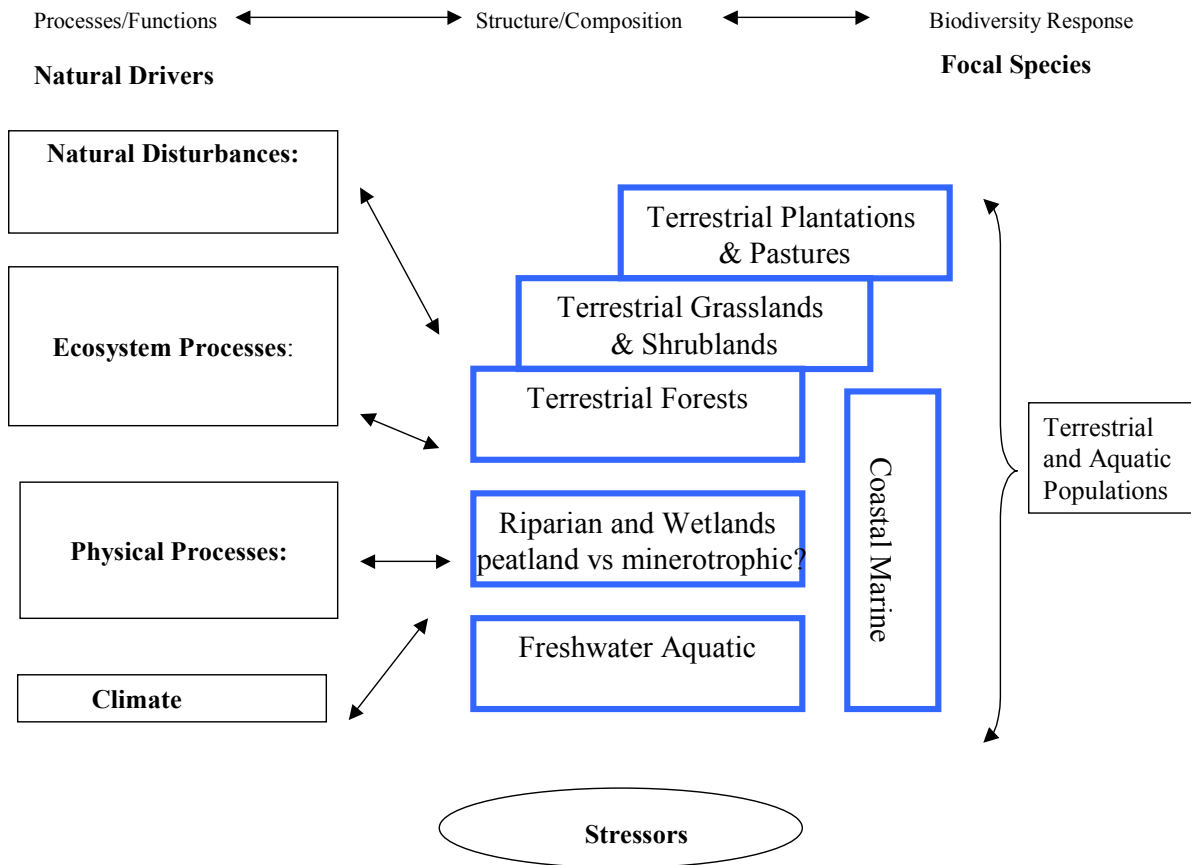


Figure 2.2. Conceptual model for terrestrial ecological systems in the NETN. The model may well emphasize how structural and compositional attributes integrate physical and biological processes/functions (drivers) and mediate the biodiversity response of focal and other species of interest. Adapted from Noon (2003).

The model also incorporates the main categories used by NatureServe and its member programs (Natural Heritage Programs) to assess ecological integrity (NatureServe 2002), namely, condition, size, and landscape context (see section 1.3.3). However, in the NatureServe methodology, size is treated as a category, whereas here it is treated as a component of stand condition. Further review is needed to resolve what the essential structural/compositional categories are. In any case, these categories focus on measures of structural and compositional aspects of a system at both stand and landscape levels. The model can also incorporate Harwell et al. (1999) and Young and Sanzone's (2002) categories for describing process, structure and function, much as Hemstrom et al.'s (1998) model does, as follows (see also Figure 2.2):

The model incorporates at least two scales directly into the system, that of landscape and stand. These two scales are often of strong interest to resource managers. Temporal considerations also need to be considered for each of the categories and their attributes. Finally, anthropogenic stressors can be added to the model, showing which part of the system the stressors are impacting.

The model is, in Noon's (2003) terminology, a hybrid between an "effects-oriented model" and a "predictive or stressor-oriented model." That is, the model uses both indicators of ecological integrity that reflect the past and current effects of natural processes (drivers) on the system, and measures of system stressors (see also Figs. 2 and 3 in Chapter 1). When indicators are selected, higher priority may be given to those that measure both system integrity and stressor response. The advantage of such an approach is that the emphasis is placed on anticipated cause-effect relationships, expressed as changes in the value of an indicator, which allows for a more focused management response (Noon 2003). However, given that all potential stressors cannot be identified in advance, complete adoption of this approach has some risk, as stated by Noon (2003):

"without a thorough assessment of ecological condition [integrity], the possibility exists of failing to detect the ecological impacts of significant but unanticipated stressors or management consequences if a wrong or incomplete set of indicators is selected."

This is a serious risk, and we address this risk in our model by incorporating the ecological integrity ranking methodology of NatureServe, which provides a set of indicators that measure the relative integrity of the system, regardless of particular stressors (see section 1.3.3), and propose to add additional stressor indicators that may guide management. Such a model will strengthen the goals of both conservation and resource management.

The general model is then developed for each ecological system found in the park, with the systems processes, structure, and function are based on range-wide information of that system (see System Types below). Each ecological system model specifically integrates the drivers, stressors, and attributes that may influence that specific system.

At the park level it may be of interest to integrate the various system models together to see if and how they share drivers, stressors, and structural/functional components. Such an approach could be extended to all systems, not just terrestrial ones, as shown in Figure 2.2. An assessment of the parks focal resources (see Figs. 1.2 and 1.3 in Chapter 1) will affect how the modeling at the park level is completed.

Terrestrial Ecosystem Model and Attributes: Forests

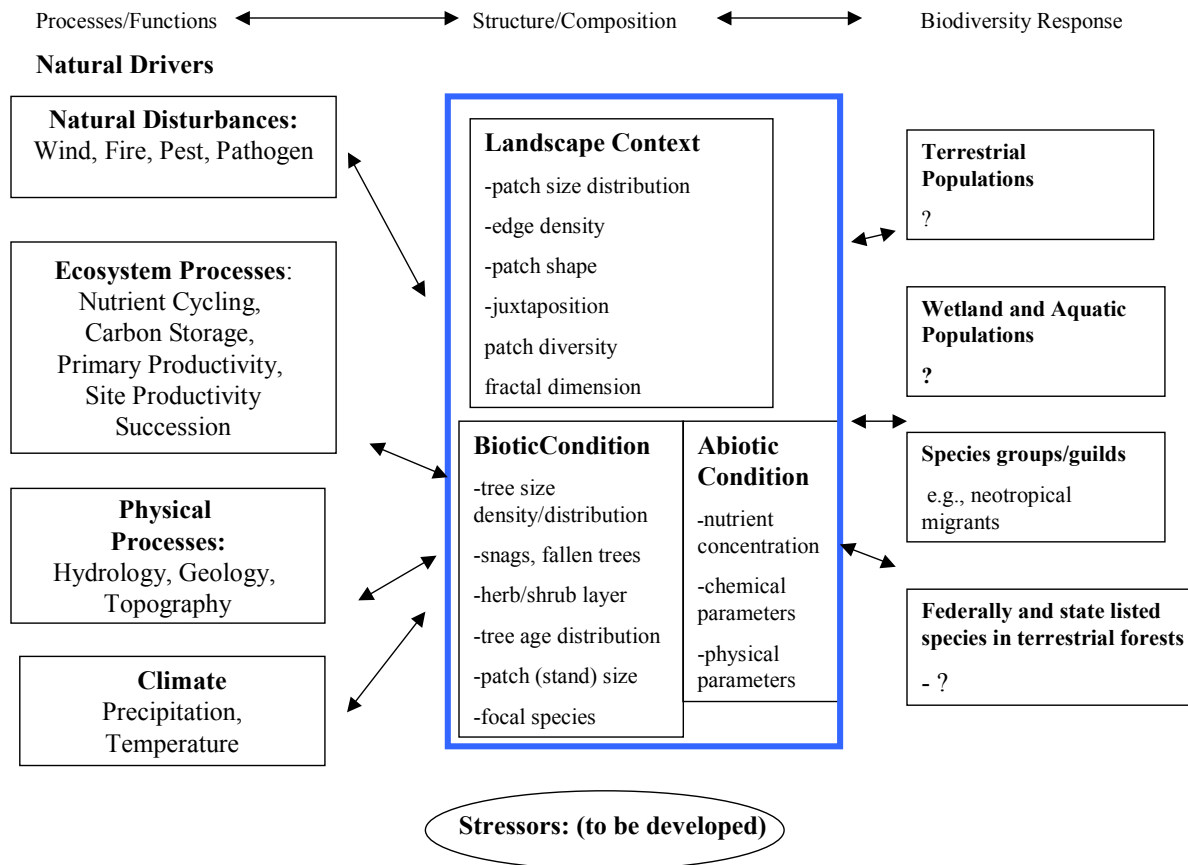


Figure 2.3. Conceptual Model that displays the interaction among individual system models (as displayed in Fig. 2.2).

The general model identifies the key ecological communities within parks and the natural and anthropogenic stressors that influence those systems. Specific resources and processes will be identified for each ecosystem type in individual models. For example, we present the working draft of the hemlock hardwood forest model. This model describes, and where possible broadly quantifies, the impact of important drivers and stressors on the hemlock-hardwood forest. It identifies attributes of the ecosystem that could be selected as monitoring indicators as well as some common measures of those attributes.

At a more specific level, it may be helpful to develop subsystem models of specific components of a system. We later provide an example for vernal pools (Fig. 2.5). In the northeast, vernal pools typically occur within terrestrial forest systems (including upland and bottomland/floodplain situations), but they form a distinctive subsystem with distinctive drivers and attributes, and are often a management concern. The model can be linked to the terrestrial ecological system model (Fig. 2.2), as a separate box in the biodiversity response part of the model. The implication would be that if the structural and functional attributes of the overall terrestrial forest systems within which the vernal pools occur show high ecological integrity, then the vernal pools may be expected to do so as well. But, given their special features, some monitoring indicators may still be needed to verify how the biodiversity of the vernal pool subsystem is responding.

Finally, we also develop a model for a species, the Jefferson salamander (*Ambystoma jeffersonianum*). This is typically listed as a species of special concern for parks that have this salamander, and it may also serve as a focal species for vernal pool subsystems; that is, it serves to indicate the relative ecological integrity of a vernal pool. Selection of species that need their own conceptual models is a critical step in the review process. In general we expect that conceptual modeling will focus on all terrestrial systems in

the parks, with perhaps special emphasis given to system types of special management concern, but only a selected set of species that warrant special attention.

2.3.1 Components of NETN freshwater conceptual models

Conceptual models of freshwater ecosystems within the park include; a hydrologic model of the freshwater inflows and outflows contributing to the ecosystem, and the drivers and stressors which have the potential to effect the quality and quantity of the freshwater making up these ecosystems. Information about the freshwater resource is included if available. Drivers are defined as major, naturally occurring forces of change, operating both inside and outside the park boundaries that affect the freshwater ecosystems. Stressors are the physical, biological or chemical perturbations to the freshwater ecosystem and are divided into either stressors that affect water flowing into the park, stressors that affect freshwater within the park, or both. Stressors can be foreign to the system, or natural to the system, but applied at a excessive (or deficient) level ([Appendix A](#)). Ecosystem-wide processes such as precipitation and evaporation occur throughout the park. Ground-water/surface-water interactions occur in both directions and also occur throughout the park.

2.4 *Case Studies of Conceptual Ecological Models*

2.4.1 Case Study 1: Hemlock-Hardwood Forest Conceptual Model

2.4.1.1 Framework and definitions

The core of the conceptual ecological model was constructed by identifying the important drivers and monitoring attributes in each category, and establishing the important links between categories, as outlined in Section 2.3. The model was expanded by including biodiversity targets that are of specific interest in the system because of their rarity, or other particular importance, and by identifying the important stressors of the system and their potential impacts on the natural model elements (Fig. 2.1).

Often, the assessments of the impact of stressors include significant amounts of uncertainty. Therefore, a standard is needed for deciding which stressors to consider with respect to each system. We have analyzed impact of a given stressor on a system if there is at least one documented example of that stressor impacting an element of the system conceptual model and no body of evidence to indicate that the example is unusual or exceptional.

2.4.1.2 Conceptual Model Criteria

Driver categories

Natural disturbances--Windstorms are the primary types of natural disturbances in the hemlock-hardwood forest. Sometimes, wind damage is aided by other factors such as simultaneous ice accumulation or lightning strikes (Van Dyke and R. P. F. Landmark Consulting 1999; Ruffner and Abrams 2003). Windstorms can create relatively common but small gaps consisting of one or several trees (Frelich and Lorimer 1991; Parshall 1995; Webster and Lorimer 2002) or occasionally blow down large patches of forest (Dunn et al. 1983; Foster 1988; Peterson and Pickett 1991). Normal levels of relatively small disturbances serve to maintain the growth and structure of the stand. They are generally filled by species that are already dominant in the forest (Webster and Lorimer 2002). Larger blowdowns serve to reset succession and make habitat available for early successional, shade intolerant species and their faunal associates (Dunn et al. 1983; Peterson and Pickett 1991). Return rates vary greatly with the size of the disturbance considered, however in general most studies agree that decadal 5% to 15% of the canopy is replaced (Runkle 1982; Frelich and Lorimer 1991; Ziegler 2002; Ruffner and Abrams 2003), resulting in an average canopy residency time of 145 to 211 years (Frelich and Lorimer 1991; Dahir and Lorimer 1996; Ziegler 2002).

Because of their rarity, the frequency of catastrophic windfall events is impossible to monitor. However, medium to large disturbances can be mapped by remote sensing (ex. Miller-Weeks et al. 1999). The

overall impacts of all windfalls and other natural disturbance can be accessed through the measures of drivers and attributes such as mortality, recruitment, forest structure, and landscape succession mosaic, described below.

Ecological processes--Germination and recruitment of saplings into the canopy is regulated by conditions of relative shade and acidity in hemlock-hardwood forests (Catovsky and Bazzaz 2000). Eastern hemlock (*Tsuga canadensis*) is especially favored by such conditions. Although seedbanks are often dominated by yellow birch (*Betula alleghaniensis*) and associated understory species (Mladenoff 1990; Catovsky and Bazzaz 2000; Yorks et al. 2000), hemlock forests perpetuate themselves because hemlock is able to cast and tolerate deep shade (Canham et al. 1994). Therefore, larger openings tend to favor more shade intolerant components of the hemlock-hardwood forest such as yellow birch (Webster and Lorimer 2002). Also, openings resulting from windthrow often result in vegetative sprouting of some species such as beech (*Fagus grandifolia*) and maple (*Acer saccharum* and *A. rubrum*) (Peterson and Pickett 1991). Regeneration of hemlock is aided by the small areas of windthrow because treefall mounds can increase hemlock sapling growth and survival (Long et al. 1998). Several microsite variables such as depth and type of leaf litter are also important for the survival of young seedlings in the hemlock-hardwood forest (Collins 1990). Because regeneration is dependant on gap formation and the characteristics of the particular gap or disturbance, it is difficult to monitor the current stocks of potential regeneration for early alert to a regeneration problem. However, the density of seedlings and saplings can be used as a measure of regeneration (National Forest Health Monitoring Program 1998).

Tree growth rates vary widely for many different reasons, such as climatic events like droughts, soil conditions, available sunlight, competition, disease and age. Growth rates are inherently linked to mortality rates. For individual trees, slow growth is often related to failing health or temporary stress. Slow-growing trees are more likely to die. However, in a resource-limited system, increases in mortality increase the resources available to surviving trees and therefore can increase their growth rates. In old-growth hemlock-hardwood forests, measured diameter growth rates vary from 1.0 to 5.0 mm yr⁻¹, with rates for hemlock lower than those for hardwood species such as yellow birch (Ward and Stephens 1997; Runkle 2000; Woods 2000). Because growth rates are influenced by so many factors, they are generally difficult to interpret as measures of forest health; however if they are measured using a large enough sample size they may be useful (National Forest Health Monitoring Program 1998).

Mortality rates vary less than growth rates; however, limited baseline data on mortality is available to allow productive monitoring. Typical reported values in old-growth forests are between 0.5% and 4% annually (Whitney 1984; Runkle 1990; Runkle 2000; Woods 2000). Recruitment, growth and mortality combine to determine live and dead forest structure. The combined impact of all three processes can be observed best by monitoring changes in forest structure, where more baseline information is available. Repeated measures of forest structure (discussed below) can result in measured mortality rates with no additional effort.

Jenkins et al. (1999) and Mladenoff (1987) showed that nitrogen cycling rates in a hemlock-hardwood forest increased in response to major disturbance and in small tree-fall gaps. They suggest that such a response is typical following episodes of mortality caused by various mechanisms. Nitrogen cycling rates can have important impacts on N leaching to some downstream ecosystems.

Climate--Little published information is available about the climatic range of hemlock-hardwood forests. However, several sources report the climatic ranges of eastern hemlock and other key species in the hemlock-hardwood forest type (USDA 1990; Iverson et al. 1999). Temperature and precipitation ranges for these species are typical of the Northeast Region at mid to low elevation (below approximately 1500 m or lower in the more northern part of the region)(Eyre 1980; Reschke 1990). Therefore, the distribution of hemlock-hardwood forests is primarily determined by hydrology, topography, soil, and land use

history. However, microclimatic conditions influenced by topography and hydrology are doubtless critical for facilitating the development of hemlock-hardwood forests (Elliot 1953).

Physical Processes (hydrology and geomorphology)--Hemlock-hardwood forests occur under a variety of conditions and soil types. Generally they are found on sideslopes or bottomlands. If the soil is well drained, they are restricted to near streams. Especially in the northern part of their range they are commonly found in moist flats. Soils are generally acidic and often with a deep humus layer. Hemlock also dominates in many steep ravines (Eyre 1980; NatureServe 2003).

Attribute Categories

Landscape context--According to current ecological theory one effect of disturbance is to create a mosaic of different successional stages on a landscape. Given a large enough area, a quasi-equilibrium will be reached where the area in each successional stage remains approximately constant. Frelich and Lorimer (1991) estimate the minimum area of hemlock-hardwood forests to sustain a quasi-equilibrium structure in Michigan is approximately 5000 ha. In the northeast, the area would be less if disturbance is less frequent and more if it is more frequent than in Michigan. It is important to consider that throughout much of the Northeast, the hemlock-hardwood forest is distributed patchily on the landscape and therefore 5000 ha of hemlock-hardwood forest occupy significantly more than 5000 ha of land. Land area in hemlock-hardwood forest is a simple measure of this attribute. Also, it is possible to have a more comprehensive indicator by specifying the percentage of that forest which should belong to each ranking class (A through D; Table 2.1) for individual stand attributes (potential stand attributes are described below).

The size of each patch is also important, small patches have a large relative area in edge, which often has different compositional and structural characteristics from the interior of the patch (Mladenoff et al. 1993). Also small patches of forest may not serve the needs of all interior faunal species. Patch size, percent edge, road density, and percent of forest within a given distance of roads are potential measures of this attribute (Mladenoff et al. 1993; Heilman et al. 2002).

The composition of hemlock-hardwood forests, particularly the abundance of eastern hemlock within them can have important consequences for downstream aquatic ecosystems. In the Delaware Water Gap, Snyder et al. (2002) found that streams draining hemlock-hardwood stands had more stable hydrologic and thermal regimes and supported richer and more even assemblages of invertebrates than similar streams draining hardwood stands. In southern Ontario, St. Jacques et al. (2000) showed that a Mid-Holocene decline in hemlock resulted in eutrophication of a downstream lake and changes in the associated community of diatoms.

Such effects are external attributes to the hemlock-hardwood ecosystem, and therefore have no measures within the conceptual model. Measures of this type of attribute should be included in the conceptual models for the impacted ecosystems. Nonetheless, the attributes are included here to facilitate the interpretation of the impact of potential changes within the hemlock-hardwood forest on other ecosystems. Vernal pool subsystems are important hydrological and faunal habitat components of some hemlock-hardwood forests. Because they are also present in other forest ecosystem types, they are addressed in a separate vernal pool conceptual model.

Biotic Condition--As forests mature, their structure changes in several ways. Many living components of a hemlock-hardwood forest can serve as measures of this change. Some examples are as follows:

- ◆ The total basal area of the forest increases with age (Tyrrell and Crow 1994b; Keddy and Drummond 1996; Tyrrell et al. 1998). Common basal areas for old-growth hemlock-hardwood forests are 30 m² ha⁻¹ to 60 m² ha⁻¹ (Leak 1987; Busing 1989; Tyrrell and Crow 1994b; Dahir and Lorimer 1996; Tyrrell et al. 1998; Goodburn and Lorimer 1999; Ruffner and Abrams 2003);

- ◆ The basal area of trees over a given diameter increases. Some commonly used cutoffs are 50 and 70 cm. Basal area over 50 cm dbh ranges from 5 m² ha⁻¹ to 25 m² ha⁻¹ for old growth hemlock-hardwood forests. Basal area above 70 cm dbh ranges from zero to 10 m² ha⁻¹ (Tyrrell and Crow 1994b);
- ◆ The diameter distribution of the forest (a plot of the density of trees in each of several diameter classes) flattens out, reflecting the increasing number of large trees and decreasing number of small trees (Tyrrell and Crow 1994b). Meyer (1952) measured this flatness with a q value where q equals the density of trees in a given diameter class divided by density in the next larger class. Therefore maturing forest should have decreasing q values. Manion and Griffin (2001) calculated the “baseline mortality” of a forest, based on the q value where baseline mortality equals change in density of trees from one diameter class to the next divided by the initial density. Although their index is newer than Meyer’s (1952) and less widely referred to, it has the advantage of conceptually linking an index of forest structure to growth and mortality rates. If a forest experiences mortality greater than the baseline level during the time that the average tree grows from one diameter to the next, the basal area will decrease. If actual mortality is less than baseline it will increase. If actual mortality is equal to baseline mortality the diameter distribution (and basal area) will remain constant. Both q and baseline mortality are easily calculated from one another.

The two main dead components of the forest are coarse woody debris and snags. Coarse woody debris is downed dead woody material. It affects microsite conditions, provides suitable regeneration sites for seedlings, serves as habitat for salamanders and invertebrates, forms the basis for much of the detrital food web (Tyrrell and Crow 1994b; Tyrrell and Crow 1994a; Keddy and Drummond 1996; Ziegler 2000). Coarse woody debris also increases with forest age. It can be measured by density of pieces, volume, or mass. Typical values of the volume of logs (an important structural component of coarse woody debris) in old-growth hemlock-hardwood forests are 50 m³ ha⁻¹ to 300 m³ ha⁻¹ (Tyrrell and Crow 1994b; Tyrrell and Crow 1994a; Tyrrell et al. 1998).

Snags are standing dead trees that form important habitat for many invertebrates, birds, and mammals. The density, basal area and volume of snags are the most commonly used measurement units. Common basal areas of snags in old-growth hemlock-hardwood forests are approximately 3 m² ha⁻¹ (Tyrrell et al. 1998). Percent of standing basal area dead is another possible measuring unit (Tritton and Siccama 1990).

Species composition of a hemlock-hardwood forest is another diagnostic characteristic and indicator of maturity. Mature hemlock-hardwood forests are dominated by hemlock, beech and sugar maple. Yellow birch is a common codominant in slightly less mature stands, while an abundance of shade intolerant species such as cherry, red maple and aspen indicates a recent disturbance. In the more southern parts of the region, northern red oak is an important associate. In old-growth hemlock-hardwood forests, hemlock, beech, sugar maple and yellow birch generally account for at least 75% of the total basal area (Busing 1989; Goodburn and Lorimer 1999; Runkle 2000; Woods 2000; Ruffner and Abrams 2003), except where oak is a significant component (Nowacki and Abrams 1994).

Abiotic Condition--As discussed in relation to the drivers of the hemlock-hardwood forest, an important soil characteristic of hemlock-hardwood forests is Nitrogen cycling. Nitrogen cycling is an indicator of disturbance, and nitrogen leaching is a potential pollutant to downstream ecosystems (need reference).

Stressors

Exotic pests / pathogens--During the last century several important pests and pathogens have been introduced to eastern North America, and four have had particularly strong impacts on the hemlock-hardwood forest. Chestnut blight is an aggressive girdling canker caused by the fungus *Cryphonectria parasitica*. It has essentially eliminated American chestnut (*Castanea dentata*) as full sized trees (Manion 1991). Although most of the original chestnut was outside the hemlock-hardwood forest, in some of the

southern parts of the region, chestnut occurred with hemlock, and in some places hemlock and associated hardwoods are taking over after the removal of chestnut by chestnut blight (Busing 1989). Because of the completeness of the chestnut blight epidemic, and because chestnut is no longer an important component of the hemlock-hardwood forest anywhere, there are no measures suggested to monitor this stressor.

Hemlock woolly adelgid (*Adelges tsugae*) is an introduced insect that overwinters on hemlock and lay eggs which hatch into instars and feed on the parenchyma cells. The instars mature into two distinct types of adults: one wingless variety establishes a new generation on hemlock, the other winged variety leave in search of a suitable spruce host. However, none of the spruce species found in eastern North America appear to be suitable (McClure and Cheah 1999). The adelgid has shown some sensitivity to low winter temperatures, but its population rebounds quickly in the spring (McClure and Cheah 1999; Parker et al. 1999). The adelgid is very virulent in many stands where it has invaded (Orwig et al. 2002). It may be dispersed by wind, birds, deer, and humans (McClure 1990). Infestations can impact nitrogen cycling rates (Jenkins et al. 1999), and several avian populations (Tingley et al. 2002). Also, infestation or fear of infestation can cause landowners to engage in salvage cutting (Kizilinski et al. 2002). Therefore, the effects of hemlock woolly adelgid can be potentially far reaching. Since there is no way of knowing where, when and if the insect will spread, or if some environmental conditions will halt its spread or reduce its virulence; we recommend monitoring for its presence in areas not infected and relying on monitoring of the attributes that it may impact (especially forest structure, growth, mortality, and species composition) to show its impact.

Beech bark disease is a complex disease involving a scale insect (*Cryptococcus fagi* and sometimes *Xylococcus betulae*) and a canker causing fungus (*Nectria coccinea* var. *faginata*, and sometimes *N. galligena*). The scale insect feeds on the bark of a beech tree. In the process, it disables the trees chemical defense mechanisms making it susceptible to attack by the fungus, which kills the cambium (Manion 1991). The disease has altered the structure of the beech population. The disease kills many trees, but there is also considerable resistance in the population (Munck 2002). In some forests of the northeast, the impact of beech bark disease appears to be coming to an equilibrium, which includes beech as a smaller, shorter-lived species than it originally was (Runkle 1990; Munck 2002). However, beech bark disease also inspired a large amount of salvage cutting, which resulted in prolific beech sprouting (Houston 2001). Like hemlock woolly adelgid, the main impacts of beech bark disease are on forest structure and species composition. Also like the adelgid other ecosystem components may be impacted, for instance, beech nuts are a food for several wildlife species (insert ref). Therefore, we recommend relying on monitoring of the affected ecosystem components to detect and evaluate the impact of beech bark disease.

Gypsy moth (*Lymantria dispar*) is an introduced defoliating insect. It's larvae feed on deciduous trees, and preferentially feed on oak (Liebhold et al. 1995). The impact of gypsy moth defoliation on growth and mortality is variable, but generally repeated defoliations, low crown position, and other stress factors increase risk of mortality (Campbell and Valentine 1972; Davidson et al. 1997). Aside from contributing directly to the death of some trees, gypsy moth defoliation can alter light levels in stands and thus alter regeneration patterns (Fayvan and Wood 1996). The impact of gypsy moth defoliation in hemlock-hardwood forests is restricted to the more southern examples where oak and gypsy moth are prevalent. The impact of gypsy moth can be monitored by measuring defoliation from the ground or through remote sensing (Liebhold et al. 1997). Also, winter counts of larvae can serve as an index of gypsy moth population levels (Buss et al. 1999).

Invasive plants--We have are presently working with parks, the Exotic Plant Mgt. Team, and the developers of the Invasive Plant Atlas of New England to prioritize invasive plant issues at each NETN park.

Deer overbrowsing--In some areas with dense white tail deer (*Odocoileus virginianus*) populations, browsing can inhibit the establishment of many of the major tree species of the hemlock-hardwood forest, particularly eastern hemlock (Anderson and Loucks 1979; Whitney 1984; Rooney et al. 2000). However, simulation models indicate that in other areas, the impact of deer might be secondary to climatic and life history characteristics, despite high deer populations (Mladenoff and Stearns 1993). Some evidence suggests that the presence of large woody debris (nurse logs) or patches of balsam fir (*Abies balsamea*) saplings can facilitate the regeneration of hemlock in the presence of dense deer populations (Long et al. 1998; Borgmann et al. 1999). The impact of deer overbrowsing (if significant) can be monitored through measuring forest diameter structure, especially in the small (regeneration) diameter classes (Rooney et al. 2000). Also, deer populations can be monitored or estimated from hunting and roadkill records (Halls 1984). Browsing impact can be monitored on regeneration using exclosures.

Harvesting--Although harvesting does not occur on most National Parks, many Park areas were historically harvested, and all are set in a landscape context that includes past and present harvesting. Early harvesting included primarily white pine (*Pinus strobus*) and red spruce (*Picea rubens*), followed by extensive hemlock harvesting to feed the booming tanning industry at the turn of the twentieth Century (Whitney 1990; McMartin 1994). More recently, harvesting has generally been less intensive, although some local areas are heavily harvested for a variety of hardwood species. In mature or old-growth forests, selective logging can alter structure and species composition to favor even-aged populations of shade intolerants (Orwig and Abrams 1999). Also, salvage harvesting in response to diseases like beech bark disease and hemlock woolly adelgid can greatly increase the direct impact of the disease (Houston 2001; Kizlinski et al. 2002). There will likely be a need to monitor harvesting impacts at Marsh-Billings-Rockefeller NHP. The impact of past cutting will be reflected in measures of forest structure and species composition.

Land use change--Intensification of agriculture, suburbanization, and road construction have all contributed to increased fragmentation of the national landscape (Belanger and Grenier 2002; Heilman et al. 2002; Riitters et al. 2003). The impact of this process on avian communities has been especially well documented (Rich et al. 1994; Hargis et al. 1999; Austen et al. 2001). However, it can also strongly impact forest landscape structure in hemlock-hardwood forests and elsewhere (Mladenoff et al. 1993). The impacts of forest fragmentation can best be monitored using remote sensing techniques (Mladenoff et al. 1993; Bonneau et al. 1999a; Bonneau et al. 1999b; Orwig et al. 2002). Measures of forest fragmentation include patch size, shape, and road density (Mladenoff et al. 1993; Heilman et al. 2002).

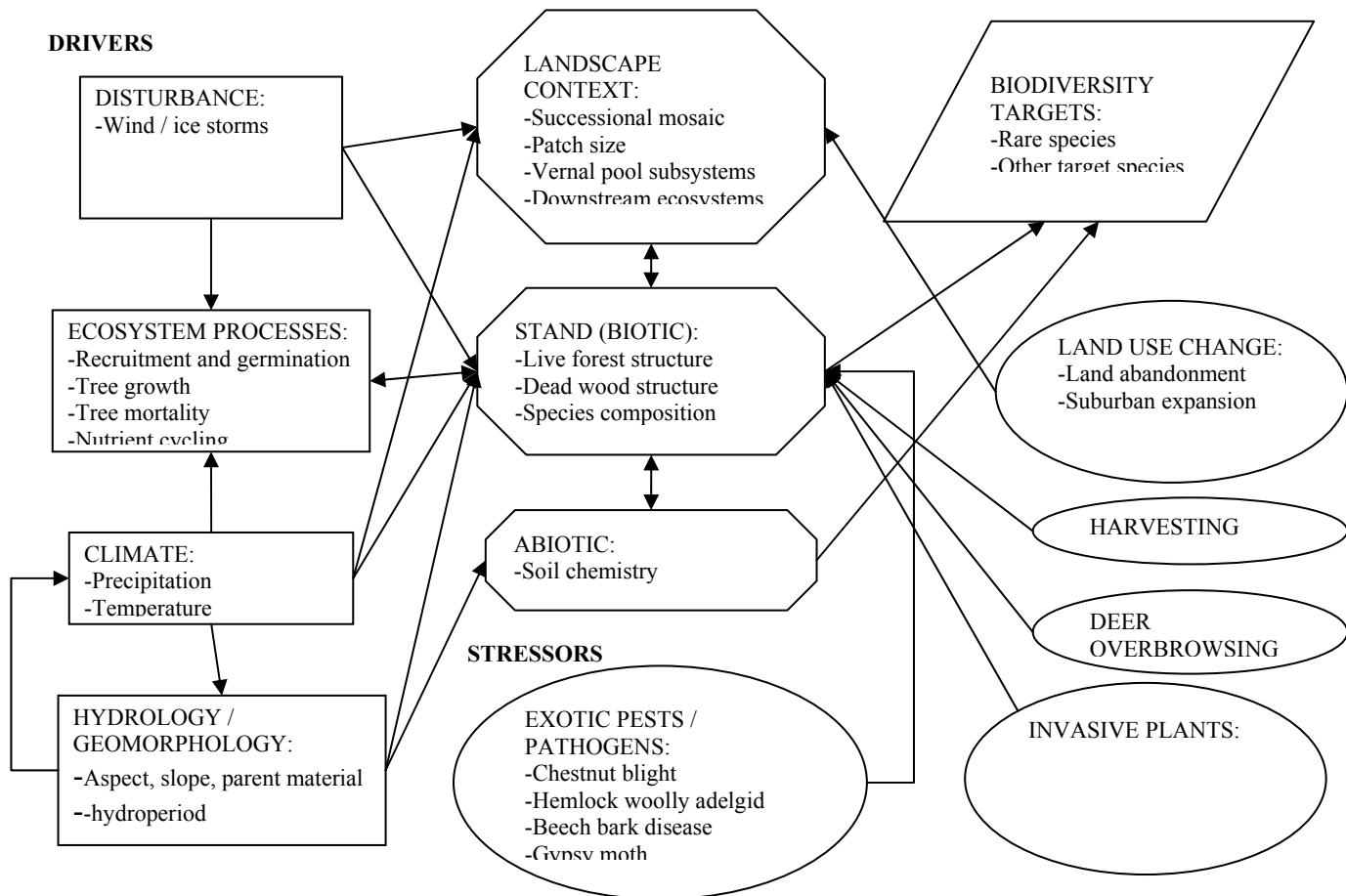


Figure 2.4. Conceptual model of an Eastern-Hemlock-Hardwood ecological community showing natural drivers, stressors, and potential attributes.

2.4.2 Case Study 2: Vernal Pools

2.4.2.1 Framework and definitions

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 unique predator-free environment 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 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.

Table 2.1. List of potential indicators of Eastern Hemlock Hardwood communities. Ranges for each ecological integrity score will be developed.

Category	Driver / Attribute	Measures	A	B	C	D	Sources
Disturbance	Windstorms	Arial extent					
Ecological processes	Recruitment	Abundance of regeneration					
	Growth rates	Diameter growth					
	Mortality rates	Mortality rates					
Landscape context	Successional mosaic	Land area of hemlock-hardwood forest					
		% of hemlock-hardwood forest with A ranking for structural measures					
		Patch size (Fragmentation)					
		Average patch size					
		% edge					
		Road density					
Biotic Condition	Live forest structure	Distance to nearest road					
		Total live basal area					
		Total live basal area (>x cm dbh)					
		Baseline mortality (% / 2.54 cm)	<12.5	12.5-17.5	17.5-22.5	>22.5	(Meyer and Stevenson 1943; Tyrrell and Crow 1994b; Manion and Griffin 2001; Rubin 2003)
	Dead wood structure	Density of CWD					
		Volume of CWD					
		Mass of CWD					
		Density of snags					
		Basal area of snags					
	Species composition	Volume of snags					
		% shade hemlock, beech, birch and					

Category	Driver / Attribute	Measures	A	B	C	D	Sources
		maple					
Abiotic Condition	Soil chemistry	Soil nitrogen					
Stressors	Hemlock wooly adelgid	Presence of HWA	Absent	Present	Present	Present	
	Gypsy moth	Defoliated area					
		Larvae counts					
	Deer overbrowsing	Deer density					
		Browsing impact					

Small temporary wetlands may serve as important repositories of biodiversity (Gibbs 1993; 2000, Semlitsch and Bodie 1998). The ephemeral nature and relatively small size of vernal pools has excluded them from conventional wetland protection status (Preisser et al. 2000). As a result, many New England states are adopting guidelines that help define vernal pools as discrete conservation units within forest systems (Kenney 1995, Preisser et al. 2000, Calhoun and deMaynadier 2003, Calhoun et al. 2003).

Vernal pool habitats are defined loosely as containing water for more than two months in the spring and summer for most years, while also having no fish species present (Kenney 1995). However, rigorous definition of these communities is lacking, owing to geographic variation and incomplete sampling (Calhoun et al. 2003). Brooks and Hayashi (2002) conducted bathymetric surveys of 34 vernal pools in central Massachusetts. Maximum depth was less than 0.5 m for the majority of pools and ranged from 0.11 – 0.94 m for all pools. The range of maximum surface area was 68-2,941 m² and the range of maximum volume was 6-506 m³. Hydroperiod was weakly related to pool shape, in that pools greater than 0.5 m in depth and 1,000 m² in area consistently held water longer, but no direct correlations to any pool metric were observed. While it is unlikely that pool size and shape alone can suitably predict hydroperiod, most studies conclude that pool persistence is paramount in defining suitability (Rowe and Dunson 1995, Snodgrass et al. 2000, Paton and Crouch 2002, Brooks and Hayashi 2003, Calhoun et al. 2003).

2.4.2.2 Conceptual Model Criteria

Drivers

Hydroperiod is likely the most important factor in determining vernal pool suitability. 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 (Semlitsch and Bodie 1998, Gibbs 2000, Snodgrass et al. 2000). Hydroperiod, which is ultimately determined by precipitation and surficial geology, can vary widely among vernal pool systems (Paton and Crouch 2002). Berven (1990) found that mean monthly rainfall affected adult survivorship of wood frogs (*Rana sylvatica*).

Abiotic Condition

The primary abiotic factors in determining vernal pool suitability within northeastern forests are those linked to water quality. Ion concentration may be of particular importance as related to amphibian development (Cook 1983, Hofstra and Smith 1984, Freda and Dunson 1986, Portnoy 1990, Turtle 2000). Low pH can be especially detrimental to developing embryos. Portnoy (1990) observed complete mortality of spotted salamander (*Ambystoma maculatum* Shaw) embryos in vernal pools having a pH of 4 or lower. Turtle (2000) found that de-icing salts heavily contaminate roadside vernal pools. Spotted salamander survivorship was significantly lower in roadside vernal pools that were contaminated by deicing salts used for highway maintenance. Likewise, Hofstra and Smith (1984) observed significant accumulation of Na and Cl in roadside soils up to 30 m from road edges.

Biotic Condition

Biotic components of vernal pool systems are those that are linked to the inherent temporary nature of these wetlands, notably obligate amphibian species. The wood frog, the eastern spadefoot toad (*Scaphiopus h. holbrooki*), and the four species of mole salamander (*Ambystoma* spp.) have evolved breeding strategies intolerant of fish predation on their eggs and larvae; the lack of fish populations is essential to the breeding success of these species. Other amphibian species, including the American toad (*Bufo americanus*), green frog (*Rana clamitans*), and the red-spotted newt (*Notophthalmus viridescens*), often exploit the fish-free waters of vernal pools but do not depend on them. Vernal pools also support rich and diverse invertebrate fauna. Some invertebrate species, such as fairy shrimp (*Eubranchipus* spp.),

are also entirely dependent upon vernal pool habitat. Invertebrates are both important predators and prey in vernal pool ecosystems (King et al. 1996).

Landscape Context

Landscape orientation of small and isolated wetlands is a critical determinant of population viability of obligate species (Gibbs 1993, Guerry and Hunter 2002). Vernal pools tend to be spatially aggregated (Brooks et al. 1998). The availability and suitability of temporary pools may fluctuate at the landscape level. Dispersal opportunities among vernal pools 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).

Habitat fragmentation and buffer loss are major anthropogenic stressors to surrounding vernal pool habitats. Pool-breeding amphibians spend the majority of their lives foraging, resting, and hibernating in the surrounding terrestrial habitat (Semlitsch 1998). Upland habitats immediately surrounding vernal pools serve as important dispersal corridors and are also used as foraging and aestivation areas for many amphibian species (Semlitsch 1998). 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 also seems to be important. 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.

Fragmentation resulting from road construction can act as a partial filter to amphibian movement (Fahrig et al. 1995, Gibbs 1998; deMaynadier and Hunter 2000). Fahrig et al. (1995) observed negative associations between road traffic intensity and amphibian abundance. The impact of road traffic and fragmentation is variable among amphibians according to the likelihood and distance of dispersal (Gibbs 1998). The combined effects of ionic inputs, edge effects (deMaynadier and Hunter 1998), and adult mortality make roads an important landscape consideration for vernal pool systems.

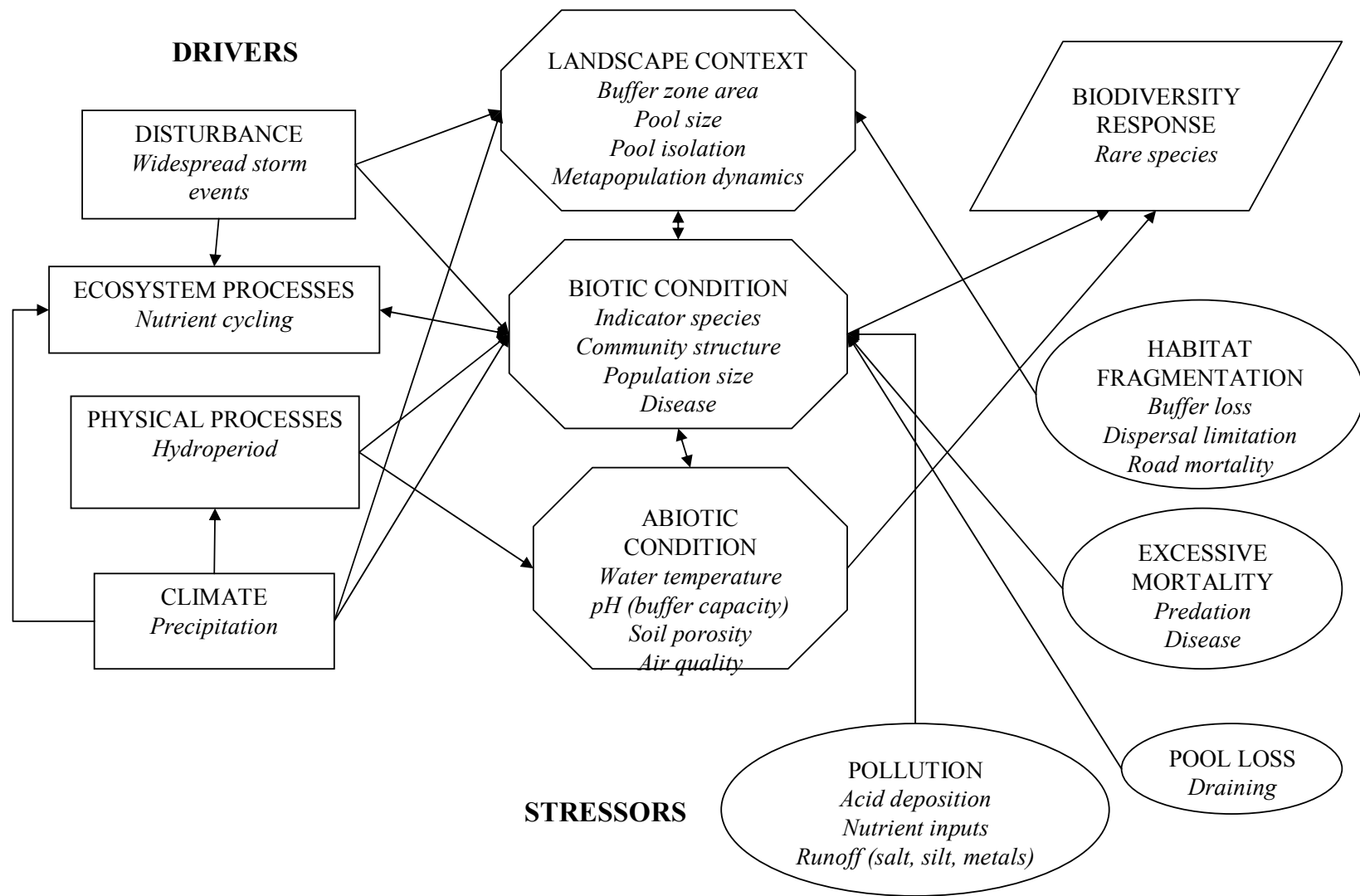


Figure 2.5. Conceptual model of a vernal pool sub-system with natural drivers, stressors, and attributes.

Table 2.2. Conceptual model criteria used to monitor vernal pool integrity. Measured are defined by four rankings (A-D) ranging from most desirable (“pristine” = A) to least desirable (“degraded” = D). Literature support for ranking criteria is provided when available.

Category	Attribute	Measures	A	B	C	D	Source
Physical Processes	Hydroperiod	Pool persistence (months)	4-9	3-4	2-3	< 2	Paton and Crouch (2002); Rowe and Dunson (1995)
Physical Processes	Hydroperiod	Depth (m)	> 0.8	60-89	20-59	< 20	Brooks and Hayashi (2002); Calhoun et al. (2003)
Abiotic Condition	Water quality	pH	> 7	6	5	< 4	Portnoy (1990); Cook (1983)
Abiotic Condition	Water quality	Nutrient/ion concentration (ppm)					Hofstra and Smith (1984)
Biotic Condition	Obligate species	<i>Ambystoma</i> spp. +/-	+	+	-	-	
Biotic Condition	State listed spp.	Number of species	3	2	1	0	Calhoun et al. (2003)
Landscape Context	Population viability	Population size, structure					
Landscape Context	Buffer area	Width of intact edge (m)	> 150				Semlitsch and Bodie (1998)
Landscape Context	Isolation	Distance to nearest pool (km)	< 0.6				loosely on Gibbs (2000)
Landscape Context	Pool density	Number of pools (km ⁻²)	1	0.7	0.5	0.01	loosely on Gibbs (2000)
Stressor	Disease, deformity	Rate of incidence					
Stressor	Fragmentation	Habitat embeddedness					Guerry and Hunter (2002)
Stressor	Isolation	Road mortality (% of population)					Laan and Verboom (1990)
Stressor	Dispersal	Colonization/extinction (% of population)					Brooks et al (1998)
Stressor	Isolation	Road mortality (% of population)					Fahrig et al. (1995)
Stressor	Fish introduction	Fish +/-					

Potential indicator species for vernal pool systems¹

Obligate species – animals that require vernal pools to successfully complete all or a portion of their life cycle.

Common name	Genus species
Blue-spotted salamander	<i>Ambystoma laterale</i>
Spotted salamander	<i>Ambystoma maculatum</i>
Jefferson salamander	<i>Ambystoma jeffersonianum</i>
Marbled salamander	<i>Ambystoma opacum</i>
Wood frog	<i>Rana sylvatica</i>
Eastern spadefoot toad	<i>Scaphiopus holbrooki</i>
Fairy shrimp	Anostraca: <i>Eubbranchipus spp.</i>

Facultative species – animals that will use vernal pools as breeding or foraging habitat, but whom do not require vernal pools to successfully complete their life cycle.

Common name	Taxonomic classification
American toad	<i>Bufo americanus</i>
Fowler's toad	<i>Bufo woodhousii</i>
Four-toed salamander	<i>Hemidactylium scutatum</i>
Gray treefrog	<i>Hyla versicolor</i>
Spring peeper	<i>Pseudacris crucifer</i>
Green frog	<i>Rana clamitans melanota</i>
Pickerel frog	<i>Rana palustris</i>
Leopard frog	<i>Rana pipiens</i>
Red-spotted Newt	<i>Notophthalmus v. viridescens</i>
Snapping turtle	<i>Chelydra serpentina</i>
Spotted turtle	<i>Clemmys guttata</i>
Wood turtle	<i>Clemmys insculpta</i>
Painted turtle	<i>Chrysemys p. pictata</i>
Blanding's turtle	<i>Emydoidea blandingii</i>
Amphibious, air-breathing snails	Basommatophora
Dobsonfly larvae	Corydalidae
Predaceous diving beetle larvae	Dytiscidae
Whirligig beetle larvae	Gyrinidae
Leeches	Hirundinea
Dragonfly larvae	Odonata: <i>Anisoptera spp.</i>
Damselfly larvae	Odonata: <i>Zygoptera spp.</i>
Water scorpion	Nepidae
Freshwater (fingernail) clams	Pisidiidae
Caddisfly larvae	Trichoptera

1. Information provided in "Guidelines for Certification of Vernal Pool Habitat", Natural Heritage and Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife

2.4.3 Case Study 3: Jefferson's Salamander Populations

2.4.3.1 Overview of Species' Biology

Jefferson's Salamander (*Ambystoma jeffersonianum*) is a large, moderately robust salamander with a long tail and long toes. Jefferson's salamander adults are quite subterranean and rarely seen outside of their

breeding migrations. In the northeastern United States these breeding migrations occur very early in the year (early March through April depending on elevation, latitude, and weather) during rainy nights, with this species being the first amphibian to breed at many localities. Generally, males arrive at the breeding sites a few days before females, and mating occurs in the water from within a few days to two weeks at any particular site.

Eggs are attached to sticks or vegetation in water in small loose masses containing 20-30 eggs, with individual females laying 100-300 eggs per season. These hatch in 4-6 weeks into aquatic larvae which will metamorphose into terrestrial juveniles between mid-July to the end of August. The larvae feed on aquatic invertebrates (including mosquito larvae), tadpoles, and other salamander larvae. In turn, they are preyed upon by predaceous diving beetles, larval dragonflies, larger salamander larvae, snakes, and, in some places, fish.

Adults eat a wide variety of earthworms, mollusks, and insects and other arthropods. These salamanders complete their complex life cycles in a variety of forest types containing temporary ponds and semi-permanent wetlands, often deciduous upland forests but sometimes lowland forests bordering disturbed and agricultural areas. Fishless ponds are preferred, but some populations breed in flooded wetlands bordering ponds or rivers with fish. The average life span of the Jefferson salamander is six years or longer (Flank 1999, Harding 1997, Petranka 1998).

A highly unusual aspect of Jefferson's salamander biology is their breeding system. The Jefferson salamander is part of a hybrid complex with other species of mole salamanders. Usually hybrids among species result in triploid females. These females apparently then reproduce gynogenetically, that is, sperm of a sympatric, diploid male is used to stimulate development of the eggs but they male's genome is not incorporated into the developing zygote. Some females, however, do reproduce through hybridogenesis (back-crossing to one of the parental species with the maturing egg eliminating an entire genome). These processes are influenced by temperature: at reduced temperatures triploid females reproduce more frequently by gynogenesis, whereas at higher temperatures the frequency of hybridogenesis increases (Bogart 1988).

The distribution of Jefferson's salamanders is spotty throughout its range; common at some sites and absent from others. The species is distributed in patches from southern New England, south and southwest through Indiana, Kentucky, West Virginia, and Virginia (Petranka 1998).

2.4.3.2 Conceptual Model of Jefferson's Salamander Populations

Population processes, and the stressors upon them, can most easily be envisioned through a "life cycle diagram" that describes each life stage and the transitions of individuals among them. For Jefferson's salamanders, the key model parameters used to estimate the number of eggs (N_e), juveniles (N_j) and adults (N_a) in a population in a given year are: (1) σ_a = adult annual survival rate, (2) ϕ = average eggs produced per reproductive individual, (3) σ_m = survival rate from egg to metamorphosis, and (4) σ_j = survival rate of juveniles through their first winter. The clutch size parameter, ϕ , incorporate the numbers of eggs per mass, number of egg masses laid per female per year, and annual breeding probability. The interactions among these life cycle stages and population parameters are depicted in Figure 2.6.

Stressors

Habitat loss and disturbance is the most serious threat to the Jefferson salamander, which tend to be more intolerant of disturbance than other *Ambystoma*. Habitat disturbance is an issue for both vernal pools (that is, embryo and larval habitat) and surrounding mature forest (the habitat of juveniles and adults). The fundamental issue with breeding habitats is that this species depends on small vernal pools. Such habitats are typically overlooked in the dry season, and in most states receive little or no protection. Moreover, slight changes in local hydrology can change the hydroperiod of such pools, and render them unsuitable

(typically drying prematurely and causing mass mortality of developing larvae). Various scenarios of climate change as it relates to warmer, drier conditions in the Northeast would exert a similar effect.

Jefferson's salamanders population likely depend on access to mosaics of vernal pools in order to persist over time. Multiple, local pools are needed as a buffer against the unpredictability of any given vernal pool drying each year. Processes that reduce pool numbers in a region and increase the distances among pools will erode the viability of salamander metapopulations.

Embryos and larvae are also sensitive to water quality. Like many other animals living in forests in the Northeast, Jefferson's salamanders are being affected by the increased acidification of breeding ponds, and have been eliminated from sites because of low pH. Specifically, low pH reduces the survival of eggs and larvae, as well as slows growth rates and thereby increases likelihood of mortality via predation or susceptibility to pond drying. Another issue germane to the northeastern United States is contamination of pools by road salt application on adjacent roads, which may influence water chemistry in pools up to 100 m away from roads. Obviously, stocking fish in suitable breeding habitats that would otherwise be fishless often eliminates reproduction. For juveniles and adults, forest clearing and development near breeding areas not only eliminate habitat, but can isolate and reduce the suitability of remaining habitats. Roads near breeding pools can create significant barriers to salamander migration. Traffic on roads that intersect breeding and terrestrial habitats may result in excessive mortality of individuals on breeding migrations, sufficient to lead to population reductions.

Forest conditions near pools can exert important influences on juvenile and adult survival. Clear-cutting can have particularly dramatic effects. Removal of the trees causes changes in the temperature, moisture levels, leaf litter depth, plant species, and numbers of invertebrates on the forest floors (DeMaynadier and Hunter, 1995). The negative effects may extend into the edges of surrounding forests for tens of meters. Selective downing or removal of individual trees from a forest has little effect on salamander abundances.

Mature forests are important for maintaining populations, so short rotation forestry, which generally reduces the amount of coarse woody debris on the ground (critical refuges and habitats for Jefferson's salamanders) will also reduce salamander populations. Conversion of natural forests to plantations also is a concern, because acidic soils are avoided by many amphibians. Any processes that degrade the forest soil organic layer will occur to the detriment of Jefferson's salamanders, e.g., soil compaction from excessive tree skidding or off-road vehicle use. A related problem is exotic species, such as exotic earthworms, that elevate rates of litter decomposition and expose bare surface soils.

Because of the close association between temperature and hybridization processes in this species (Bogart 1988) processes that change ambient temperatures could alter population genetic structure and viability. In particular under climate change scenarios or even simply forest clearance and housing development will result in higher ambient temperatures and more hybridogenesis.

Last disease issues are poorly known for salamanders, yet many of the novel pathogens affecting frogs may well also affect salamanders, including Jefferson's salamanders.

Monitoring attributes

Because of the close association between vernal pools and Jefferson salamanders, key monitoring attributes for Jefferson's salamanders have been incorporated into Table 2.1 of Case Study 2: Vernal Pools.

Jefferson's Salamander Life Cycle Diagram

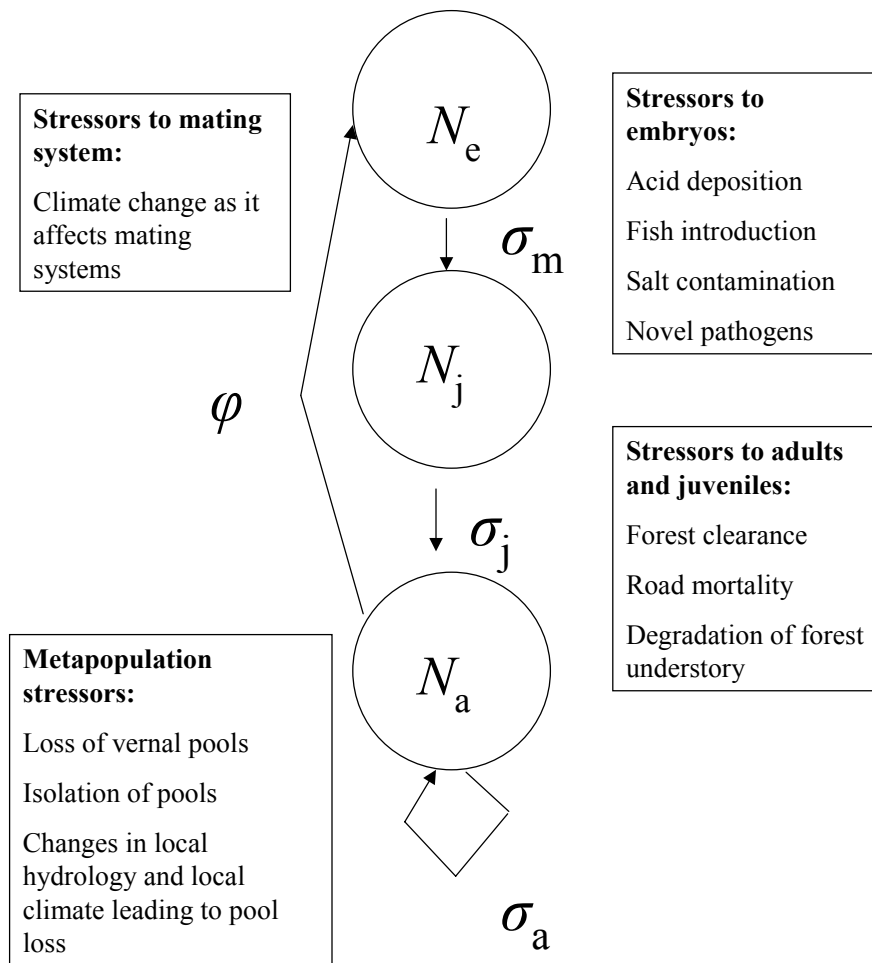


Figure 2.6. Life cycle diagram for Jefferson's salamander, where (N_e) = number of embryos, (N_j) = number of juveniles, and (N_a) = number of adults in a population and σ_a = adult annual survival rate, ϕ = average eggs produced per reproductive individual, σ_m = survival rate from egg to metamorphosis, σ_j = survival rate of juveniles through their first winter, and ϕ = clutch size/individual. Arrows mark transitions among life stages. Stressors to particular life stages and transitions are listed in boxes.

2.4.4 Case Study 4: Freshwater Monitoring at Marsh-Billings-Rockefeller NHP

Marsh-Billings Rockefeller NHP was created in 1992 and encompasses 643 acres in the Connecticut River Watershed including 550 acres of forest. The park is dedicated to presenting historic and contemporary examples of conservation stewardship.

Freshwater Bodies

Freshwaterbodies within the park consist of a pond (The Pogue), a perennial stream (Pogue Hole Brook), many intermittent streams, four wetlands and several seeps (Lautzenheiser, 2002) ([Appendix A fig.7](#)). The Pogue is a 14-acre pond, near the summit of the park, formed by an earthen dam 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 easterly 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.

There are four wetlands east of the Pogue formed by runoff and groundwater seeps and intermittently drain into Pogue Hole Brook. Additional intermittent streams drain the northern slope of Mt. Tom (Lautzenheiser, 2002).

Historic Water-Quality and Water-Quantity Monitoring

Seven stations were located inside the park boundaries during the baseline water-quality inventory and analysis conducted in 1997 for the Marsh-Billings-Rockefeller (National Park Service, 1997). None of these stations were considered long-term, having at least 6 parameters with 1 or more observations per year over at least 2 years (National Park Service, 1997). Four of the stations were established in 1994 by the Water Resources Division (WRD) of the NPS and had one observation each of nitrogen, nitrite, fecal coliform, and phosphorus. The four locations were; the Watering Trough, the unnamed creek leaving the cow pasture, 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. EPA measured 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 one day in 1984.

Current Water-Quality and Water-Quantity Monitoring

Currently there is no water-quality monitoring conducted in the park (C. Marts, oral comm., 2003).

Water-Quality and Water-Quantity Issues

E.coli is a potential problem in the Pogue Stream due to livestock in the stream. A fence has been constructed so that any future grazing will be outside the channel of the stream.

Current and Emerging Aquatic Ecosystem Threats

MABI is mostly a headwater watershed. Intermittent headwater streams initiate in the park and drain the park. For this reason, there are no major surface-water ecosystem threats coming from outside the park. Potential stressors that could adversely affect water quality within the park include forestry within the park, runoff from carriage roads and trails, and livestock grazing within the park (C. Marts, oral comm., 2003) ([Appendix A](#) fig. 8). Although in 2002 and 2003 there were not any livestock within the park, they potentially will be grazing in the park in the future.

Chapter 6 Data and Information Management

6.1 Purpose

6.1.1 Need, and Goal for Northeast Temperate Network Data Management Plan

The goals of data management are to provide accurate, efficient, and effective information and support for resource management and protection. Park managers, cooperators, and other data users need to know what data are available from the network, where it is stored, the quality, timeliness, and uses of the data, how to incorporate this data into resource management decisions, and how the data will be managed over time.

The NPS Strategic Plan, Mission Goal 1b, requires that “management decisions about resources and visitors are based on adequate scholarly and scientific information.” In addition, long-term Goal #1b1 states that acquiring “. . . outstanding data sets . . . of basic natural resource inventories of all parks. . .” is a desired outcome. The objective of the NPS I&M Program is to provide scientifically and statistically sound data for resource management, and to ensure that quality data is available for this task. These objectives establish a need:

- ◆ To develop metadata for all significant spatial and non-spatial data.
- ◆ To ensure very high quality for all significant data.
- ◆ To develop and maintain all essential data.
- ◆ To ensure that data are logically organized and retrievable by staff, cooperators, and the public.
- ◆ To ensure long term integrity of digital data and associated metadata through good archival storage standards and practices.
- ◆ To identify sensitive data and protect it from unauthorized access and inappropriate use.
- ◆ To optimize data sharing, development, and analyses.
- ◆ To ensure that all network held digital and non-digital information (i.e. data sheets, documents, published and unpublished reports, manuscripts, photographs, maps, etc.) are archived and protected in accordance with recognized archival standards.

6.2 Current Status

6.2.1 Information Management Overview

The Northeast Temperate Network intends to acquire and maintain a complete record of natural resource oriented data for all parks within the network. Digital data shall be stored by the network and made available to cooperators, park and/or network staff, and others in compliance with established data distribution policies. Historic data, in formats other than digital, will be obtained when available, and scanned into digital format and made available to cooperators, park and/or network staff, and others in compliance with established data distribution policies.

6.2.2 Legacy Data

The Northeast Temperate Network is currently acquiring datasets from a variety of sources, including State and other Federal agencies, non-governmental organizations, cooperators, and other sources. At this time, cooperators working with the network have populated the National Park Service Dataset Catalog with more than 700 known data sets.

6.2.3 Data Inventory

During Fiscal Year 2004, the Northeast Temperate Network has agreed to cooperatively fund a project with Acadia National Park to inventory and obtain copies of natural resource oriented datasets. The work will build upon the existing northeastern based dataset catalog that currently contains in excess of 700

listings. Datasets identified in the existing catalog that the network does not currently possess will be acquired, and data under current development will be added to the catalog.

6.3 *Physical Resources*

6.3.1 Hardware

Table 6.1. Hardware Resources List

Hardware	Description
Desktop Computers	1 Dell 2.0 GHz, 512 MB RAM, 40 GB HDD, 21" Monitor, 32x8x8 CDRW (laptop) 1 Dell 2.2 GHz, 1 GB RAM, 2-40 GB HDD, 22" Monitor, 32x8x8 CDRW and 250 MB ZIP drives (laptop) 1 Dell 3.2 GHz, 2.0 GB RAM, 2-160 GB HDD, 19" Monitor, 4xDVD+RW, 16xDVD, 32x8x8 CDRW and 250 MB ZIP drives
Printers/ Scanners	1 HP 5500DN Color LaserJet, with 96 Mb, Ethernet, PostScript, and duplexing 1 HP 7490c Color Scanner
Field Data Recorders & GPS units	2 Compaq iPAQ 5450 Pocket PC w/64 MB RAM 2 Garmin GPS Plus Digital Photo Systems

6.3.2 Software

Table 6.2. Software Resources List

Application or Function	Software Package and Version
Word processing	MS Word XP
Database (DBMS)	MS Access XP; ANCS+
Graphics and presentations	Adobe Acrobat 5.0; Adobe GoLive 6.0; Adobe ; Adobe PageMaker; MS Powerpoint XP
Desktop GIS tool	Arc 8 Suite: ArcMap, Arc Tools, Arc Catalog; ArcView GIS 3.3 (2); Blue Marble Geographic Transformer 4.5
Spreadsheet	MS Excel XP
Statistics	SPSS for Windows

6.4 *Personnel resources*

6.4.1 Data Manager

In January 2003, the Northeast Temperate Network hired a Data Manager to oversee issues related to data acquisition, organization, security, access, dissemination, and documentation. Beyond data stewardship, the Data Manager will work with cooperators and park staff on database design and standards issues, will be responsible for determining whether data sets are complete enough for inclusion into master NPS data systems, and will evaluate field data forms and data entry modules.

6.5 *Data Management Standards and Guidelines*

Data management begins with the conception and design of a project and continues until the desired end product is made available to the intended audience. The value of good data management is fully realized when data is readily accessible to a broad audience, and fulfills the intended purpose of the project. Data management includes such activities as; data collection sheet design, metadata fields, data collection protocols, quality assurance measures, establishing archival sites and procedures, updating and maintenance schedules, and setting access policies. Good data management practices support sound park management decisions, promote scientific credibility, and yield consistent data and information products.

To ensure maximum utility, all data collected by the network will abide by any and all applicable Federal, agency, or industry standards.

6.5.1 Project Planning and Standards

The network Data Manager will meet with cooperators, researchers, and park staff to ensure that projects comply with applicable standards and are properly documented. Project documentation shall include, at a minimum, what data is to be collected, for what purpose and for whom, reporting standards and due dates, and required formats.

6.5.2 Metadata

Executive Order 12906 (April 1994) mandates that federal agencies create metadata, or “information about data,” for all geospatial data. The Executive Order states that “Geographic information is critical to promote economic development, improve our stewardship of natural resources, and protect the environment.

The Northeast Temperate Network shall create Federal Geographic Data Committee (FGDC) metadata for all final data sets that are available for distribution by the Northeast Temperate Network. However, the network reserves the right to release provisional versions of data sets to restricted audiences (i.e., cooperators, park and/or network staff, academic researchers, etc.) while they are currently under development AND prior to creation of final metadata records.

6.6 *Data Acquisition and Management*

6.6.1 Data Collection

The Northeast Temperate Network shall develop data collection standards that will be used by cooperators, park and network staff, and others to establish desired data formats, accuracy standards, minimum required documentation, and general project background.

6.6.2 Quality Assurance/Quality Control

Controls shall be established to ensure that the collected and created data is of a known quality. The Network QA/QC requirements shall include:

- ◆ Protocols and standards:
 - applicable scientific measurement protocols
 - applicable and documented SOPs (standard operating procedures)
- ◆ Verification, validation, and editing:
 - applicable and documented SOPs
- ◆ Data documentation & metadata standards:
 - applicable and documented SOPs
 - data documentation (e.g., Data set Catalog, etc.)
- ◆ Data summaries and analyses:
 - applicable and documented SOPs to evaluate precision and accuracy

6.7 *Data Integration*

Data collected, maintained, and/or stored by the Northeast Temperate Network shall be entered into the applicable National Park Service “national” data systems. This includes, but may not be limited to: NPSpecies; NatureBIB; Dataset Catalog; ANCS+. Beyond entering data into the aforementioned databases, data collected, maintained, and/or stored by the network will be made available to parks within the network using pre-established commonly accepted formats and standards.

6.8 *Data Distribution*

6.8.1 Distribution Mechanisms

Data collected, maintained, and/or stored by the network will be made available on the network internet web page (under development), or other means by special request. All network data that is entered into a national system shall also be available through the associated national data access.

6.8.2 FOIA and Sensitive Data Protection

The Northeast Temperate Network will work with cooperating agencies, organizations, and individuals to protect the security of any and all sensitive data. The network shall establish a data protection policy for handling sensitive data, and shall provide a copy of that policy to any cooperator, park and/or network employee, or other individual who has access to network based sensitive natural resource data. The policy shall identify: acquisition requirements; disclosure conditions; the specific dataset point-of-contact; and, protocols for assembling, analyzing and distributing the data.

6.9 *Data Storage and Archiving*

Data collected, maintained, and/or stored by the network will be housed locally on computers in the network office at the Marsh-Billings-Rockefeller National Historic Park, Woodstock, Vermont. On-line versions of these data, destined for internet access and distribution, shall be stored on a NPS internet server. All network data shall be archived on CD, DVD, or tape, and stored at a separate location (to be determined).

6.9.1 Computer Back-up Guidelines

A redundant version of the network's "working" file structure is periodically copied to a separate computer attached to the Local Area Network. A compressed format version (zip) of the working file structure is also periodically backed-up to a separate network drive. System independent, permanent back-ups of the file structure shall be archived on CD, DVD, or tape, and stored at a separate location (to be determined).

Chapter 11: Literature Cited

- Abel, N., H. Ross, and P. Walker. 1998. Mental models in rangeland research, communication and management. *Rangeland Journal* 20(1):77-91.
- Anderson, R. C. and O. L. Loucks. 1979. White-tail deer (*Odocoileus virginianus*) influence on structure and composition of *Tsuga canadensis* forests. *J Applied Ecology* 16: 855-861.
- Austen, M. J. W., C. M. Francis, D. M. Burke and M. S. W. Bradstreet. 2001. Landscape context and fragmentation effects on forest birds in southern Ontario. *Condor* 103: 701-714.
- Barrett, W. G., G. M. VanDyne, and E. P. Odum. 1976. Stress ecology. *BioScience* 26:192-194.
- Belanger, L. and M. Grenier. 2002. Agriculture intensification and forest fragmentation in the St. Lawrence valley, Quebec, Canada. *Landscape Ecol.* 17: 495-507.
- Berven, K.A. 1990. Factors affecting population fluctuations in larval and adult stages of the wood frog (*Rana sylvatica*). *Ecology* 71:1599-1608.
- Bonneau, L. R., K. S. Shields and D. L. Civco. 1999a. A technique to identify changes in hemlock forest health over space and time using satellite image data. *Biol. Invasions* 1: 269-279.
- Bonneau, L. R., K. S. Shields and D. L. Civco. 1999b. Using satellite images to classify and analyze the health of hemlock forests infested by the hemlock woolly adelgid. *Biol. Invasions* 1: 255-267.
- Borgmann, K. L., D. M. Waller and T. P. Rooney. 1999. Does balsam fir (*Abies balsamea*) facilitate the recruitment of eastern hemlock (*Tsuga canadensis*)? *Am. Midl. Nat.* 141: 391-397.
- Brooks, R. T., and M. Hayashi. 2002. Depth-area-volume and hydroperiod relationships of ephemeral (vernal) forest pools in southern New England. *Wetlands* 22:247-255.
- Brooks, R. T., J. Stone, and P. Lyons. 1998. An inventory of seasonal forest ponds on the Quabbin Reservoir watershed, Massachusetts. *Northeastern Naturalist* 5:219-230.
- Bush and Trexler. 2002.**
- Busing, R. T. 1989. A half century of change in a Great Smokey Mountains cove forest. *Bull. Torr. Bot. Club* 116: 283-288.
- Buss, L. Y., D. G. McCullough and C. W. Ramm. 1999. Comparison of three egg mass survey methods in relation to gypsy moth (Lepidoptera: Lymantriidae) defoliation in Michigan. *Environ. Ento* 28: 485-495.
- Calhoun, A. J. K. and P. K. deMaynadier. 2003. Forestry habitat management guidelines for vernal pool wildlife. United States Environmental Protection Agency, Boston, MA, USA.
- Calhoun, A. J. K., T. E. Walls, S. S. Stockwell, and M. McCollough. 2003. Evaluating vernal pools as a basis for conservation strategies: a Maine case study. *Wetlands* 23:70-81.
- Campbell, R. W. and H. T. Valentine. 1972. Tree condition and mortality following defoliation by the gypsy moth. USDA For. Serv. Research Paper NE-236. Upper Darby, PA.
- Canham, C. D., A. C. Finzi, S. W. Pacala and D. H. Burbank. 1994. Causes and consequences of resource heterogeneity in forests: interspecific variation in light transmission by canopy trees. *Can. J. For. Res.* 24: 337-349.
- Catovsky, S. and F. A. Bazzaz. 2000. The role of resource interactions and seedling regeneration in maintaining a positive feedback in hemlock stands. *J. Ecol.* 88: 100-112.
- Collins, S. L. 1990. Habitat relationships and survivorship of tree seedlings in hemlock-hardwood forest. *Can. J. Bot.* 68: 790-797.
- Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological Systems of the United States: A Working Classification of U.S. Terrestrial Systems. NatureServe, Arlington, Virginia. 61 pp. + Appendices
- Cook, R. P. 1983. Effects of acid precipitation on embryonic mortality of *Ambystoma* salamanders in the Connecticut Valley of Massachusetts. *Biological Conservation* 27:77-88.
- Crouch, W. B. and P.W. Paton. 2002. Assessing the use of call surveys to monitor breeding anurans in Rhode Island. *Journal of Herpetology* 36: 185-192.

- Dahir, S. E. and C. G. Lorimer. 1996. Variation in canopy gap formation among developmental stages of northern hardwood stands. *Can. J. For. Res.* 26: 1875-1892.
- Davidson, C. B., K. W. Gottschalk and J. E. Johnson. 1997. Tree mortality following defoliation by the European gypsy moth (*Lymantria dispar* L.) in the United States: A review. *For. Sci.* 45: 74-84.
- De Leo, G. A. and S. Levin. 1997. The multifaceted aspects of ecosystem integrity. *Conservation Ecology* [online] 1:3. Available from <http://www.consecol.org/vol1/iss1/art3>
- deMaynadier, P. G. and M. L. Hunter, Jr. 1998. Effects of silvicultural edges on the distribution and abundance of amphibians in Maine. *Conservation Biology* 12:340-352.
- deMaynadier, P.G., and M.L. Hunter, Jr. 2000. Road effects on amphibian movements in a forested landscape. *Natural Areas Journal* 20:56-65.
- DiMauro, D. and M. L. Hunter, Jr. 2002. Reproduction of amphibians in natural and anthropogenic temporary pools in managed forests. *Forest Science* 48:397-406.
- Dunn, C. P., G. R. Guntenspergen and J. R. Dorney. 1983. Catastrophic wind disturbance in an old-growth hemlock-hardwood forest, Wisconsin. *Can. J. Bot.* 61: 211-217.
- Elliot, J. C. 1953. Composition of upland second growth hardwood stands in the transition zone of Michigan as affected by soils and man. *Ecol. Monogr.* 23: 271-288.
- Eyre, F. H. 1980. *Forest Cover Types of the United States and Canada*. Society of American Foresters, Washington DC.
- Fahrig, L.; J. Pedlar, H. Shealagh, E. Pope, P. D. Taylor, J. F. Wegner. 1995. Effect of road traffic on amphibian density. *Biological Conservation* 73: 177-182.
- Fayvan, M. A. and J. M. Wood. 1996. Stand structure and development after gypsy moth defoliation in the Appalachian Plateau. *For. Ecol. & Manage.* 89: 79-88.
- FGDC. 1997. Vegetation classification standard. FGDC-STD-005. Vegetation Subcommittee, Federal Geographic Data Committee. FGDC Secretariat, U.S. Geological Survey, Reston, Virginia, USA. [Web resource: <http://www.fgdc.gov/standards>]
- Foster, D. R. 1988. Disturbance history, community organization and vegetation dynamics of the old-growth Pisgah Forest, south-western New Hampshire, U.S.A. *J. Ecol.* 76: 105-134.
- Freda, J. and W. A. Dunson. 1986. Effects of low pH and other Chemical Variables on the local distribution of amphibians. *Copeia*, 2: 454-466.
- Frelich, L. E. and C. G. Lorimer. 1991. Natural disturbance regimes in hemlock-hardwood forests of the upper Great Lakes region. *Ecol. Monogr.* 61: 145-164.
- Gibbs, J. P. 1998. Amphibian movements in response to forest edges, roads, and streambeds in southern New England. *Journal of Wildlife Management*, 62: 584-589.
- Gibbs, J. P. 1993. Importance of small wetlands for the persistence of local populations of wetland-associated animals. *Wetlands* 13:25-31.
- Gibbs, J. P. 2000. Wetland loss and biodiversity conservation. *Conservation Biology* 14:314-317.
- Goodburn, J. M. and C. G. Lorimer. 1999. Population structure in old-growth and managed northern hardwoods: an examination of the balanced diameter distribution concept. *For. Ecol. & Manage.* 118: 11-29.
- Grossman, D.H., D. Faber-Langendoen, A.S. Weakley, M. Anderson, P.S. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. International Classification of Ecological Communities: terrestrial Vegetation of the United States. Volume I. The national vegetation classification system: development, status, and applications. The Nature Conservancy, Arlington, Virginia, USA.
- Groves, C. R. 2003. Drafting a conservation blueprint: A practitioner's guide to planning for biodiversity. Island Press.
- Guerry, A. and M. L. Hunter, Jr. 2002. Amphibian distributions in a landscape of forests and agriculture: An examination of landscape composition and configuration. *Conservation Biology* 16:745-754.
- Halls, L. K. e. 1984. *White-Tailed Deer: Ecology and Management*. Stackpole Books, Harrisburg, PA.

- Hargis, C. D., J. A. Bissonette and D. L. Turner. 1999. The influence of forest fragmentation and landscape pattern on American martens. *J. Appl. Ecol.* 36: 157-172.
- Harwell, M.A., V. Myers, T. Young, A. Bartuska, N. Gassman, J.H. Gentile, C.C. Harwell, S. Appelbaum, J. Barko, B. Causey, C. Johnson, A. McLean, R. Smola, P. Templet, S. Tosini. 1999. A framework for an ecosystem integrity report card. *BioScience* 49 (7): 543-556).
- Heilman, G. E. J., J. R. Strittholt, N. C. Slosser and D. A. Dellasala. 2002. Forest fragmentation of the conterminous United States: assessing forest intactness through road density and spatial characteristics. *BioScience* 52: 411-422.
- Hemstrom, M.**, T. Spies, C. Palmer, R. Kiester, J. Teply, P. McDonald, and R. Warinbington. 1998. Late-successional and old-growth forest effectiveness monitoring plan for the Northwest forest plan. USFS General Technical Report PNW-GTR-438.
- Hemstrom. 2003.**
- Hofstra, G.** and D. W. Smith. 1984. The effects of road deicing salt on the levels of ions in roadside soils in southern Ontario. *Journal of Environmental Management* 19: 261-271.
- Houston, D. R.** 2001. Effect of harvesting regime on beech root sprouts and seedlings in a north-central Maine forest long affected by beech bark disease. USDA For. Serv. Research Paper NE-717. Newtown Square, PA.
- Iverson, L. R.**, A. M. Prasad, B. J. Hale and E. K. Sutherland. 1999. Atlas of current and potential future distributions of common trees of the eastern United States. General Technical Report. NE-265 USDA Forest Service. Newtown Square, PA.
- Jenkins et al. 2002.**
- Jenkins, J. C., J. D. Aber and C. D. Canham. 1999. Hemlock woolly adelgid impacts on community structure and N cycling rates in eastern hemlock forests. *Can. J. For. Res.* 29: 630-645.
- Jennings, M.**, O. Loucks, D. Glenn-Lewin, R. Peet, D. Faber-Langendoen, D. Grossman, A. Damman, M. Barbour, R. Pfister, M. Walker, S. Talbot, J. Walker, G. Hartshorn, G. Waggoner, M. Abrams, A. Hill, D. Roberts, and D. Tart. 2003. Standards for the associations and alliances of the U.S. National Vegetation Classification. The Ecological Society of America, Vegetation Classification Panel, Version 2.0 May 2003.
- Keddy, P. A. and C. G. Drummond. 1996. Ecological properties for the evaluation, management, and restoration of temperate deciduous forest ecosystems. *Ecol. Appl.* 6: 748-762.
- Kenney, L. P.** 1995. Wicked big puddles: A guide to the certification and study of vernal pools. US Government Printing Office, Washington, D.C., 58 pp.
- King, J.L, Simovich, M.A; R.C Brusca. 1996. Species richness, endemism and ecology of crustacean assemblages in northern California vernal pools. *Hydrobiologia* 328:85-116.
- Kizlinski, M. L., D. A. Orwig, R. C. Cobb and D. R. Foster. 2002. Direct and indirect ecosystem consequences of an invasive pest on forests dominated by eastern hemlock. *J. Biogeography* 29: 1489-1503.
- Larsson, T.-B.** 2001. Biodiversity evaluation tools for European forests. *Ecological Bulletin* 50:1-237.
- Leak, W. B.** 1987. Fifty years of compositional change in deciduous and coniferous forest types in New Hampshire. *Can. J. For. Res.* 17: 388-393.
- Leibfreid, T.** 2003. Example of a Phase I Vital Signs Monitoring Plan for the Cumberland Piedmont Network (Working draft - Feb. 14, 2003). National Park Service Cumberland Piedmont Inventory and Monitoring Network.
- Liebholt, A. M.**, K. W. Gottschalk, E. R. Luzader, D. A. Mason, R. Bush and D. B. Twardus. 1997. Gypsy moth in the United States: an atlas. USDA Fo. Serv. General Technical Report NE-233. Randor, PA.
- Liebholt, A. M.**, K. W. Gottschalk, R. M. Muzika, M. E. Montgomery, R. Young, K. O'Day and B. Kelley. 1995. Suitability of North American tree species to gypsy moth: A summary of field and laboratory tests. Gen. Tech. Rep. USDA For. Serv. Radnor, PA.

- Lindenmayer and Franklin.** 2002. Conserving forest biodiversity: A comprehensive multiscaled approach. Island Press, Washington, DC. 351 p.
- Long, Z. T., W. P. Carson and C. J. Peterson. 1998. Can disturbance create refugia from herbivores: an example with hemlock regeneration on treefall mounds? *J. Torr. Bot. Soc.* 125: 165-168.
- Manion,** P. D. 1991. *Tree Disease Concepts*. Prentice Hall, Englewood Cliffs, NJ.
- Manion, P. D. and D. H. Griffin. 2001. Large landscape scale analysis of tree death in the Adirondack Park, New York. *For. Sci.* 47: 542-549.
- Maddox,** D., K. Poiani, and R. Unnasch. 1999. Evaluating management success: Using ecological models to ask the right monitoring questions. Pp. 563-584 in *Ecological Stewardship. A common reference for ecosystem management*. Vol. III. W.T. Sexton, A.J. Malk, R.C. Szaro, and N.C. Johnson, editors. Elsevier Science.
- McClure, M. S. 1990. Role of wind, birds, deer, and humans in the dispersal of hemlock woolly adelgid (Homoptera: Adelgidae). *Environ. Ento.* 19: 36-43.
- McClure, M. S. and A. S.-J. Cheah. 1999. Reshaping the ecology of invading populations of hemlock woolly adelgid, *Adelges tsugae* (Homoptera: Adelgidae), in eastern North America. *Biol. Invasions* 1: 247-254.
- McMartin,** B. 1994. *The Great Forests of the Adirondacks*. North Country Books, Utica, NY.
- Meyer,** H. A. 1952. Structure, growth, and drain in balanced uneven-aged forests. *J. For.* 50: 85-92.
- Meyer,** H. A. and D. D. Stevenson. 1943. The structure and growth of virgin beech-birch-maple-hemlock forests in northern Pennsylvania. *J. Agri. Res.* 67: 465-484.
- Miller-Weeks,** M., C. Eager and C. M. Petersen. 1999. The northeastern ice storm 1998: a forest damage assessment. Northeast Forester's Association.
- Mladenoff, D. J. 1987. Dynamics of nitrogen mineralization and nitrification in hemlock and hardwood treefall gaps. *Ecology* 68: 1171-1180.
- Mladenoff, D. J. 1990. The relationship of the soil seed bank and understory vegetation in old-growth northern hardwood-hemlock treefall gaps. *Can. J. For. Res.* 68: 2714-2721.
- Mladenoff, D. J. and F. Stearns. 1993. Eastern hemlock regeneration and deer browsing in the northern Great Lakes region: a re-examination and model simulation. *Cons. Biol.* 7: 889-900.
- Mladenoff, D. J., M. A. White, J. Pastor and T. R. Crow. 1993. Comparing spatial pattern in unaltered old-growth and disturbed forest landscapes. *Ecol. Appl.* 3: 294-306.
- Mulder, B. S., B. R. Noon, T. A. Spies, R. Martin, G. Palmer, J. Craig, A. R. Olsen, G. H. Reeves, H. Welsh, and H. Hartwell, H. 1999. The strategy and design of the effectiveness monitoring program for the Northwest Forest Plan. Gen. Tech. Rep. PNW-GTR-437. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 138 p.
- Munck, I. A. 2002. *Impact of beech bark disease on the sustainability of American beech in New York State*. Master's Thesis. Department of Environmental and Forest Biology, State University of New York, College of Environmental Science and Forestry. Syracuse, NY.
- National Forest Health Monitoring Program. 1998. Forest Health Monitoring in the Northeast States. USDA Forest Service, Northeastern Research Station. Online source: www.na.fs.fed.us/spfu/fhm/northeast/NE98.htm. Accessed February 4, 2003.
- NatureServe. 2003a (in press). A Working Classification of Terrestrial Ecological Systems in the Conterminous United States. NatureServe, Arlington, VA. __pp + appendices
- NatureServe. 2003b. International Ecological Classification Standard: International Vegetation Classification. Central Databases, NatureServe, Arlington, Virginia, USA.
- NatureServe. 2002. Vascular Plant Inventories and Field Plot Establishment in Cumberland Piedmont and Appalachian Highlands Networks of NPS. Reports are in progress.
- NatureServe. 2003. International Ecological Classification Standard: Terrestrial Ecological Systems of the United States. Natural Heritage Central Databases. NatureServe. Arlington, VA.
- Noon. 2002.**
- Noon. 2003.**

- Nowacki, G. J. and M. D. Abrams. 1994. Forest composition, structure, and disturbance history of the Alan Seeger Natural Area, Huntington County, Pennsylvania. *Bull. Torr. Bot. Club* 121: 277-291.
- Orwig, D. A. and M. D. Abrams. 1999. Impacts of early selective logging on the dendroecology of an old-growth hemlock-white pine-northern hardwood forest on the Allegheny Plateau. *J. Torr. Bot. Soc.* 126: 234-244.
- Orwig, D. A., D. R. Foster and D. L. Mausel. 2002. Landscape patterns of hemlock decline in New England due to the introduced hemlock woolly adelgid. *J. Biogeography* 29: 1475-1487.
- Parrish, J.D., D. Braun, and R. Unnasch. 2003. Are we conserving what we say we are?: measuring ecological integrity in evaluations of protected area management effectiveness (draft paper)
- Parker, B. L., M. Skinner, S. Gouli, T. Ashikaga and H. B. Telson. 1999. Low lethal temperature for hemlock woolly adelgid (Homoptera: Adelgidae). *Environ. Ento.* 28: 1085-1091.
- Parshall, T. 1995. Canopy mortality and stand scale change in a northern hemlock-hardwood forest. *Can. J. For. Res.* 25: 1466-1478.
- Peterson, C. J. and S. T. A. Pickett. 1991. Treefall and resprouting following catastrophic windthrow in an old-growth hemlock-hardwoods forest. *For. Ecol. & Manage.* 42: 205-217.
- Portnoy. 1990.**
- Preisser, E.L., J.Y. Kefer, J.D. Lawrence, and T.W. Clark. 2000. Vernal pool conservation in Connecticut: an assessment and recommendations. *Environmental Management* 26:503-513.
- Reschke, C. 1990. *Ecological Communities of New York State*. New York Natural Heritage Program NYS Department of Environmental Conservation, Latham, NY.
- Rich, A. C., D. S. Dobkin and L. J. Niles. 1994. Defining forest fragmentation by corridor width: the influence of narrow forest dividing corridors on forest-nesting birds in southern New Jersey. *Cons. Biol.* 8: 1109-1121.
- Riitters, K. H., J. W. Coulston and J. D. Wickham. 2003. Localizing national fragmentation statistics with forest maps. *J. For.*: 18-22.
- Roman, C. T. and N. E. Barrett. 1999. Conceptual framework for the development of long-term monitoring protocols at Cape Cod National Seashore. U.S. Geological Survey, Patuxent Wildlife Research Center. Available at <http://www.nature.nps.gov/im/monitor/caco.pdf>
- Rooney, T. P., R. J. McCormick, S. L. Solheim and D. M. Waller. 2000. Regional variation in recruitment of hemlock seedlings and saplings in the upper Great Lakes, USA. *Ecol. Appl.* 10:1119-1132.
- Rowe and Dunson. 1995.**
- Rubin, B. D. 2003. *Assessment of the Health and Sustainability of New York Forests based on Forest Structure, Mortality, and Disease*. Ph.D. Dissertation. Environmental and Forest Biology, State University of New York College of Environmental Science and Forestry. Syracuse, NY.
- Ruffner, C. M. and M. D. Abrams. 2003. Disturbance history and stand dynamics along a topographic gradient in old-growth hemlock-northern hardwood forests of the Allegheny Plateau, USA. *Nat. Areas J.* 23: 98-113.
- Runkle, J. R. 1982. Patterns of disturbance in some old-growth mesic forests of eastern North America. *Ecology* 63: 1533-1546.
- Runkle, J. R. 1990. Eight years of change in an old *Tsuga canadensis* woods affected by beech bark disease. *Bull. Torr. Bot. Club* 117: 409-419.
- Runkle, J. R. 2000. Canopy tree turnover in old-growth mesic forests of eastern North America. *Ecology* 81: 554-567.
- Semlitsch, R. D. 1998. Biological delineation of terrestrial buffer zones for pond-breeding amphibians. *Conservation Biology* 12:1113-1119.
- Semlitsch, R. D. and J. R. Bodie. 1998. Are small, isolated wetlands expendable? *Conservation Biology* 12:1129-1133.
- Snodgrass, J.W., M.J. Komoroski, A.L. Bryan, Jr., and J. Burger. 2000. Relationships among isolated wetland size, hydroperiod, and amphibian richness: implications for wetland regulations. *Conservation Biology* 14:414-419.

- Snyder, C. D., J. A. Young, D. P. Lemarie and D. R. Smith. 2002. Influence of eastern hemlock (*Tsuga canadensis*) forests on aquatic invertebrate assemblages in headwater streams. *Can. J. Fish. & Aquat. Sci.* 59: 262-275.
- Sustainable Forestry Board (SFB) 2002. *Sustainable Forestry Initiative Program 2002-2004 Edition*. American Forest & Paper Association, Washington, DC.
- St. Jacques, J.-M., M. S. V. Douglas and J. H. McAndrews. 2000. Mid-Holocene hemlock decline and diatom communities in van Nostrand Lake, Ontario, Canada. *J. Paleolimno.* 23: 385-397.
- Stein and Davis. 2000.**
- Thompson and Sorenson. 2000.**
- Tingley, M. W., D. A. Orwig, R. Field and G. Motzkin. 2002. Avian response to removal of a forest dominant: consequences of hemlock wooly adelgid infestations. *J. Biogeography* 29: 1505-1516.
- The Nature Conservancy. 2000. Five-S Framework for Site Conservation: A practitioner's handbook for site conservation and measuring conservation success. Arlington, VA.
- Tritton, L. M. and T. G. Siccama. 1990. What proportion of the standing trees in forests of the Northeast are dead? *Bull. Torr. Bot. Club* 117: 163-166.
- Turtle, S.L. 2000. Embryonic survivorship of the spotted salamander (*Ambystoma maculatum*) in roadside and woodland vernal pools in southeastern New Hampshire. *Journal of Herpetology* 34:60-67
- Tyrrell, L. E. and T. R. Crow. 1994a. Dynamics of dead wood in old-growth hemlock-hardwood forests of northern Wisconsin and northern Michigan. *Can. J. For. Res.* 24: 1672-1683.
- Tyrrell, L. E. and T. R. Crow. 1994b. Structural characteristics of old-growth hemlock-hardwood forests in relation to age. *Ecology* 75: 370-386.
- Tyrrell, L. E., G. J. Nowacki, T. R. Crow, D. S. Buckley, E. A. Nauertz, J. N. Niese, J. L. Rollinger and J. C. Zasada. 1998. Information about old growth for selected forest type groups in the eastern United States. USDA Forest Service Gen. Tech. Rep. - NC - 197. St. Paul, MN.
- USDA. 1990. Silvics of North American Trees Volumes 1 and 2. USDA Agriculture Handbook 654. Washington, DC.
- Van Dyke, O. and R. P. F. Landmark Consulting. 1999. A literature review of ice storm impacts on forests in eastern North America. SCSS Technical Report #112. Ontario Ministry of Natural Resources.
- Ward, J. S. and G. R. Stephens. 1997. Survival and growth of yellow birch (*Betula alleghaniensis*) in southern New England. *Can. J. For. Res.* 27: 156-165.
- Webster, C. R. and C. G. Lorimer. 2002. Single-tree versus group selection in hemlock-hardwood forests: are smaller openings less productive? *Can. J. For. Res.* 32: 591-604.
- Whitney, G. G. 1984. Fifty years of change in the arboreal vegetation of Heart's Content, an old growth hemlock-white pine-northern hardwood stand. *Ecology* 65: 403-408.
- Whitney, G. G. 1990. The history and status of the hemlock-hardwood forests of the Alleghany Plateau. *J. Ecol.* 78: 443-458.
- Woodley, S. 1993. Monitoring and measuring ecosystem integrity in Canadian National Parks. Pp 155-176, in S. Woodley, J. Kay, and G. Francis (editors). *Ecological Integrity and Ecosystem Management*. St. Lucie Press.
- Woods, K. D. 2000. Dynamics in late-successional hemlock-hardwood forests over three decades. *Ecology* 81: 110-126.
- Woodward et al. 1999 (and/or Woodward 1999).
- Yorks, T. E., D. J. Leopold and D. J. Raynal. 2000. Vascular plant propagule banks of six eastern hemlock stands in the Catskill Mountains of New York. *J. Torr. Bot. Soc.* 127: 87-93.
- Young, T. F. and S. E. Sanzone. 2002. A Framework for Assessing and Reporting on Ecological Condition. Ecological Reporting Panel, Ecological Processes and Effects Committee, EPA Science Advisory Board EPA-SAB-EPEC-02-009. Washington, DC.

- Young, T. F. and S. E. Sanzone. 2002. A Framework for Assessing and Reporting on Ecological Condition. Ecological Reporting Panel, Ecological Processes and Effects Committee, EPA Science Advisory Board EPA-SAB-EPEC-02-009. Washington, DC.
- Ziegler, S. S. 2000. A comparison of structural characteristics between old-growth and postfire second-growth hemlock-hardwood forests in Adirondack Park, New York, U. S. A. *Glob. Ecol. & Biogeogr.* 9: 373-389.
- Ziegler, S. S. 2002. Disturbance regimes of hemlock-dominated old-growth forests in northern New York, U.S.A. *Can. J. For. Res.* 32: 2106-2115.

Glossary

Adaptive Management is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. Its most effective form—"active" adaptive management—employs management programs that are designed to experimentally compare selected policies or practices, by evaluating alternative hypotheses about the system being managed.

Attributes are any living or nonliving feature or process of the environment that can be measured or estimated and that provide insights into the state of the ecosystem. The term **Indicator** is reserved for a subset of attributes that is particularly information-rich in the sense that their values are somehow indicative of the quality, health, or integrity of the larger ecological system to which they belong (Noon 2002). See Indicator.

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.

Ecosystem is defined as, "a spatially explicit unit of the Earth that includes all of the organisms, along with all components of the abiotic environment within its boundaries" (Likens 1992).

Ecosystem drivers are major external driving forces such as climate, fire cycles, biological invasions, hydrologic cycles, and natural disturbance events (e.g., earthquakes, droughts, floods) that have large scale influences on natural systems.

Ecosystem management is the process of land-use decision making and land-management practice that takes into account the full suite of organisms and processes that characterize and comprise the ecosystem and is based on the best understanding currently available as to how the ecosystem works. Ecosystem management includes a primary goal of sustainability of ecosystem structure and function, recognition that ecosystems are spatially and temporally dynamic, and acceptance of the dictum that ecosystem function depends on ecosystem structure and diversity. Coordination of land-use decisions is implied by the whole-system focus of ecosystem management.

Focal resources are park 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 would be monitored as an indication of ecosystem integrity. Focal resources might include ecological processes such as deposition rates of nitrates and sulfates in certain parks, or they may be a species that is harvested, endemic, alien, or has protected status.

Indicators are a subset of monitoring attributes that are particularly information-rich in the sense that their values are somehow indicative of the quality, health, or integrity of the larger ecological system to which they belong (Noon 2002). Indicators are a selected subset of the physical, chemical, and biological elements and processes of natural systems that are selected to represent the overall health or condition of the system, known or hypothesized effects of stressors, or elements that have important human values.

Measures are the specific feature(s) used to quantify an indicator, as specified in a sampling protocol.

Stressors are physical, chemical, or biological perturbations to a system that are either (a) foreign to that system or (b) natural to the system but applied at an excessive [or deficient] level (Barrett et al. 1976:192). Stressors cause significant changes in the ecological components, patterns and processes in natural systems. Examples include water withdrawal, pesticide use, timber harvesting, traffic emissions, stream acidification, trampling, poaching, land-use change, and air pollution.

Vital Signs, as used by the National Park Service, are synonymous with Indicator, and are defined as any measurable feature of the environment that provides insights into changes in the state of the ecosystem. Vital signs are intended to track changes in a subset of park resources and processes that are determined to be the most significant indicators of ecological condition of those specific resources that are of the greatest concern to each park. This subset of resources and processes is part 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. Vital signs may occur at any level of organization including landscape, community, population, or genetic levels, 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).

Freshwater Issues for Parks of the Northeastern United States

PHASE I: A Scoping Report for the Northeast Temperate Network (NETN)

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ABSTRACT

INTRODUCTION

The Northeast Temperate Network (NETN) is made up of the following ten National parks (NP), National Historical Parks (NHP), National Recreation Areas (NRA) and National Historic Sites (NHS):

1. Acadia NP, ME (ACAD)
2. Boston Harbor Island NRA, MA (BOHA)
3. Marsh-Billings-Rockefeller NHP, VT (MABI)
4. Minute Man NHP, MA (MIMA)
5. Morristown NHP, NJ (MORR)
6. Roosevelt-Vanderbilt NHS, NY (ROVA)
7. Saint-Gaudens NHS, NH (SAGA)
8. Saugus Iron Works NHS, MA (SAIR)
9. Saratoga NHP, NY (SARA)
10. Weir Farm NHS, CT (WEFA)

In all of the NETN parks, freshwater resources are subjected to natural and anthropogenic impacts and alterations. In many cases, such stressors have affected them for many years. Threats confronting National Park Service (NPS) aquatic ecosystems throughout the northeastern US include; visitor usage, organic and inorganic contaminant inputs from agriculture and septic system leachate, hydrologic and hydraulic alterations such as the installation and renovations of bridges, roads, culverts, and drainages, groundwater withdrawal impacts on surface freshwater resources, air deposition of contaminants, invasive and non-native species encroachments, and industry within the watersheds.

The level of Water-Quality and Water-Quantity data is variable across the NETN Parks. Although limited water-quality monitoring has occurred in each of the parks, in no case has there been systematic Water-Quality and Water-Quantity data collection 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 for stressors in park freshwater ecosystems.

Purpose and Scope

The purpose of this report is to locate and reference baseline data in the NETN parks that exists, and to identify and prioritize additional baseline data that would be necessary to detect change in park freshwater-resource attributes. This report is part of a larger inventory and freshwater-resources monitoring design project that will be conducted in three phases:

PHASE I: Produce a Scoping Report for the Northeast Temperate Network.

PHASE II: Design prototype guidance for monitoring of freshwater resources in the Northeast Temperate Parks Network.

PHASE III: Conduct feasibility (pilot) testing of recommended freshwater-quality/aquatic-resource monitoring components at select national park freshwater resources in order to finalize Network freshwater resource monitoring design.

This report is limited to phase I in which a resource inventory for freshwater resources in the NETN will be created upon which the design of long-term freshwater-resources monitoring efforts can be based. It will include the following: (note: current draft report includes 1-5).

1. A description of ongoing inventory or monitoring programs related to park freshwater resources and water quality
2. Draft conceptual models of NETN key ecosystems
3. Descriptions of current and emerging threats for NETN ecosystems and important agents of change that could impact NETN aquatic resources
4. Description of the freshwater body types present within the park using existing published information such as classifications from NWI and bathymetry maps
5. Summarization of information from State 305(b) reports and 303(d) lists to USEPA
6. Identification of specific freshwater resources that are of unique importance on watershed or regional scales
7. Freshwater body area statistics based on park-GIS coverages, National Wetland Inventory databases, and State coverages
8. Network-wide water-quality objectives and candidate monitoring variables

METHODS AND APPROACH

The first step in developing the scoping report was to locate and compile information regarding freshwater resources, freshwater-quality data, and threats to freshwater ecosystems in each of the ten parks within the NETN. Relations between freshwater bodies and the stressors or threats to these freshwater bodies were identified and conceptual diagrams were developed. These diagrams will be used to assist natural resource managers working in the parks to visualize the relations between freshwater ecosystems, and threats to these ecosystems, and to identify measures that can be used to monitor changes in the attributes of the freshwater ecosystems.

Data Compilation

Natural resource managers at each of the parks assisted in the identification of water-quality monitoring that has been conducted in each park, water-quality monitoring that is currently being conducted, and natural-resource partners who were also conducting monitoring. 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 U.S. Environmental Protection Agency (EPA) maintains two data management systems containing 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 an operational system actively being populated with water-quality data since January 1, 1999. Both systems contain raw biological, chemical, and physical data on surface- and ground-water collected by federal, state, and local agencies, Indian tribes, volunteer groups, academics, and others (Environmental Protection Agency, 2003). There only is minimal checking of data entered into STORET. The possibilities of data-entry errors, inappropriate measurement techniques, sample mishandling, and lack of quality assurance are all potential sources of error (National Park Service, 1994). Furthermore, there is no guarantee that all data collected in the parks have made it into the database. Thus, while STORET is a good way to identify agencies collecting data in and around the parks, the data retrieved from this database should be used with caution.

Although USGS data 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, NWIS web, in which surface water, ground water and water-quality data collected by the USGS are stored, and can be queried or searched (US Geological Survey, 2003).

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 (SAIR and BOHA) have baseline reports. Baseline reports contain historical water-quality monitoring stations for each park in an area extending at least three miles upstream and one mile downstream from the park boundary (National Park Service, 1994). Monitoring stations that were within park boundaries were identified.

Various NPS and state GIS data layers were compiled from state offices of GIS and the NPS Data Clearinghouse website, http://www.nps.gov/gis/data_info/clearinghouse.html. Layers include park boundaries, National Wetland Inventories, streams, rivers and lakes, roads, county and quad boundaries, and digital orthophoto quads. The small scale GIS layers compiled by the NPS as a part of their baseline water-quality data inventory and analysis reports were used to locate water-quality monitoring stations identified in the baseline analysis.

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 are included except in cases where there is no discharge gaging station within park boundaries. In these cases, a representative gaging station that could best be used to estimate discharge on waterbodies within the park was included. Criteria used to select the most appropriate gage include length of record, drainage area and proximity to 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 EPA 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 purposes the State has designated. The calculation must also account for seasonal variation in water quality.

EPA'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/>). TMDLs were referenced for park waterbodies.

Conceptual Model Development

Conceptual diagrams for the parks are based on NPS Guidelines within the Inventory and Monitoring Program and 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 relationships between stressors, drivers, ecosystem attributes and measures used to track changes in these attributes

Conceptual models of freshwater ecosystems within the park include; a hydrologic model of the freshwater inflows and outflows contributing to the ecosystem, and the drivers and stressors which have the potential to effect the quality and quantity of the freshwater making up these ecosystems. Information about the freshwater resource is included if available. Drivers are defined as major, naturally occurring forces of change, operating both inside and outside the park boundaries that affect the freshwater ecosystems. Stressors are the physical, biological or chemical perturbations to the freshwater ecosystem and are divided into either stressors that affect water flowing into the park, stressors that affect freshwater within the park, or both. Stressors can be foreign to the system, or natural to the system, but applied at a excessive (or deficient) level (Chapt 2: Conceptual Ecological Model). Ecosystem-wide processes such as precipitation and evaporation occur throughout the park. Ground-water/surface-water interactions occur in both directions and also occur throughout the park.

DATA COMPILATION

The majority of the data is compiled by park and each park summary includes descriptions of the following; freshwater bodies, historic and current water-quality and water-quantity monitoring, water-quality and quantity issues within the park, current and emerging aquatic ecosystem threats, a list of natural-resource partners assisting with data collection or compilation within the park, and a list of references of data or planning documents associated with the park.

A table of representative surface-water-discharge gaging stations includes all parks and is presented in Appendix 1. None of the parks (except ACAD) have a continuous-record

surface-water gaging station within their boundaries. In parks such as SAIR, the representative gage is on the same water body 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 due to a lack of a representative stations. In phase II of this project, gaging stations will be further assessed to determine if they can reasonably estimate water quantity within the parks.

305b reports of water quality standards and 303d lists and attainment status for each freshwater body within each park are summarized in a table in appendix 2. 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.

Each park description also includes a map and a conceptual diagram of freshwater resources in the park. Figures 1a-1e are the freshwater systems and the attributes and measures which are important within each type of system; brooks/rivers, ponds/lakes, precipitation, wetlands and groundwater respectively. Figures 1a-1e are referenced on the individual park diagrams. The chart (figure 2) indicates potential links between drivers and stressors, and the measures that can be used to monitor changes in freshwater-ecosystem attributes. It can be used in two ways: 1) if a given stressor is a known problem in the park, the chart can be used to select measures which could help monitor change caused by this stressor, or 2) if a measure is indicating that change is occurring in a freshwater attribute, then potential drivers and stressors can be identified which may be causing this change. Conceptual diagrams 1 and 2 (fig.1 and 2) are common to all of the parks and are presented below. They should be used in concert with the conceptual diagrams presented with the parks.

Figure 1a-1e. Freshwater systems and associated attributes and measures.

Figure 2. Relations between drivers and stressors, and the measures which can be used to monitor changes in freshwater-ecosystem attributes.

Acadia National Park

In progress

Boston Harbor Islands National Recreation Area

In progress

Marsh-Billings-Rockefeller National Historical Park

Marsh-Billings Rockefeller NHP was created in 1992 and encompasses 643 acres in the Connecticut River Watershed including 550 acres of forest. The park is dedicated to presenting historic and contemporary examples of conservation stewardship.

FRESHWATER BODIES

Freshwaterbodies within the park consist of a pond (The Pogue), a perennial stream (Pogue Hole Brook), many intermittent streams, four wetlands and several seeps (Lautzenheiser, 2002) (fig.7). The Pogue is a 14-acre pond, near the summit of the park, formed by an earthen dam 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 easterly 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.

There are four wetlands east of the Pogue formed by runoff and groundwater seeps and intermittently drain into Pogue Hole Brook. Additional intermittent streams drain the northern slope of Mt. Tom (Lautzenheiser, 2002).

HISTORIC WATER-QUALITY AND WATER-QUANTITY MONITORING

Seven stations were located inside the park boundaries during the baseline water-quality inventory and analysis conducted in 1997 for the Marsh-Billings-Rockefeller (National Park Service, 1997). None of these stations were considered long-term, having at least 6 parameters with 1 or more observations per year over at least 2 years (National Park Service, 1997). Four of the stations were established in 1994 by the Water Resources Division (WRD) of the NPS and had one observation each of nitrogen, nitrite, fecal coliform, and phosphorus. The four locations were; the Watering Trough, the unnamed creek leaving the cow pasture, 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. EPA measured 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 one day in 1984.

CURRENT WATER-QUALITY AND WATER-QUANTITY MONITORING

Currently there is no water-quality monitoring conducted in the park (C. Marts, oral comm., 2003).

WATER-QUALITY AND WATER-QUANTITY ISSUES

E.coli is a potential problem in the Pogue Stream due to livestock in the stream. A fence has been constructed so that any future grazing will be outside the channel of the stream.

CURRENT AND EMERGING AQUATIC ECOSYSTEM THREATS

MABI is mostly a headwater watershed. Intermittent headwater streams initiate in the park and drain the park. For this reason, there are no major surface-water ecosystem threats coming from outside the park. Potential stressors that could adversely affect water quality within the park include forestry within the park, runoff from carriage roads and trails, and livestock grazing within the park (C. Marts, oral comm., 2003) (fig. 8).

Although in 2002 and 2003 there were not any livestock within the park, they potentially will be grazing in the park in the future.

Figure 7. Map showing freshwater resources at Marsh-Billings-Rockefeller NHP

Figure 8. Conceptual model of freshwater resources at Marsh-Billings-Rockefeller NHP

NATURAL RESOURCE PARTNERS

REFERENCES

Lautzenheiser, T., 2002, Marsh-Billings-Rockefeller National Historical Park, Natural Community Report, University of Vermont, January 2002, 39 p.

National Park Service, 1997, Baseline Water-quality Data Inventory and Analysis Marsh-Billings-Rockefeller National Historical Park, Fort Collins, CO, National Park Service Water Resources Division, Technical Report NPS/NRWRD/NRTR-97/143, December 1997.

Minute Man National Historical Park

Minute Man National Historical Park encompasses 967 acres distributed in three parcels located approximately 15 miles northwest of Boston, Massachusetts. The North Bridge Unit contains approximately 112 acres, the Wayside Unit contains approximately six acres, and the Battle Road Unit contains approximately 849 acres (National Park Service, 2003a). The Concord River flows through the North Bridge Unit, while 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 variety of public and conservation lands.

The park supports a variety of habitats. Forest is the dominant land cover type, 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).

FRESHWATER BODIES

MIMA NHP includes numerous surface water bodies including sections of the Concord River, Elm Brook, and Mill Brook, several ponds, and approximately 200 acres of wetlands (fig. 9). The park supports several types of wetlands, including forested wetlands, seasonal ponds, swamps, bogs, and emergent wetlands.

HISTORIC WATER-QUALITY AND WATER QUANTITY MONITORING

The Baseline Water-quality Data Inventory and Analysis (National Park Service, 1996) does not include any water-quality or quantity monitoring sites within the park. According to park natural resource specialist, Chris Davis (personal communication, 2003), no water-quality monitoring has been done inside the park other than the Level 1 inventory completed by the NPS.

A nutrient Total Maximum Daily Load (TMDL) evaluation was conducted from June 2001 through September 2002 on the Concord River by ENSR, in cooperation with the Army corps of Engineers and the Department of Environmental Protection (ENSR, 2003). Measurements of the hydrology, water quality and aquatic biology of the Concord River were conducted in 12 surveys. Although no sites were located inside the park boundaries, one site was in Concord, just outside of the boundary.

A rapid bioassessment using macroinvertebrates was conducted at Mill Brook in Concord in 1996 (personal communication Art Johnson, DEP, 2003).

CURRENT WATER-QUALITY AND WATER-QUANTITY MONITORING

There is no water-quality or quantity monitoring currently occurring inside the park. There is a USGS stream gage on the Concord River below River Meadow Road at Lowell, MA, which is downstream from the park. Its period of record is 1936 to the current year. Low flows are regulated by upstream mills. The Organization for the Assabet River has monitored water quality since 1992 on the Assabet River in the lower reach, just upstream of 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.

WATER-QUALITY AND WATER-QUANTITY ISSUES

A Baseline Water-quality Data Inventory and Analysis showed that sites outside the park boundaries on the Concord River and its tributaries occasionally exceed EPA 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, 2003). 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 which 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).

CURRENT AND EMERGING AQUATIC ECOSYSTEM THREATS

Stressors affecting water quality at the park include road runoff, agricultural practices, residential developments and industrial deposition of heavy metals (fig.10). Leachate from septic systems both in and outside the park pose a threat to water quality. There are Superfund sites upstream of the Concord River (North Bridge Unit) on the Assabet and

Sudbury Rivers (Chris Davis, personal communication, 2003). The deposition of aircraft exhaust from cargo planes taking off over the Concord River is another potential threat to water quality. There have been some unsubstantiated claims of dead fish in one of the unnamed ponds by the visitor center in the Battle Road Unit (Chris Davis, personal communication, 2003).

Figure 9. Map showing freshwater resources at Minute Man NHP

Figure 10. Conceptual model of freshwater resources at Minute Man NHP

NATURAL RESOURCE PARTNERS

The Organization for the Assabet River

They have done water-quality monitoring on the Assabet River (upstream of the park) from 1992-1997. All data is on their website.

978-369-3956

SuAsCo River Council

This group does not do any monitoring themselves, but has an extensive database of those who do monitor within the Sudbury, Assabet and Concord River Basins.

978-461-0735

REFERENCES

ENSR, 2003, SuAsCo Watershed Concord River TMDL Study Assessment Final Report, ENSR International, Document Number 9000-280, February 2003, 231 p.

National Park Service, 1996, Baseline Water-quality data inventory and analysis
Minuteman National Historical Park, Fort Collins, CO, National Park Service
Water Resources Division, Technical Report NPS/NRWRD/NRTR-96/86, April 1996.

National Park Service, 2003a, Minute Man National Historical Park: accessed on August 23 at URL, <http://www.nps.gov/mima/index.htm>.

National Park Service, 2003b, Annual Performance Plan for Minute Man National Historical Park,

Morristown National Historical Park

Morristown National Historic Park is approximately 1,711 acres. It is 30 miles west of New York City and is made up of four separate units. The Jockey Hollow Encampment Area is 1,320 acres, the New Jersey Brigade Encampment Area is 321 acres, the Washington's headquarter Area is 10 acres and the Fort Nonsense Area is 35-acres. The park receives approximately 380,000 visitors annually.

A Water Resources Scoping Report was completed by Morristown National Historic Park in 1993 (National Park Service, Water Resources Division, 1993). The report summarizes water resources in the park, monitoring that has been completed, and proposed water-resource-related monitoring. This document should be consulted before any water-quality monitoring plans are initiated.

FRESHWATER BODIES

Significant surface water bodies in Morristown NHP include portions of the East and West Branches of Primrose Brook and Jersey Brook in the Jockey Hollow Unit, and portions of the upper Passaic River and Indian Grave Brook in the New Jersey Brigade Units (fig.11).

While most of the springs contributing to Primrose Brook surface within the park near Sugar Loaf and Mount Kemble, the source spring of the East Branch Primrose Brook is found in an area known as Military Hill, located on private land just outside the northeastern boundary of the park. The one-quarter-mile-long headwaters of Jersey Brook, a tributary of Primrose Brook, originates from springs in the southwestern portion of the Jockey Hollow Unit. The upper Passaic River is impounded at Leddell's Pond about one mile before it passes through this unit (National Park Service, 2003)

The Jockey Hollow Unit and the New Jersey Brigade Units are located within the upper reaches of the 55.6 mi² 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, 2003).

A small artificial pond, Cat Swamp Pond, and two small marshes are also located within the upper Primrose Brook drainage (Ehrenfeld, 1977). 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. While 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 within the New Jersey Brigade unit (Ehrenfeld and Dibeler 1987).

There are many small wetland and riparian areas in the park associated with streams and minor tributaries making up roughly 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 floodplain of Indian Grave Brook within 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 groundwater in scattered locations. Park visitor facilities, administrative buildings, and seven park residences rely on drilled wells. Both the Jockey Hollow and New Jersey Brigade Units contain numerous natural springs and seeps emanating from a shallow aquifer (Mele 1983).

HISTORIC WATER-QUALITY AND WATER-QUANTITY MONITORING

Mele and Mele (1983) conducted quarterly fecal coliform bacterial monitoring 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 Morristown NHP were monitored quarterly from the summer of 1986 through the summer of 1987 (Trama and Galloway, 1988).

The results of the retrievals for the MORR study area from the Baseline Water Quality Data Inventory and Analysis include 4 industrial/municipal dischargers, no drinking water intakes, and 1 U. S. Geological Survey gaging station (National Park Service, 1994). The results of the STORET retrieval for the study area yielded 787 observations for 64 separate water-quality parameters collected by 4 federal and state government agencies at 6 water-quality stations. No stations are located 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 located 500 feet below the outlet of Pocahontas Lake (National Park Service Station ID MORR 0006) yielded long-term records consisting of multiple observations for several important water-quality parameters.

The baseline study conducted for MORR indicates that STORET data exist for all Level I parameter groups in the study area except for the EPA priority toxic pollutants. Limited quantities of data were retrieved for most of the required chemical parameters. All data were collected before 1985. No data are available within the park boundary.

A 1992 Water-quality Inventory: Macro Invertebrate Sampling Study (United States Department of Agriculture, 1992) with one sampling site for Primrose Brook near the park boundary was conducted by the USDA Natural Resources Conservation Service (1992).

The Great Swamp Watershed Association completed a Watershed Management Plan with several QW monitoring sites measured downstream of park in the Great Brook, Primrose Brook and Passaic River Watersheds. Water quality parameters were measured between 1999-2001.

A section of the Passaic River that runs through the New Jersey Brigade Unit is the only portion of the park lying within a 100-year floodplain (National Park Service, 2003).

CURRENT WATER-QUALITY AND WATER-QUANTITY MONITORING

The park monitors key water-quality parameters on a monthly basis at 11 stations. The confluence of the East and West Branches of Primrose Brook is utilized as a water-quality monitoring site by several state and federal agencies including the U.S. Fish and Wildlife Service and U.S. Geological Survey. The State of New Jersey, Department of Environmental Protection, Division of Watershed Monitoring, conducts macro invertebrate sampling on the West Branch of Primrose Brook near the Trail Center parking lot (National Park Service, 2003).

The FWS initiated a program in 1991 to monitor 15 physical, chemical and biological parameters at 16 sites in the Great Swamp Watershed. One site (FWS station ID 165) is

located on Primrose Brook (NPS Station ID E-1) within the park. This is an excellent baseline water-quality site since it is relatively unimpacted

The New Jersey Department of Environmental Protection and Energy 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 (National Park Service, 1993).

USGS gage (station ID 01378690) is located on the Passaic River near Bernardsville, NJ, just downstream of the park. It has a drainage area of 8.83 square miles and a mean annual flow of 18.62 cubic feet per second. It was gaged from 1965-1971. Two stage gages were installed at the confluence of the east and west branch of Primrose Brook in 2003.

The US Geological Survey is in the process of initiating a National Water Quality Assessment Program (NAWQA) site in Morristown NHP.

WATER-QUALITY AND WATER-QUANTITY ISSUES

The results of the MORR water-quality criteria screen for the baseline water-quality report completed in 1994 (National Park Service, 1994) found 3 parameters that exceeded screening criteria at least once within the study area. The pH exceeded the EPA chronic criteria for the protection of aquatic life. Indicator bacteria (total coliform and fecal coliform) concentrations exceeded NPS WRD 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 standard units (EPA chronic criteria for freshwater aquatic life). One observation in the Whippany River, 500 feet below Pocahontas Lake (MORR 0006), was equal to pH 9.4, and one observation in the Whippany River at Ridgedale Avenue was equal to pH 6.5.

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 1000 MPN/CFU per 100 ml total coliform criteria, and the 200 MPN/CFU per 100 ml fecal coliform criteria. The criteria were exceeded at 3 stations located in Indian Grave Brook and the Whippany River (MORR 0002, MORR 0005, MORR 0006).

Based on the limited data inventories and analyses contained in the Baseline report, surface waters within the MORR study area generally appear to be of good quality, with some indications of impacts from development. Results indicate that the streams within the park generally exhibit very good to excellent water quality, being well oxygenated at all times, neutral in pH, low to moderate in alkalinity, and containing low to moderate nutrient concentrations. Total suspended solids, total dissolved solids, specific conductance, and chlorides, while low in streams, 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 close proximity of Tempe Wick Road to Jersey Brook and the low-density residential

development found 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. In the early 1990s the park closed a public potable water source located at the Pennsylvania Line parking lot due to continual high levels of coliform. The source of bacteria found in the water samples of this study is 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 total recoverable aluminum concentrations in the stream water that would not pose a threat to aquatic life. Further analysis revealed high aluminum content in local soils. While it is unlikely that the aluminum poses a threat to aquatic organisms, in the event that aluminum from the soil was mobilized both water quality and aquatic biota could be impacted.

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 FW2-TP, trout production fresh waters.

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 within the Great Swamp Watershed, Primrose Brook is the least human-influenced stream within the park (Trama and Galloway 1988).

The high 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 (NPDES) discharges are known to occur into any of the streams above the park.

CURRENT AND EMERGING AQUATIC ECOSYSTEM THREATS

Fecal coliform is the biggest ecosystem threat in the park according to Robert Masson, natural resource manager at Morristown National Park (personal communication, 2003). Development just outside the park including the construction of townhouses are a concern to Park Service Staff. The park is also downstream of 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 golf course, lawn and garden chemicals (fertilizers, pesticides, and lime), septic system leachate from visitor facilities, administrative buildings and employee residences within the park and new and existing development surrounding the park, and leaking underground petroleum storage tanks (fig. 12).

Figure 11. Map showing freshwater resources at Morristown NHP

Figure 12. Conceptual model of freshwater resources at Morristown NHP

NATURAL RESOURCE PARTNERS

Great Swamp Watershed Association (GSWA)

Mail: P.O. Box 300, New Vernon, NJ 07976
Phone: 973.966.1900
Fax: 973.966.1009

(Friends of) Great Swamp National Wildlife Refuge
152 Pleasant Plains Road
Basking Ridge, NJ 07920
(973) 425-1222

Ten Towns Committee
Harry G. Gerken, Executive Director
2 Ridgedale Ave
Cedar Knolls, NJ 07927

Drew University Dr. Lee Pollock
College of St. Elizabeth: Dr. Neil Borman

Dr. Lee Pollock, is studying the number and variety of macro-invertebrates, as indicators of the water quality of a stream. Dr. Neil Borman and his students are measuring bacterial concentrations along Loantaka Brook, including Kitchell Pond.

REFERENCES

- Mele, J.A. and M.R. Mele. 1983. Final Report: A Water Resources Assessment and Inventory of Benthic Invertebrates, Fish, and Amphibians of Morristown national Historical Park. Final Report: for the period of October 15, 1982 through October 15, 1983. Associated Ecologists. 81 pp.
- National Park Service, 2003, Morristown National Historical Park Draft General Management Plan and Environmental Impact Statement, New Jersey, Boston Support Office Planning and Legislation, February, 2003.
- National Park Service, Water Resources Division, 1993, Morristown National Historic Park Water Resources Scoping Report, Technical Report NPS/NRWRD/NRTR-93/17, October, Narragansett, RI, 44 p.
- National Park Service, 1994, Baseline Water Quality data inventory and analysis Morristown National Park, Fort Collins, CO, National Park Service Water resources Division, Technical Report NPS/NRWRD/NRTR-94/29, September, 1994.
- Trama, F. B. and L.M.Galloway, 1988, "Morristown National Historical Park Watershed Study: Phase II- Aquatic Resources. Center for Coastal and Environmental Studies. Rutgers, The State University of New Jersey, New Brunswick (Contract 4-02-8217 DI-NPS-0006, 108 pp.
- United States Department of Agriculture, Natural Resource Conservation Service, 1992 (1994), Water Quality Inventory: Macro Invertebrate Sampling Study, USDA

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. Both the Home of Franklin D. Roosevelt and Vanderbilt Mansion National Historic Sites border on the Hudson River. The river forms a freshwater estuary 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.

Park staff are actively involved in many local and regional planning efforts, including the Hudson River Valley Greenway, the Hudson River National Heritage Area, the Hyde Park Trail, and the American Heritage River.

FRESHWATER BODIES

The aquatic resources of Roosevelt-Vanderbilt National Historic Sites 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.13). A 25-acre tidal marsh lies between the Home of Franklin D. Roosevelt NHS and the Hudson River (National Park Service, 2003).

The damming of Fall-Kill Creek by the Roosevelt family in 1925 created an extensive wetlands complex at Eleanor Roosevelt NHS. 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 and discharge measurements often result in zero flow.

The DEC is the agency responsible for protecting and regulating water resources in New York State. Under State law, water bodies 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). There is a lengthy formal procedure established to upgrade a stream's classification system. At present, all park streams currently rated Class D have been proposed for upgrading to Class C (National Park Service, 2003).

HISTORIC WATER-QUALITY AND WATER-QUANTITY MONITORING

The baseline water-quality data inventory and analysis search of ROVA NHP (National Park Service, 1995) resulted in information on 11 water-quality stations within the 3 sites that make up the park. None of these were considered long-term stations by the National Park Service (1995) (having at least 6 parameters with 1 or more observations per year over at least 2 years). All were NPS monitoring stations. Eight of these stations were at the Eleanor Roosevelt National Historic Site. Six of the 8 stations are located on Fall

Kill, a tributary of the Hudson River; one is on a pond of Fall Kill and 1 on a wetland near the park caretakers house. Five of these stations (including the pond and the wetland) were sampled 7 times in 1978-1979 and the remaining three were sampled 7 times in 1994-1995. Dissolved oxygen concentrations were below the EPA criterion for the protection of aquatic life one time at each of four stations. PH exceeded EPA criteria for freshwater aquatic life one time at each of three stations. The highest reported pH was 11.3 standard units in Fall Kill site 2 (National Park Service ID ROVA06) in February 1995. Total chloride concentration exceeded the EPA drinking water criterion at the pond on Fall Kill in December 1978.

Two sites on Meriches Kill in the Franklin D Roosevelt National Historic Site and two sites on Crum Elbow Creek in the Vanderbilt Mansion national Historic Site were measured up to 7 times from 1994 to 1995. pH for one observation at each site exceeded EPA criteria for freshwater aquatic life.

The park initiated a water-quality monitoring program in 1994. Basic data such as temperature, pH, dissolved oxygen, salinity, and conductivity is being collected at all three sites on a monthly basis. Data on additional parameters, including chloride, alkalinity, phosphate, turbidity, and nitrate are being collected quarterly. Starting in 1998, this work has been contracted to a laboratory to assure reliable test results (National Park Service, 2003).

A bathymetric study of the impounded portion of Fall-Kill Creek was conducted by Pandullo-Quirk Associates (1979) and by NPS (1986). Water quantity data is not available for Vanderbilt Mansion NHS or for the Home of FDR NHS, except for a bathymetric study of the Roosevelt's Ice Pond conducted by the NPS in 1986.

The park area with the most complete set of data is Eleanor Roosevelt National Historic Site (Pandullo-Quirk Associates 1979), however, this data is 11 years old. While the 1979 data was not collected in a way in order to provide evidence to justify a classification upgrade, at the time of collection Fall-Kill Creek met the water-quality standards for Class A streams (suitable for drinking and all other uses). Any effort to upgrade stream classification would require additional data collection. No systematic water-quality projects have been completed at HOFR or VAMA.

Park staff have not noticed any significantly elevated chloride concentrations in the winter due to road runoff. No samples have been taken for petroleum elements (Benzene, Tolrene, Ethyl-Benzene, Xylene) (personal communication, David Hayes, 2003).

William Bode with the Water Division of the Department of Environmental Conservation in Albany completed 2 macro-invertebrate studies in the park.

CURRENT WATER-QUALITY AND WATER-QUANTITY MONITORING

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. Water-quality monitoring for this project will probably be done by Park Service staff (personal communication, David Hayes, 2003).

WATER-QUALITY AND WATER-QUANTITY ISSUES

CURRENT AND EMERGING AQUATIC ECOSYSTEM THREATS

Water quality in the park is considered good overall. The major potential polluters of park waters are the Hyde Park municipal water treatment plant on Crum Elbow Creek, 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.14). Contamination of private wells along Haviland Road (north of Val-Kill) by benzene, a petroleum element, 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 within the park. Flow levels are adequate to preserve natural processes and cultural features. There are no known flow reductions by upstream landowners.

According to David Hayes (personal communication, 2003), the biggest threat to water quality at the park is septic systems and residential development. Most of the 25,000 people in Hyde Park have houses with septic systems, which may be contributing to eutrophication of the surface-water bodies. Agriculture is much less of an issue, as there is only one active farm left on the western edge of the town of Hyde Park.

Figure 13. Map showing freshwater resources at Roosevelt-Vanderbilt NHS

Figure 14. Conceptual model of freshwater resources at Roosevelt-Vanderbilt NHS

NATURAL RESOURCE PARTNERS

REFERENCES

National Park Service, 2003, Natural Resources at Roosevelt-Vanderbilt National Historic Site; accessed on August 28, 2003 at URL:
http://www.nps.gov/vama/nr_intro.html.

National Park Service, 1995, Baseline Water-quality data inventory and analysis Roosevelt Vandervilt National Historic Site, Fort Collins, CO, National Park Service Water Resources Division, Technical Report NPS/NRWRD/NRTR-95/64, September, 1995.

Pandullo-Quirk Associates, 1979 (this reference was cited in National Park Service Natural Resources website, but have not found full citation).

Saint-Gaudens National Historic Site

SAGA is a 150-acre rural park located approximately 15 miles south of Lebanon in Cornish, New Hampshire.

FRESHWATER BODIES

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.15). 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 up to 7-8 ft by the dam and average 3.8 ft over the pond as a whole (Cronan and Associates, 1981).

HISTORIC WATER-QUALITY AND WATER-QUANTITY MONITORING

Historic water-quality monitoring in the park has been sporadic and(or) one-time efforts. There are 13 surface-water locations and 1 ground-water well where water-quality monitoring has occurred. The USGS has 2 historical stations in the park, a surface water-quality station on Blow-Me-Up Brook where 27 water-quality parameters were measured 1 time in 1967 and a ground-water well where 86 water-quality parameters were measured 1 time in 1988. Cronan and Associates (1981) mapped the pond bathymetry and the wetlands and measured approximately 13 water-quality parameters 4 times during 1 year at 6 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 between 1982-1991 (Roman, 1992). The Soil Conservation Service mapped the 10-, 100- and 500-year flood plain of Blow-Me-Down Pond in 1977 (SCS, 1977).

A Water Resources Monitoring Study Plan by Brenan Zubricki was completed in 1995 (Zubricki, 1995) and a baseline water-quality data inventory and analysis for SAGA was completed in August, 2000 (National Park Service, 2000).

CURRENT WATER-QUALITY AND WATER-QUANTITY MONITORING

Currently, the NPS has a water-quality monitoring program in place at 5 stations inside the park and 1 station just upstream of the park on Blow-Me-Down Brook. Inside the park, three stations are on Blow-Me-Down Brook, 1 station is on Blow-Me-Up Brook and 1 station is on Blow-Me-Down Pond. This network has been in place since 1997 and is reported annually (Walasewicz, 2002). 15-20 water-quality parameters, including water temperature, water depth, DO, conductivity, pH, and turbidity are measured monthly at all stations from May to November. Instantaneous discharge is measured monthly at 3 stations within the park from May to November. Inorganic nutrients (nitrogen and phosphorus) are measured monthly June-November. Fecal coliform is measured 3 times at 4 stations and biological assessments are conducted 4 times at 4 stations each year. These data and the annual report are all prepared and reviewed internally by SAGA park staff. No known water-quality monitoring has occurred in the wetland surrounding Blow-Me-Down Pond or the Farm Pond.

There are no long-term water quantity or quality data inside or upstream of the park. The closest long-term water-quality monitoring stations are on the Connecticut River, approximately 1 mile downstream of the park. The closest active continuous record stream gaging stations are USGS station number 01151500, the Ottauquechee River at North Hartland, VT (approximately 5 miles North of park; drainage area 221 sq. miles; period of record started in 1930) and USGS station number 01152500, the Sugar River at

West Claremont, NH (approximately 10 miles south of park; drainage area is 269 square miles, period of record started in 1928).

WATER-QUALITY AND WATER-QUANTITY ISSUES

Cronan and Associates (1981) found levels of coliform bacteria and fecal streptococci that are “probably a cause for concern with respect to water quality” (exceeding NY DEC limits for Class A and B waters). Currently, overall water quality and biological integrity of aquatic ecosystems at SAGA are in good condition (Walasewicz, 2002). 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). Blow-Me-Up Brook (NPS station 1) routinely was the lowest scorer in SQS index, bringing down the average. This is probably due to the small size, less habitat, and shadier site (Walasewicz, 2002).

CURRENT AND EMERGING AQUATIC ECOSYSTEM THREATS

Roman (1992) identified increased residential and commercial development in the watershed and acid rain impacts documented in the vicinity (i.e. Hubbard Brook) as potential threats to the aquatic ecosystem in the park (fig.16). Both Blow-Me-Up Brook and Blow-Me-Down Brook have headwaters adjacent to land uses such as residential septic systems, limited agriculture, logging and development (Cronan and Associates, 1981; Walasewicz, 2002). Significant use of deicing chemicals on Rte 12A and other areas may also 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 within or upstream of the park.

NATURAL RESOURCE PARTNERS

REFERENCES

- Cronana and Associates, 1981, Saint-Gaudens National Historic Site: A Natural Resource Inventory, August 1981.
- National Park Service, 2000, Baseline Water-quality data inventory and analysis Saint-Gaudens National Historic Site, Fort Collins, CO, National Park Service Water Resources Division, Technical Report NPS/NRWRD/NRTR-99/242, August 2000.
- Roman, C.T., 1992, Review of water-quality sampling in the Blow-Me-Down Watershed from 1982-1991, National Park Service, May 1992, 12 p.
- Walasewicz, S.A., 2002, Water Resources Monitoring 2002 Annual Report, Cornish, NH,
- Zubricki, B., 1995, Water Resources monitoring Study Plan, Saint-Gaudens National Historic Site.

Figure 15. Map showing freshwater resources at Saint-Gaudens NHS

Figure 16. Conceptual model of freshwater resources at Saint-Gaudens NHS

Saugus Iron Works National Historic Site

Saugus Iron Works (SAIR) is in eastern Massachusetts on the Saugus River in the town of Saugus. SAIR was established as a NHS an example of iron works from the late 17th century. It operated from 1646 until 1670. The Saugus River was critical to the iron works both for the power it provided to the water wheels and as a means of transportation of raw materials to the site and finished products to the Atlantic Ocean. The Saugus River watershed extends approximately 45 miles and encompasses the park and several neighboring towns. The park area is a glacial out-wash plain, situated within the Boston Basin.

DESCRIPTION OF FRESHWATER BODIES

The Saugus River is a tidally influenced perennial stream and estuary with a watershed of 23.3 square miles. The river and wetland surrounding it make up a large portion of the SAIR NHS (fig. 17). The Saugus Iron Works NHS site is located at the head of a riverine estuary. 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 and created a wetland marsh (National Park Service, 2003).

The wetlands or marsh within the Saugus River floodplain and estuary is approximately 4-acres in size and is comprised primarily of common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), and narrow-leaved cattail (*Typha angustifolia*). In addition, trees such as staghorn sumac (*Rhus typhina*), green ash (*Fraxinus pensylvanica*), and black willow (*Salix nigra*) are also present within the marsh. The marsh is classified as a persistent emergent wetland.

Two fresh water 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, 2003).

HISTORIC WATER-QUALITY AND WATER-QUANTITY MONITORING

Massachusetts Department of Environmental Protection (MDEP) conducted an extensive water-quality assessment of the North Coastal Basin in Massachusetts, including the Saugus River Basin (MDEP, 1998). MDEP collected background water-quality data and macro invertebrate samples during 1997 and 1998. One sampling location was just east of SAIR.

In 1989 through 1990, Hudsonia Limited conducted a Baseline Assessment of the Saugus River system, analyzing physical, chemical and biological parameters from 10 stations along the river, including one station at Saugus Iron Works (Tashiro and others, 1991).

The Massachusetts Division of Water Pollution Control assessed water quality of the Saugus River at twelve 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. Water-quality sampling information was documented by Sandy Wignot (SAIR seasonal Park Ranger), in a student report "Baseline Water-quality Data for the Saugus River" in spring 1988 (National Park Service, 2003).

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 relationship 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 within the turning basin area (Daniel Noon, NPS, written comm., 2003): In November of 1993 Goff-Chem, Inc. collected three soil cores at five depths in the vicinity of the dock and slag pile (Goff-Chem, Inc, 1994). The metal concentrations for this area generally exceeded "average" geological concentrations, suggesting an anthropogenic source. PPM and PAH exceeded the MCP standards within the surface and sub-surface samples. Arsenic concentrations exceeded Imminent Hazard criteria at depths of 3.0 and 5.0 feet (Woodard and Curran, 1995).

In addition, a Phase I 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 west side of the Saugus River is contaminated with PPM and PAH, 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).

CURRENT WATER-QUALITY AND WATER-QUANTITY MONITORING

The USGS maintains a stream-flow gage just north of the park, Saugus River at Saugus Iron Works (USGS gaging station number 01102345). The period of record for this site is 1994 to present 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 provided funding to update the existing stream flow gage 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. The weather station does not meet National Weather Service standards for station location, but is used by the Park for interpretive work. The USGS conducts water-quality testing, and collects soil and fish tissue samples monthly.

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) in recent years by the Saugus River Watershed Council (SRWC), overseen by Director, Joan La Blanc. Parameters sampled include bacteria, pH, turbidity and DO.

The USGS, in cooperation with the Massachusetts Department of Environmental Protection 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 of the Saugus Iron Works from (off park property).

The sample was analyzed for: **inorganic elements**: Ca, Mg, Na, K, P, Al, Sb, As, Ba, Be, Bi, Cd, Cr, Co, Cu, Fe, La, Pb, Li, Mn, Mo, Ni, Sc, Ag, Sr, Sn, Ti, W, V, Y, Zn, Zr); **polyaromatic hydrocarbons** (Naphthalene, 2-Methylnaphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene, Dibenz(a,h)anthracene, Benzo(g,h,i)perylene); **polychlorinated biphenyls** (1016, 1221, 1232, 1242, 1248, 1254, 1260); and **organochlorine pesticides** (Aldrin, alpha-BHC, beta-BHC, delta-BHC, gamma-BHC, alpha-Chlordane, gamma-Chlordane, Chlordane, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, Dieldrin, Endosulfan I, Endosulfan II, Endosulfan Sulfate, Endrin, Endrin aldehyde, Endrin Ketone, Heptachlor, Heptachlor epoxide, Methoxychlor, Toxaphene);

Grain-size analysis (sand/fine) split was done on the sample. Results for this study are not yet published (R.F. Breault, USGS, written comm, 2003).

A flood damage control project for the Saugus River and Tributaries, Lynn, Malden, Revere and Saugus, Massachusetts has been underway for several years. The U.S. Army Corps of Engineers published the main report in 1989.

WATER-QUALITY AND WATER-QUANTITY ISSUES

The Saugus River, which runs through Saugus Iron Works National Historic Site, 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 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). While the Saugus River has comparatively low levels of chemical pollution, in some areas, high levels of coliform bacteria have been found.

CURRENT AND EMERGING AQUATIC ECOSYSTEM THREATS

The Saugus River in an urban area in Massachusetts has been impacted by human activities for over 300 years (Gomez and Sullivan, 2003). 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, the once navigable Saugus River has been reduced to a narrow and shallow rivulet.

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 four acres of the river are choked with invasive plants, displacing native species and contribute to the channeling (narrowing and deepening) of the riverway, 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. Despite a new sewage pumping station installed by the town of Saugus in 1987, there are many older septic systems in the watershed that leach their contents into the river.

Seasonal flooding of the Saugus River is also 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. Household waste is carried from upstream; some of which is deposited in the Basin area within Park boundaries as the waters recede (Tashiro and others, 1991).

Control of the invasive plants infesting the park's marsh area is an important aspect of a potential project needed to restore the open water condition of the Saugus River tidal basin and the park's waterfront area. The NPS is proposing to restore the Saugus Iron Works turning basin and adjacent riverbed and wetlands within the historic site (Daniel Noon, NPS, written comm., 2003).

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 (MDEM) is working in cooperation with the Lynn Water and Sewer Commission (LWSC) to better control and time their withdrawals of fresh water from the Saugus River, which are used as the drinking supply for the city of Lynn. The MDEM is also seeking funding to install a fish ladder at the LWSC diversion dam, located at the Colonial Hilton in Lynnfield, to return alewives to their natural spawning areas at Lake Quannapowet, Wakefield (National Park Service, 2003).

Figure 17. Map showing freshwater resources at Saugus Iron Works NHP

Figure 18. Conceptual model of freshwater resources at Saugus Iron Works NHP

NATURAL RESOURCE PARTNERS

The Saugus River Watershed council
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781-233-5046

REFERENCES

- National Park Service, 2003a (draft), Resource Management Plan, September 1, 2003.
- Goff-Chem, Inc., 1994, Soil Core Sampling & Analysis for Hazardous Substances, Saugus Iron Works National Historic Site Saugus, MA
- Goff-Chem, Inc., 1996, Imminent Hazard Evaluation Saugus Iron Work's National. Historic Site Saugus, MA

- Gomez and Sullivan, 2002, Saugus River Water Budget and Instream Flow Study, Massachusetts Department of Environmental Management, Gomez and Sullivan Engineers and Environmental Scientists, Weare, NH, June 2002, 227 p.
- Massachusetts Department of Environmental Protection, 1998, Water-quality Assessment of Gloucester harbor, The North, Salem/Peabody, The Saugus River, Smallpox Brook, Salisbury.
- Tashiro, J.S., R.E. Schmidt, E. Kiviat, and D.R. Roeder, 1991, Baseline Assessment of the Saugus River System, Massachusetts (Final Report), Prepared for New England Natural Resources Research Center and Massachusetts Public Interest Research Group, Hudsonia Limited, New York, March 11, 1991, 54 p.
- U. S. Army Corps of Engineers, 1989, Saugus River and Tributaries Flood Damage Reduction, Water Resources Investigation, New England Division.
- Wignot, S., 1987 List of Marsh Plants at Saugus Iron Works, Unpublished, Saugus, Ma.
- Wignot, S., 1988, Baseline Water-quality Data for the Saugus River, student report.
- Woodward & Curran Environmental Services, 1995, Licensed Sue Professional (LSP) Review for Saugus Iron Works NHS

Saratoga National Historical Park

Saratoga National Historical park (SARA), in Stillwater, New York in Saratoga County, is 3,406 acres along the Hudson River and is visited by about 250,000 people annually (mostly June-October). Saratoga NHP is composed of four non-contiguous sites. The Battlefield Unit is located in Stillwater and is what many people typically 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 available to visitors and no programs or interpretive services are offered there.

NPS's Water Resources Division in cooperation with Saratoga National Historical Park staff developed a Water Resources Management Plan in January 2001 (Vana-Miller and others, 2001). This plan includes an inventory of existing freshwater resources, and the monitoring that has been done on them, the 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. This document is located at the park and should be used to guide any water-quality monitoring conducted within the park.

DESCRIPTION OF FRESHWATER BODIES

Tributaries to the Hudson River drain SARA, including Kroma-Kill, Mill Creek, American's Creek and Devil's Hollow (fig.19). Originating northeast of the park, Kroma Kill drains the largest area and flows through the park as a third-order stream. All of the Mill Creek drainage is contained within park boundaries. It enters the Hudson as a

second order stream. American's Creek is the name given by the park to a small, first-order stream entering the Hudson just south of the Mill Creek confluence with the Hudson. Devil's Hollow (locally used name) in the southern end of the park is a second order stream that flows through a Hemlock-laden cascade with a gradient drop of over 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 was completed in 1823. It runs along Rte 4 on the eastern edge of the park.

A wetland inventory for the park (Tiner and others, 2000) was conducted by the U.S. Fish and Wildlife Service in conjunction with the National Wetlands Inventory. Based on this inventory, the park has 176 acres of Palustrine wetlands (~6% of the park).

Two small farm ponds and 4 springs are located within the park.

HISTORIC WATER-QUALITY AND WATER-QUANTITY MONITORING

Water-quality monitoring at 11 stations inside the park was done from 1987-1990. Eight water-quality parameters were measured including water temperature, specific conductance, DO, pH, salinity, nitrate, lead and phosphate at each station. Five additional stations were tested for PCBs and/or lead one time in 1987. These stations were monitored internally by the NPS. Additionally, there is one USGS ground-water well in the park. The results of the above-mentioned monitoring is included in the Horizon report for SARA.

Other than the Hudson River, no fluvial system within or adjacent to SARA is or 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 Hydro-Climatic Data Network (HCDN) station that is most representative of streamflow conditions at the park is the Hudson River at Stillwater. Closest water-gaging sites are just outside the park boundary on the Hudson River, USGS 01330980 and USGS 01330995. The difference between drainage areas of Hudson River at this location and any of the small streams in the park is significant.

An intensive investigation of the ground water resources within the park was conducted by Heath and others (1963). The results of this investigation are summarized in The Water Resources management Plan for the park (Vana-Miller and others, 2001).

CURRENT WATER-QUALITY AND WATER-QUANTITY MONITORING

None (Chris Martin, personal communication, 2003). Park staff continues to record monthly depths-to-ground-water readings from the USGS observation well.

WATER-QUALITY AND WATER-QUANTITY ISSUES

The results of the SARA water-quality criteria screen found that 4 groups of parameters exceeded EPA screening criteria at least once within the park. DO, pH, fecal coliform and lead exceeded their respective EPA criteria for the protection of freshwater aquatic life. Lead exceeded its drinking water criteria on the Old Champlain Canal ½

mile north of where Kroma Kill enters the canal (NPS site SARA0042), and just downstream of the confluence of Kroma Kill and a tributary to Kroma Kill (SARA0049), and in an area of backwater created by the Hudson River near where American Creek enters Hudson River (NPS site SARA0058); fecal coliform exceeded NPS WRD screening limits for freshwater bathing at site SARA0049 and on Mill Creek, just downstream of the confluence of Robbie's Ditch and Mill Creek (NPS site SARA0053). Dissolved oxygen exceeded its EPA standard at 2 locations on Mill Creek (NPS sites SARA0061 and SARA0054), one location on Devil's Hollow (NPS site SARA0062) and one location on American Creek near where it enters the Hudson River (NPS site SARA0057). PH exceeded its screening criteria at NPS sites SARA0061 and SARA0057.

12 groups of parameters exceeded screening criteria at least once within the study area (2 miles upstream of the park and 1 mile downstream). Dissolved oxygen, pH, cadmium, chromium, copper, lead, and mercury exceeded their respective EPA criteria for the protection of freshwater aquatic life. Nitrite, cadmium, lead, mercury, and methylene chloride exceeded their respective EPA drinking water criteria. Bacteria concentrations (total coliform and fecal coliform) and turbidity exceeded the WRD screening limits for freshwater bathing and aquatic life, respectively.

CURRENT AND EMERGING AQUATIC ECOSYSTEM THREATS

The Natural Resource Specialist at SARA, Chris Martin, indicated that some of the biggest threats to aquatic ecosystems in the park include nonpoint source pollution, agriculture and active dairy farms, and residential development upstream of the park (personal communication, 2003) (fig.20). In the case of Mill creek, the stream flows out of the park boundary, across agricultural land and then back into the park. Additionally, road salt and auto exhaust, gasoline and oil product contamination from residential runoff and bacterial and infectious agent contamination from failing septic systems, beaver re-colonization of Mill Creek and the potential risk of zebra mussel colonization have all been identified as potential threats to the freshwater ecosystem (Vana-Miller, 2001).

The park is bounded by the Hudson River, which all of its streams drain into. The Hudson River is a Superfund site. Although the Park boundary is the mean high-water mark of the Hudson River, backwater that could be caused if the Hudson is dredged for PCBs, could affect the park.

There are no industrial or municipal facilities in the park or within the watersheds draining into the park.

Figure 19. Map showing freshwater resources at Saratoga NHP

Figure 20. Conceptual model of freshwater resources at Saratoga NHP

NATURAL RESOURCE PARTNERS

REFERENCES

National Park Service, 1997, Baseline Water-quality data inventory and analysis Saratoga National Historical Park, Fort Collins, CO, National Park Service Water Resources Division, Technical Report NPS/NRWRD/NRTR-97/96, March 1997.

Tiner, R., I. Huber, G. Smith, and M. Starr, 2000, Wetlands Inventory of Saratoga National historical park. Produced for the National Park Service under agreement FWS-14-16-0009-01-1807, Saratoga National Historical Park, Stillwater, NY.

Vana-Miller, D., 2001, Water Resources Management Plan Saratoga National Historical Park, New York, January 2001, 69 p.

Weir Farm National Historic Site

Weir Farm NHS is a historic farmstead and reserve in western Connecticut that is located in the Norwalk River watershed in the towns of Wilton and Ridgefield (fig. 21). It is comprised of 60 acres, 39 of which are hardwood and 6 acres of which are pasture and meadowland. Water resources include 15 acres of aquatic habitat, including an artificial pond just under 4 acres, and herbaceous or shrub/scrub wetlands. The entire Park is within the geological 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 Slyer 1995). This geology influences the chemical composition of the major water bodies making them more alkaline with a higher pH and conductivity than other Connecticut lakes. Two new parcels of land, located one-half a mile away, totaling 11 acres, have recently been added to the park.

DESCRIPTION OF FRESHWATER BODIES

Freshwater bodies include Weir Pond, an unnamed Pond, an unnamed stream, some intermittent streams, 7 wetlands and groundwater. Groundwater appears to contribute the majority of the base flow to the pond, which is 7 ft at its deepest point (US Department of Agriculture, 1995).

The site lies within the Norwalk River drainage basin. The site 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 four-acre pond, which was artificially impounded in 1896 (US Department of Agriculture, 1995).

HISTORIC WATER-QUALITY AND WATER-QUANTITY MONITORING

A Baseline Water-quality Data Inventory and Assessment was completed for this park in 1997. No monitoring stations were located by this assessment within or upstream of the park. Because of the lack of water-quality data within the park, a Level I water-quality inventory was prescribed. This Level I survey was completed in 1999 by Charles N. Farris at the Cape Cod National Seashore (Farris and others, 1999). Additional Level I water-quality data was collected by park staff in the summer of 2000.

An NRCS water-quality resource evaluation of the park was completed in 1995. 7 wetlands have been identified and mapped on the site (U.S. Fish and Wildlife Service, 1992). Wetland areas drain into the Norwalk River or into Weir Pond. Based on the Federal Emergency Management Agency's Flood Insurance Rate Map, there are no areas of floodplain within the park's boundaries. According to the state of Connecticut Water-quality Standards, effective May 15, 1992, the groundwater resources on Weir Farm are

streams in class GA because no domestic sewage or industrial waste is discharged into them.

There are no long-term monitoring sites for water quality or water quantity in the park, in the watershed upstream of the park or within the study area as defined by the Baseline Water-quality Data Inventory and Assessment (3 miles upstream or 1 mile downstream of the park). The US Geological Survey has a water gaging station in South Wilton and precipitation stations in Bridgeport and the Stevenson Dam.

CURRENT WATER-QUALITY AND WATER-QUANTITY MONITORING

There is no known water-quality monitoring currently in the park. Plans for water-quality monitoring in the park include the Level 1 water-quality inventory.

WATER-QUALITY AND WATER-QUANTITY ISSUES

The pond can be described as eutrophic with a vulnerability to increased nutrient loading. This may be a function of its shallow water depth (7 ft). Water clarity ranges from 4-5 ft with no evidence of planktonic algae bloom.

CURRENT AND EMERGING AQUATIC ECOSYSTEM THREATS

The primary concern is the impact of adjacent residential development on the Weir Pond watershed and the various wetlands (fig.22). Residential development can lead to nutrient loading in the watershed from septic systems, landscaping activities, and forest clearance that increases runoff. A proposed highway expansion project could impact the watershed of the wetlands in the northeast corner of the park. Development projects within the Park including a proposed restroom building may also influence aquatic resource water quality. Other threats would include acid rain, and other climatic deposition, visitor usage, and possibly road runoff within the park. Land use adjacent to Weir Farm is low-density residential with much of the private residences on 2-5 acre lots, extensively landscaped and serviced by on-site septic systems. This land use tends to be associated with increased nutrient loading from ground water input and surface water runoff.

Figure 21. Map showing freshwater resources at Weir Farm NHS

Figure 22. Conceptual model of freshwater resources at Weir Farm NHS

NATURAL RESOURCE PARTNERS

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Connecticut Chapter
55 High Street
Middletown, CT 06457-3788
Phone: (860) 344-0716
Fax: (860) 344-1334
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Norwalk River Watershed Association, Inc.
P.O. Box 197

Georgetown, CT 06829
(203) 846-8210

REFERENCES

- Canavan R.W. and P.A. Siver, 1995, Connecticut lakes: A Study of the chemical and physical properties of fifty-six Connecticut lakes. Connecticut College Arboretum, New London, CT, 299 p.
- Farris, C.N. and K. Chapman, 2000, Level I Water-quality Inventories-Weir Farm National Historical Site, Cape Cod National Seashore, 14 p.
- National Park Service, 2000, Baseline Water-quality data inventory and analysis Saint-Gaudens National Historic Site, Fort Collins, CO, National Park Service Water Resources Division, Technical Report NPS/NRWRD/NRTR-99/242, August 2000.
- US Department of Agriculture, 1995, the Weir Farm Natural Resource Evaluation Project, USDA Natural Resources Conservation Service Interagency Agreement #IA 1600-3-9001, Connecticut, September 1995.

IDENTIFICATION OF NETWORK-WIDE WATER-QUALITY OBJECTIVES AND CANDIDATE MONITORING VARIABLES

SUMMARY

REFERENCES CITED

- Environmental Protection Agency, 2003, About STORET: accessed September 8, 2003 at URL <http://www.epa.gov/STORET/about.html>.
- US Geological Survey, 2003, NWISWeb Data for the Nation, accessed September 8, 2003 at URL <http://waterdata.usgs.gov/usa/nwis/nwis>.

APPENDICES

Appendix 1. USGS surface-water-discharge gaging stations and ground-water wells in Northeast Temperate Network National Historical Parks.

Appendix 2. Summary of 305(b) Reports and 303(d) lists for fresh waterbodies in or near NETN National Parks.

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Appendix 1. USGS surface-water-discharge gaging stations and ground-water wells in Northeast Temperate Network NHPs. [Note: If there is not a gaging station in a park, the station that is most representative of the park for which it is listed is given.]

Park	Station Name	Station Number	Lat Long	DA (mi ²)	Yrs of Record	Data Type	In Park?
MABI	Ottauquechee River at North Hartland, VT	01151500	43°36'09" 72°21'17"	221	1927-2001 1930-2002 1954-1999	Peak Q Daily Q QW	No
MIMA	Concord River below Meadow Brook at Lowell, MA	01099500	42°38'12" 71°18'09"	400	1938-2001 1936-2002 1952-1994	Peak Q Daily Q QW	No
	Several ground-water wells					GW	Yes
MORR	Passaic River near Bernardsville, NJ	01378690	40°44'03" 74°32'25"	8.83	1968-2001 1967-1976 1965-1979	Peak Q Daily Q QW	No
	WB Primrose Brook in Morristown National Historic Park, NJ	01378775	40°46'11" 74°32'10"		2003	QW Q?	Yes
	EB Primrose Brook in Morristown National Historic Park, NJ	01378778	40°46'14" 74°31'26"		2003	QW	Yes
ROVA	Crum Elbow Creek at Hyde Park, NY	01372040	41°47'24" 73°55'53"	17.3	1960-1976 1960-1962 1966	Peak Q Daily Q QW	No
SAGA	Sugar River at West Claremont, NH	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, VT	01151500	43°36'09" 72°21'17"	221	1927-2001 1930-2002 1954-1999	Peak Q Daily Q QW	No
SAIR	Saugus River at Saugus Iron Works at Saugus, MA	01102345	42°28'10" 71°00'27"	20.8	1994-2000 1994-2002 1994-2001	Peak Q Daily Q QW	No
SARA	Hudson River at Mechanicville, NY	01335500	42°54'45" 73°40'45"	4500	1869-1977 1887-1956 1977	Peak Q Daily Q QW	No
	Saratoga National Park, SA-1072	430013073370401	43°01'13" 73°37'04"	224 ft	1959-1995	GW levels	Yes
WEFA	Comstock Brook at North Wilton, CT	01209600	41°12'45" 73°27'31"	3.53	1960-1975 1964-1976	Peak Q QW	No

Appendix 2. Summary of 305(b) Reports and 303(d) lists for fresh waterbodies in or near NETN National Parks. [Note: Waterbodies listed in **bold text** are within the park boundaries. Waterbodies listed in plain text are adjacent to or near park boundaries.]

Marsh-Billings-Rockefeller National Historic Park, Vermont (MABI)					
Waterbody	305(b) Assessment Information¹		303(d) Information²		
	Unit ID	Impairments	List ID	Reason	TMDL³
All rivers and lakes	n/a	n/a	VT3526_LR-1998	FCA mercury	
The Pogue Pond					
Pogue Hole Brook					
Barnard Brook	VT10-10_00	nutrients, sediment			
Ottauquechee River (Lower)	VT10-01_00	nutrients, sediment, low DO, thermal modifications, flow alteration;			
Ottauquechee River (Upper)	VT10-05_00	same as above plus pathogens			

¹ http://oaspub.epa.gov/waters/w305b_report.state?p_state=VT

² <http://www.blitzco.com/max/list.asp?state=VERMONT>

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 Information¹		303(d) Information²		
	Unit ID	Impairments	List ID	Reason	TMDL³
All rivers and lakes	n/a	n/a	MA4348_LR-1998	FCA mercury	
Concord River	MA82A-07_00	metals, total toxics	MA82A-08_1998 MA82A-07_1998 MA82A-09_1998	metals, nutrients metals, nutrients, pathogens nutrients, pathogens	
Elm Brook	MA83-05_00	nutrients, pathogens, turbidity			
Mill Brook	MA42-10_00 MA41-07_00				

¹ http://oaspub.epa.gov/waters/w305b_report.state?p_state=MA

² <http://www.blitzco.com/max/list.asp?state=MASSACHUSETTS>

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 2. (cont)

Morristown National Historic Park, New Jersey (MORR)					
Waterbody	305(b) Assessment Information¹		303(d) Information²		
	Unit ID	Impairments	List ID	Reason	TMDL³
Primrose Brook	not available	not available			
East Branch Primrose Brook	not available	not available			
West Branch Primrose Brook	not available	not available			
Jersey Brook	not available	not available			
Great Swamp	not available	not available			
Cat Swamp Pond	not available	not available			
Indian Grave Brook	not available	not available			
Passaic River	not available	not available			
Ledell's Pond	not available	not available			

¹ http://oaspub.epa.gov/waters/w305b_report.state?p_state=NJ

² <http://www.blitzco.com/max/list.asp?state=NEWJERSEY>

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 Information¹		303(d) Information²		
	Unit ID	Impairments	List ID	Reason	TMDL³
Fall Kill Creek	not available	not available			
Crum Elbow Creek	not available	not available			
Meriches (Maritje) Kill	not available	not available			

¹ http://oaspub.epa.gov/waters/w305b_report.state?p_state=NY

² <http://www.blitzco.com/max/list.asp?state=NEW+YORK>

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 2. (cont)

Saint-Gaudens National Historic Site, New Hampshire (SAIG)					
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			
Blow-Me-Up Brook	not available	not available			
Blow-Me-Down Pond	not available	not available			
Farm Pond	not available	not available			

¹ http://oaspub.epa.gov/waters/w305b_report.state?p_state=NH

² <http://www.blitzco.com/max/list.asp?state=NEW+HAMPSHIRE>

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

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	

¹ http://oaspub.epa.gov/waters/w305b_report.state?p_state=MA

² <http://www.blitzco.com/max/list.asp?state=MASSACHUSETTS>

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 2. (cont)

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			
Mill Creek	not available	not available			
American's Creek	not available	not available			
Devil's Hollow	not available	not available			
Champlain Canal	NA				
Hudson River					

¹ http://oaspub.epa.gov/waters/w305b_report.state?p_state=NY

² <http://www.blitzco.com/max/list.asp?state=NEW+YORK>

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

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			CT4015_LR-1998	FCA Mercury	
Weir Pond					
Cooper Pond Brook					
Norwalk River	CT7300-00_01 CT7300-00_04 CT7300-00_06 CT7300-00_05 CT7300-00_03 CT7300-00_02	metals, mercury, flow alt., pathogens same as above plus "unknown" metals, mercury, low DO, pathogens metals, mercury, pathogens metals, mercury, pathogens, unknown metals, mercury, pathogens	CT-7300-1998	Inadequate fish passage, pathogens, unknown	
Barrets Brook					
Streets Pond					
Comstock Brook					

¹ http://oaspub.epa.gov/waters/w305b_report.state?p_state=CT#assessed_waters

² <http://www.blitzco.com/max/list.asp?state=CONNECTICUT>

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

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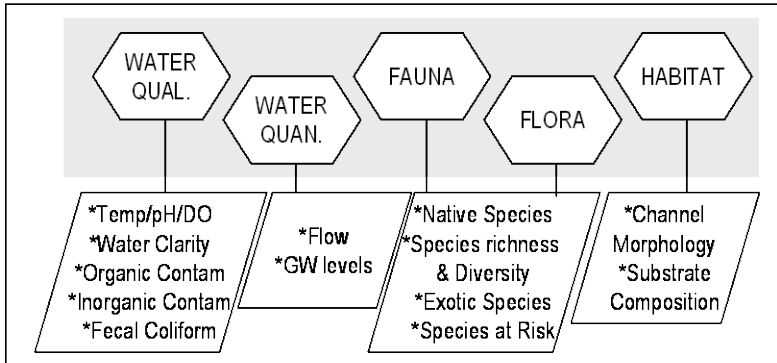
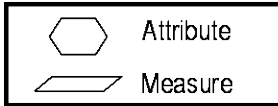


Figure 1a. Brook/River attributes and measures

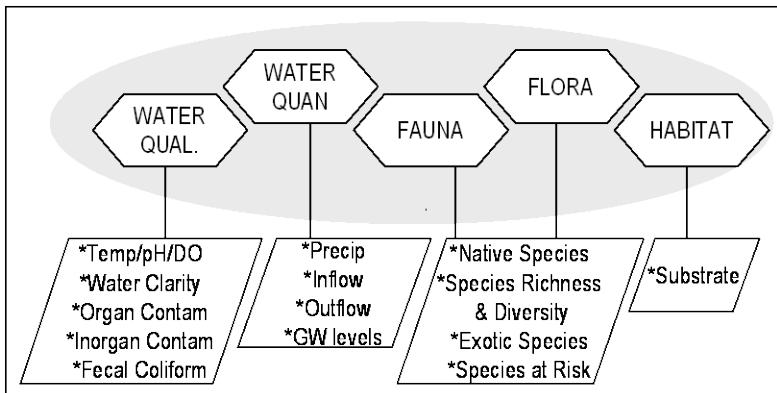


Figure 1b. Pond/Lake attributes and measures

Figures 1a-1e. Attributes and measures for freshwaterbody types

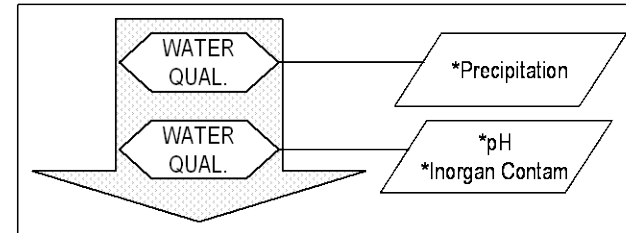


Figure 1c. Precipitation attributes and measures

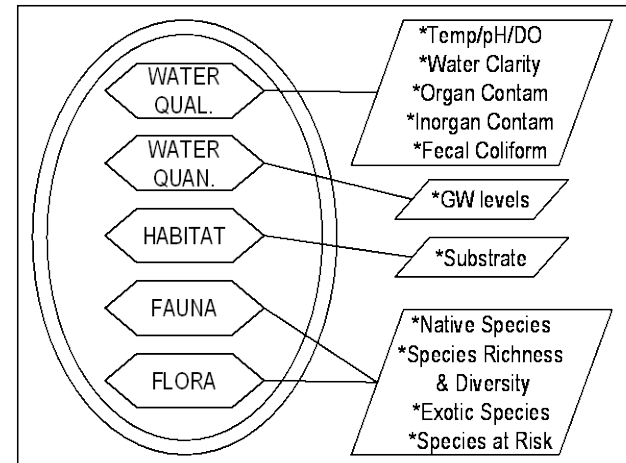


Figure 1d. Wetland attributes and measures

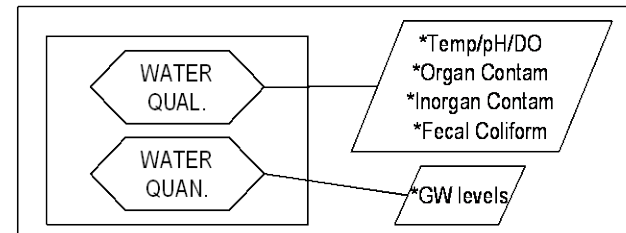


Figure 1e. Ground Water attributes and measures

Driver/Stressor→ Attribute: Measure of Change:	Clim ate	Hyd Cycle	Disturb. Regime	Air Chem	Landsc. Patterns	Climate Change	Acid Rain	Salt on Rd	Invasive Species	Develop ment	Visitor Use	Ag	Logging
Water Qual:Temp/DO/pH	x		x	x	x	x	x	x		x	x	x	x
Water Qual: Water Clarity			x						x	x	x	x	x
Water Qual: Contaminants: Organic									x	x	x	x	
Water Qual: Contaminants: Inorganic							x	x		x		x	
Water Qual: Fecal Coliform										x	x	x	
Water Quan: Flow	x	x	x			x				x		x	
Water Quan: Water Levels		x	x			x				x		x	
Fauna: Native Species	x		x		x	x	x	x	x	x		x	x
Fauna: Species Richness/diversity	x		x	x	x	x		x	x	x		x	x
Fauna:Exotic Species						x			x	x	x		x
Fauna: Species at Risk			x	x		x	x	x		x		x	x
Flora: Comp and Structure	x	x	x	x	x	x			x			x	x
Flora: Native Species	x	x	x		x	x	x	x	x	x		x	x
Flora: Species Richness/diversity	x	x			x	x			x	x		x	x
Flora: Species at Risk			x	x		x	x	x	x	x		x	x
Flora: Exotic Species			x	x	x	x			x	x	x	x	
Habitat: Channel Morphology			x							x			x
Habitat: Substrate Composition			x										x

Figure 2. Links between measures used to quantify change in freshwater ecosystem attributes and the drivers and/or stressors causing the change

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Marsh-Billings-Rockefeller National Historical Park

EXPLANATION

- Park Boundary
- Stressor
- ▭ Driver
- ▭ Surface water
- ➡ Surface- water flow
- ⬆ Ecosystem-wide processes
- ↕ Ground-water surface-water interactions

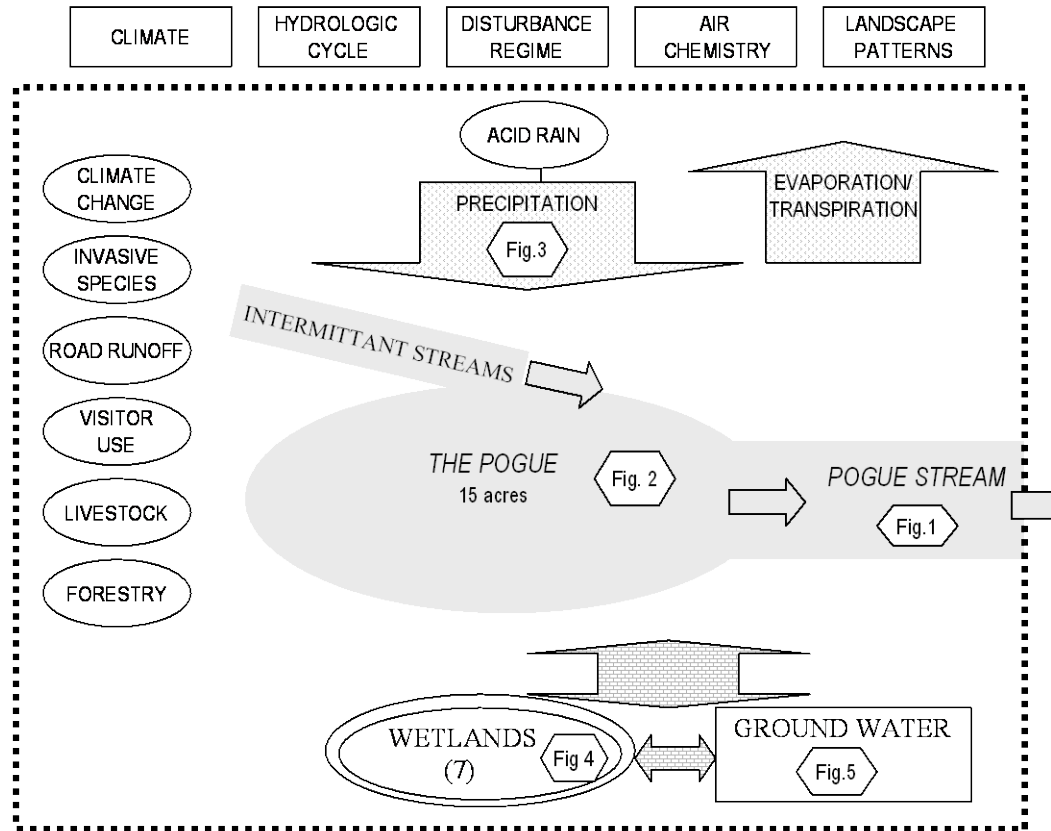


Figure 8. Conceptual model of freshwater ecosystem at Marsh-Billings-Rockefeller National Historical Park

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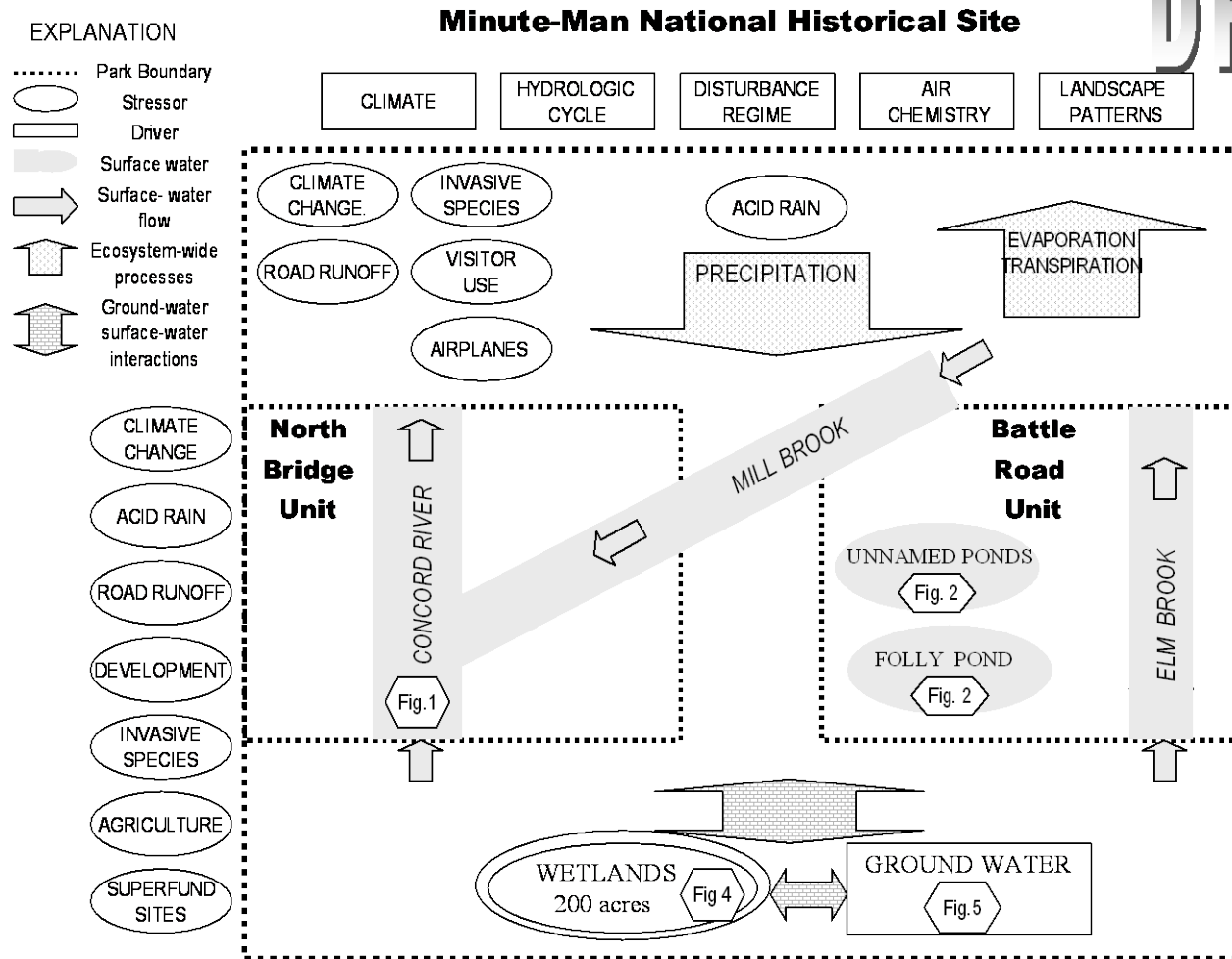


Figure 10. Conceptual model of freshwater ecosystem at Minute-Man National Historical Site

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EXPLANATION

- Park Boundary
- Stressor
- ▬ Driver
- ▬ Surface water
- ➡ Surface-water flow
- ⬆ Ecosystem-wide processes
- ⬆ Ground-water surface-water interactions

Morristown National Historical Park

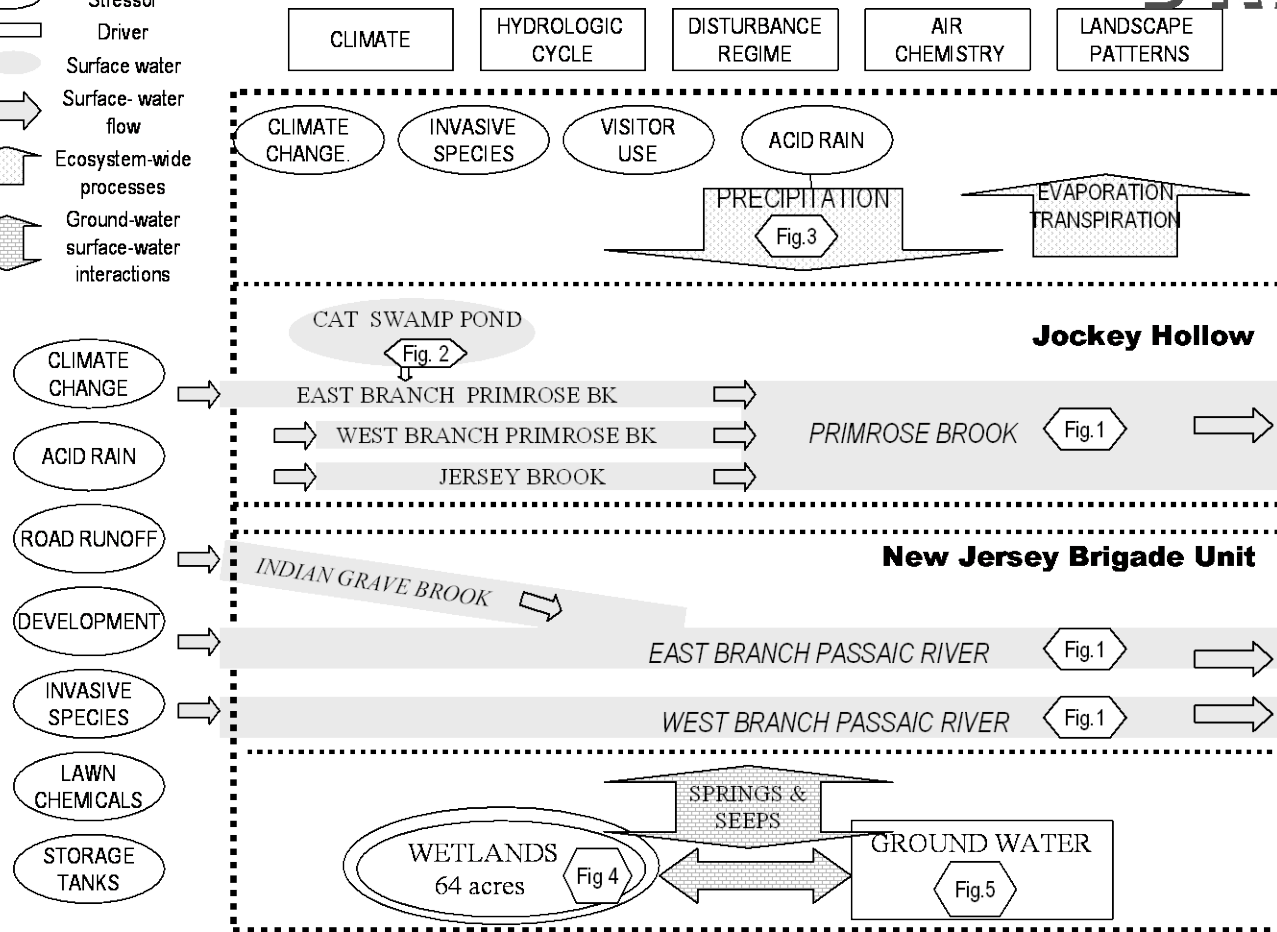


Figure 12. Conceptual model of freshwater ecosystems at Morristown National Historical Park

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Roosevelt-Vanderbilt National Historical Site

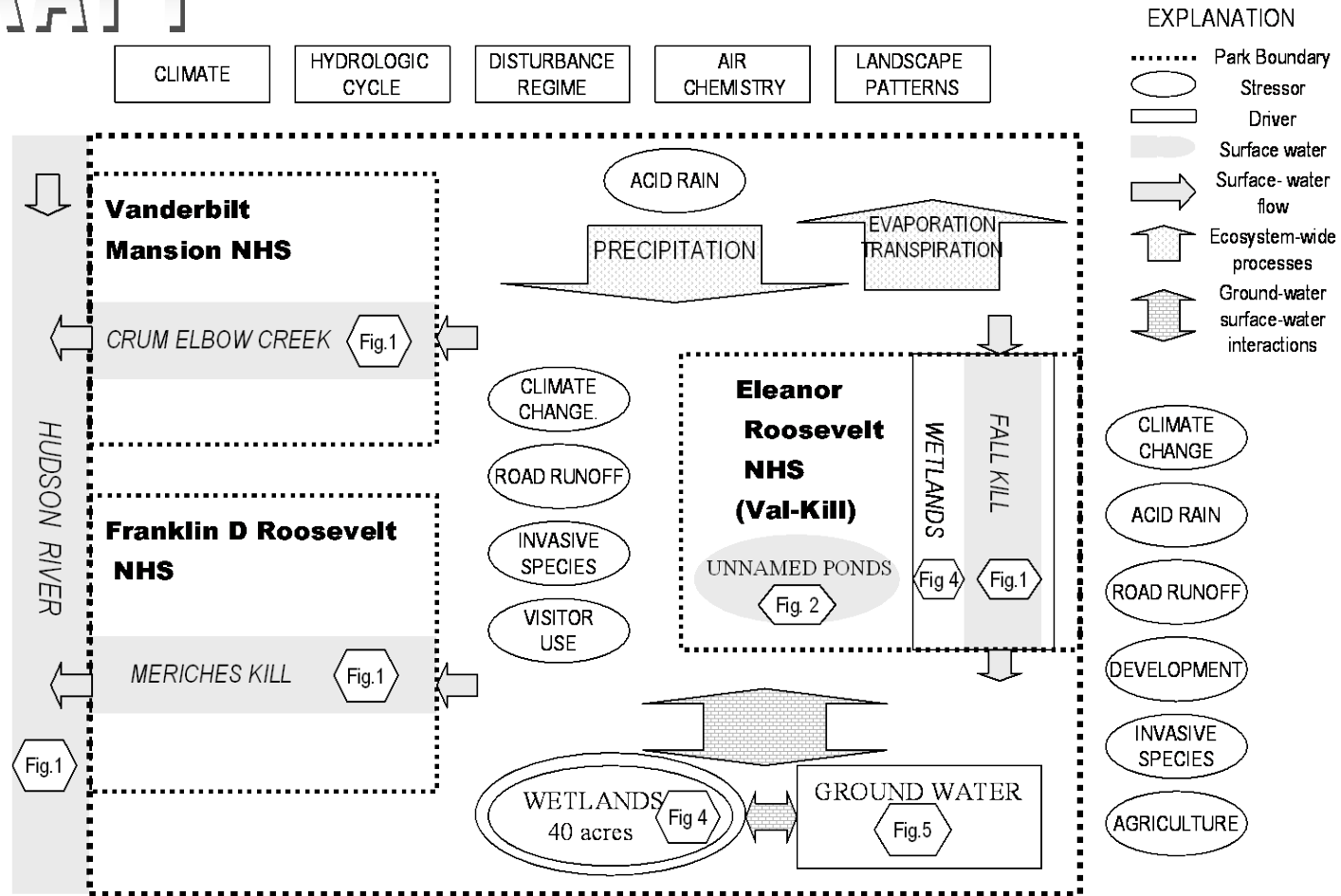


Figure 14. Conceptual model of freshwater ecosystems at Roosevelt-Vanderbilt National Historical Site

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EXPLANATION

- Park Boundary
- Stressor
- ▭ Driver
- ▭ Surface water
- ➔ Surface-water flow
- ⬆ Ecosystem-wide processes
- ⬆ Ground-water surface-water interactions

Saint Gaudens National Historic Site

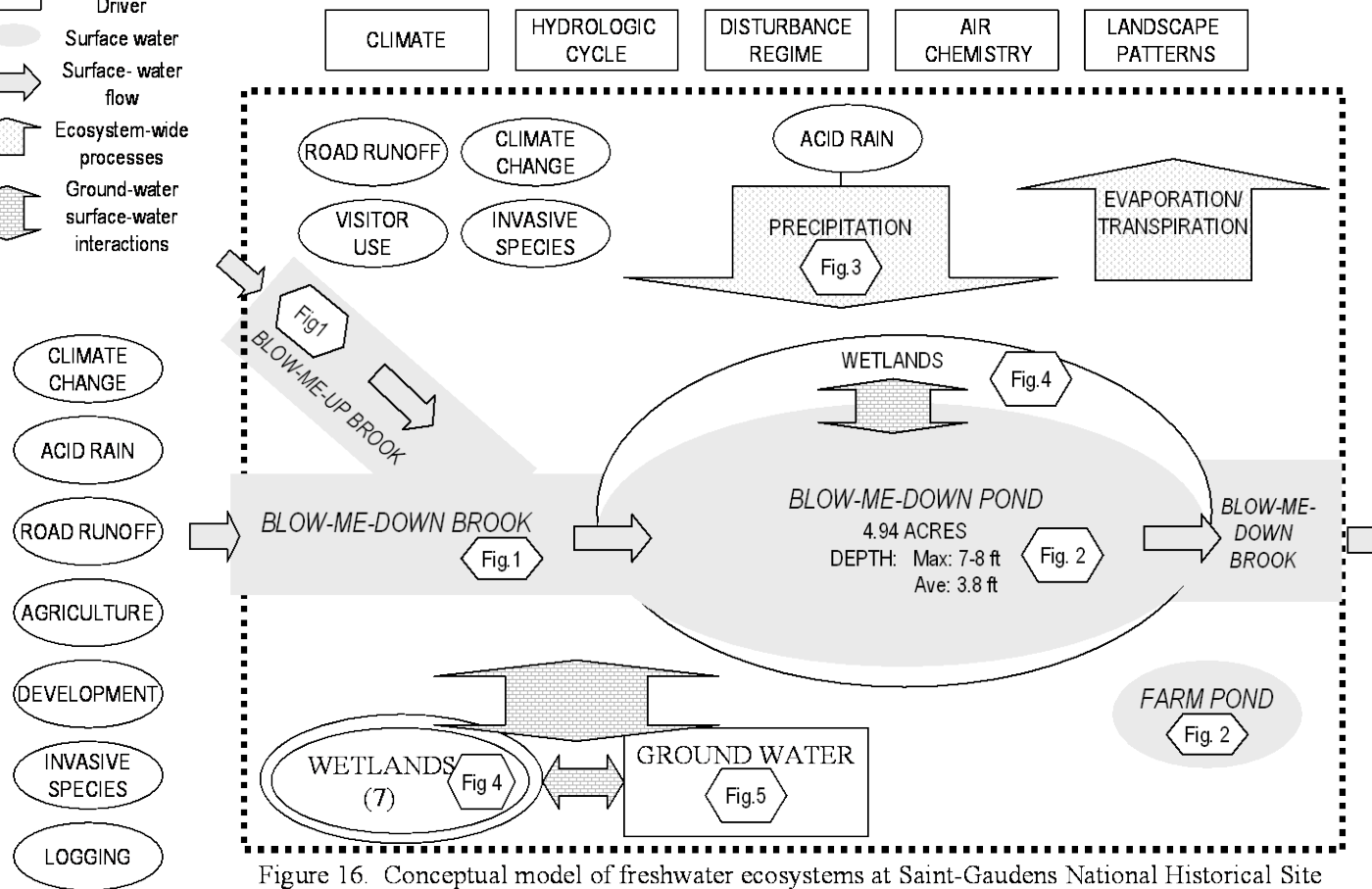


Figure 16. Conceptual model of freshwater ecosystems at Saint-Gaudens National Historical Site

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EXPLANATION

- Park Boundary
- Stressor
- ▬ Driver
- ▬ Surface water
- ➡ Surface-water flow
- ⬆ Ecosystem-wide processes
- ⬆ Ground-water surface-water interactions

Saugus Iron Works National Historic Site

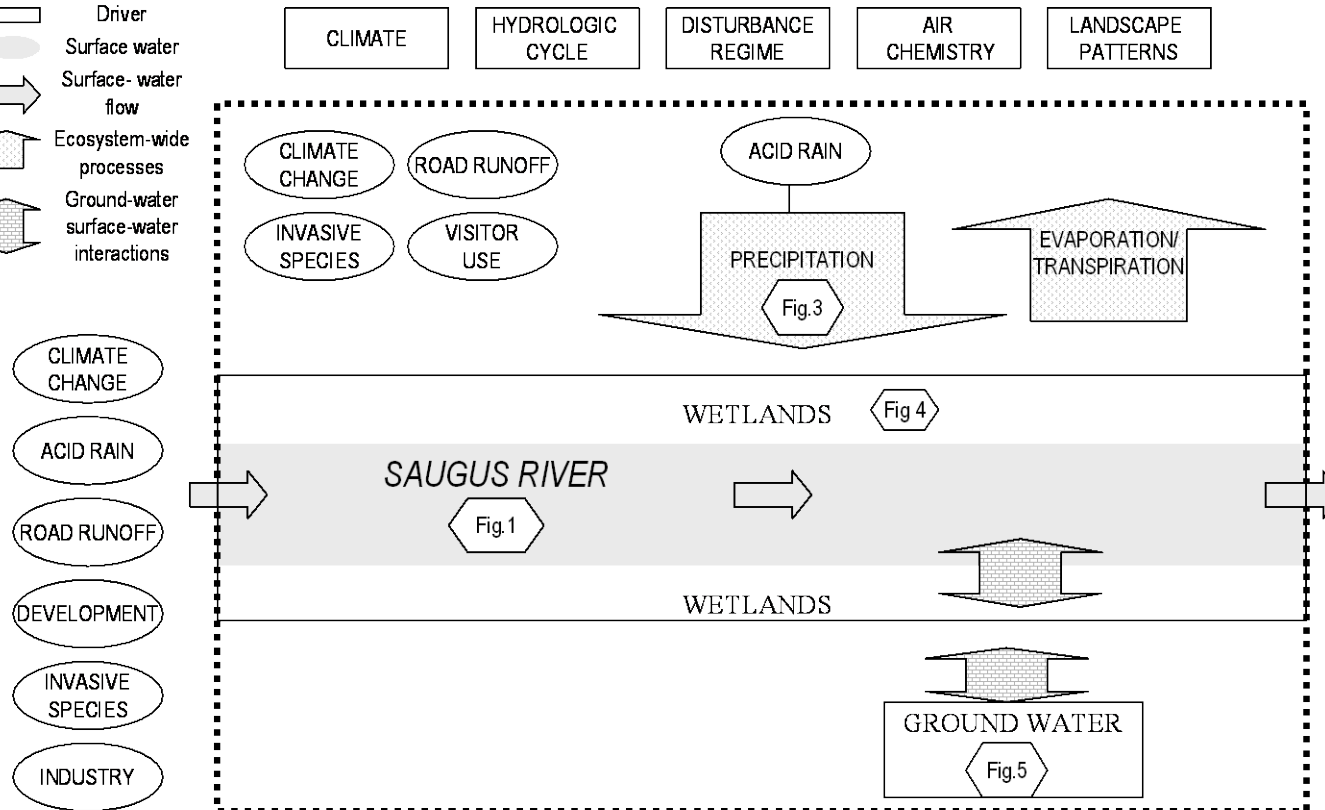


Figure 18. Conceptual model of freshwater ecosystems at Saugus Iron Works National Historical Site

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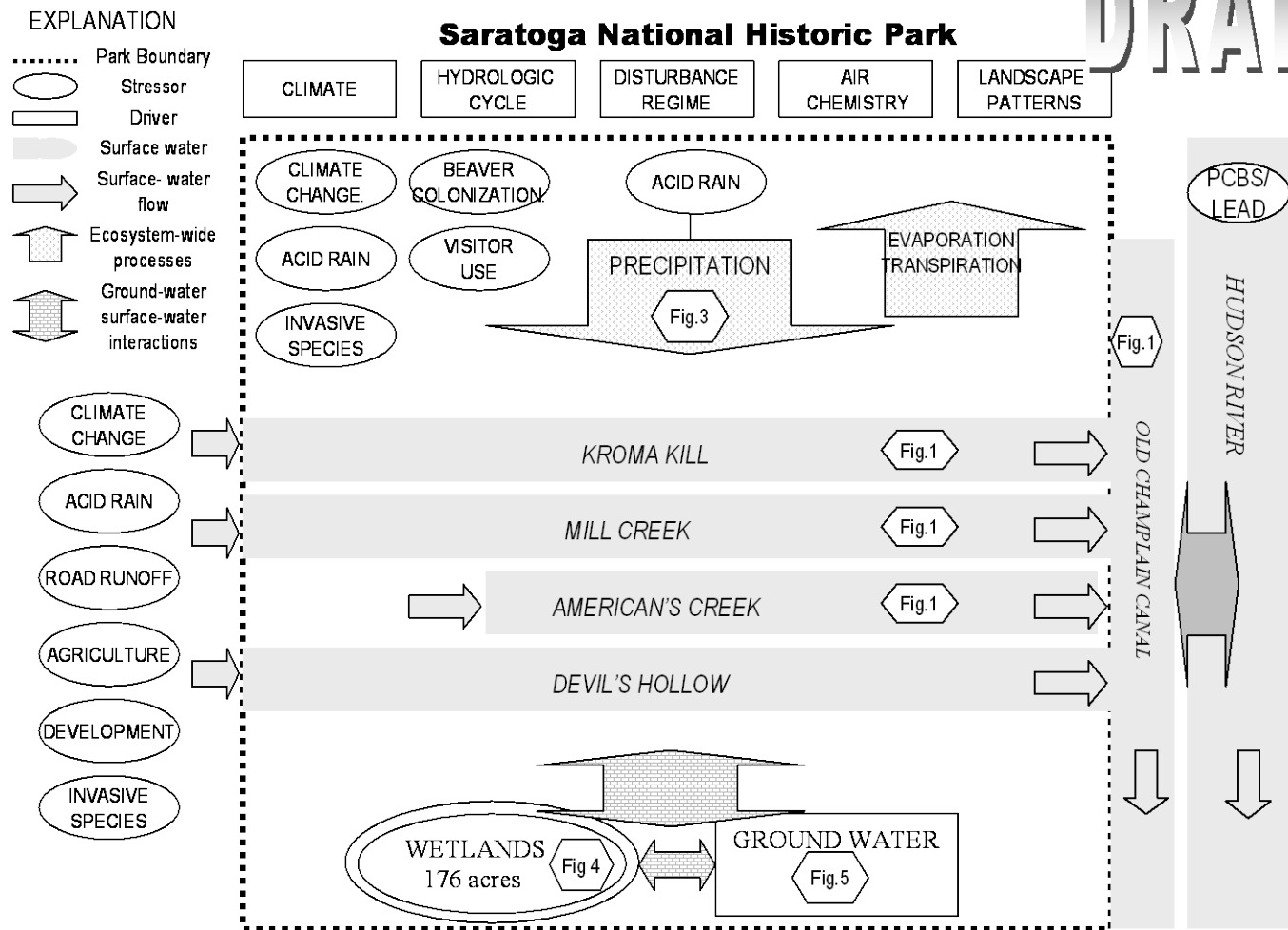


Figure 20. Conceptual model of freshwater ecosystems at Saratoga National Historic Park

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Weir Farm National Historic Site

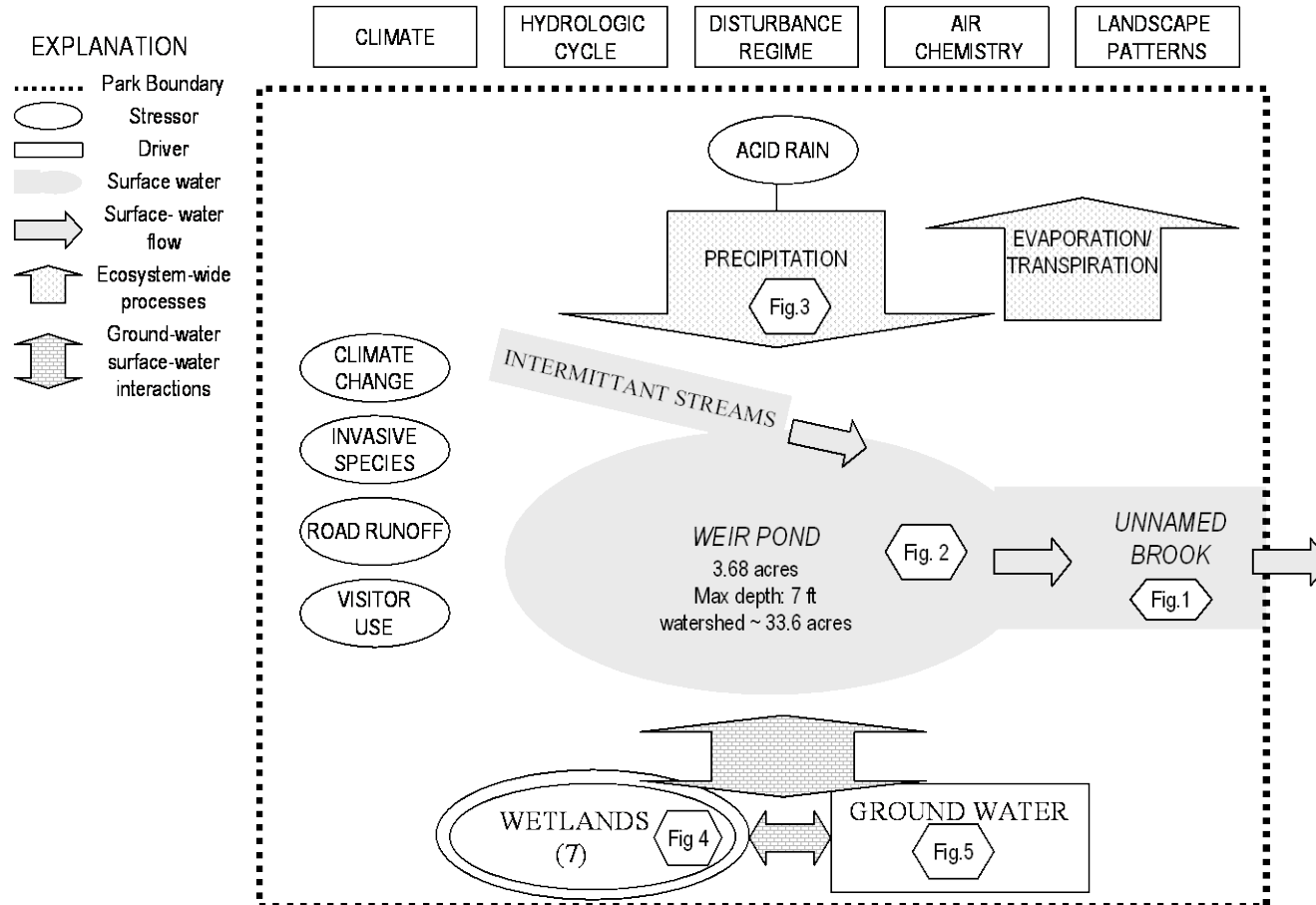


Figure 22. Conceptual model of freshwater ecosystems at Weir Farm National Historic Site

APPENDIX B: Summary of parks in the NETN

Acadia National Park (ACAD, Maine)

Acadia National Park was originally established in 1916 as the Sieur de Monts National Monument by Presidential Proclamation 1339. In 1929, the name was changed to Acadia National Park (45 Stat. 1083) which authorized the expansion of the park. Presently, Acadia National Park protects 47,498 acres, including the highest rocky headlands on the Atlantic shore of the United States (Fig. A.1). Acadia National Park protects 30,300 on Mount Desert Island, 2,728 acres on Isle Au Haut 2,194 acres on Schoodic Peninsula, 10,452 acres in conservation easements and 1,110 other acres, all within the Acadian Archipelago of down east coastal Maine. The glacial history that has shaped Acadia is especially apparent in Somes 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, Acadia has temperate climate greatly influenced by the maritime conditions. 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.

The ecological importance of the Acadian archipelago is widely accepted with special interest to the role the islands play as nesting and wintering sites for a large number and wide diversity of bird species. Acadia is located in a broad transition zone between southern deciduous and northern coniferous forests with local habitats ranging from seashore to mountaintop including but not limited to old growth spruce forests, wetlands, and jack pine forests. The park also 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*). The enabling legislation mentions Acadia's historic significance and great scientific interest. 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 have been designated as locally rare or State-listed, 6 are globally rare, and these numbers might increase with additional floristic inventory. One third of the vascular plants (283 species) are exotic.

APPENDIX B: Summary of parks in the NETN

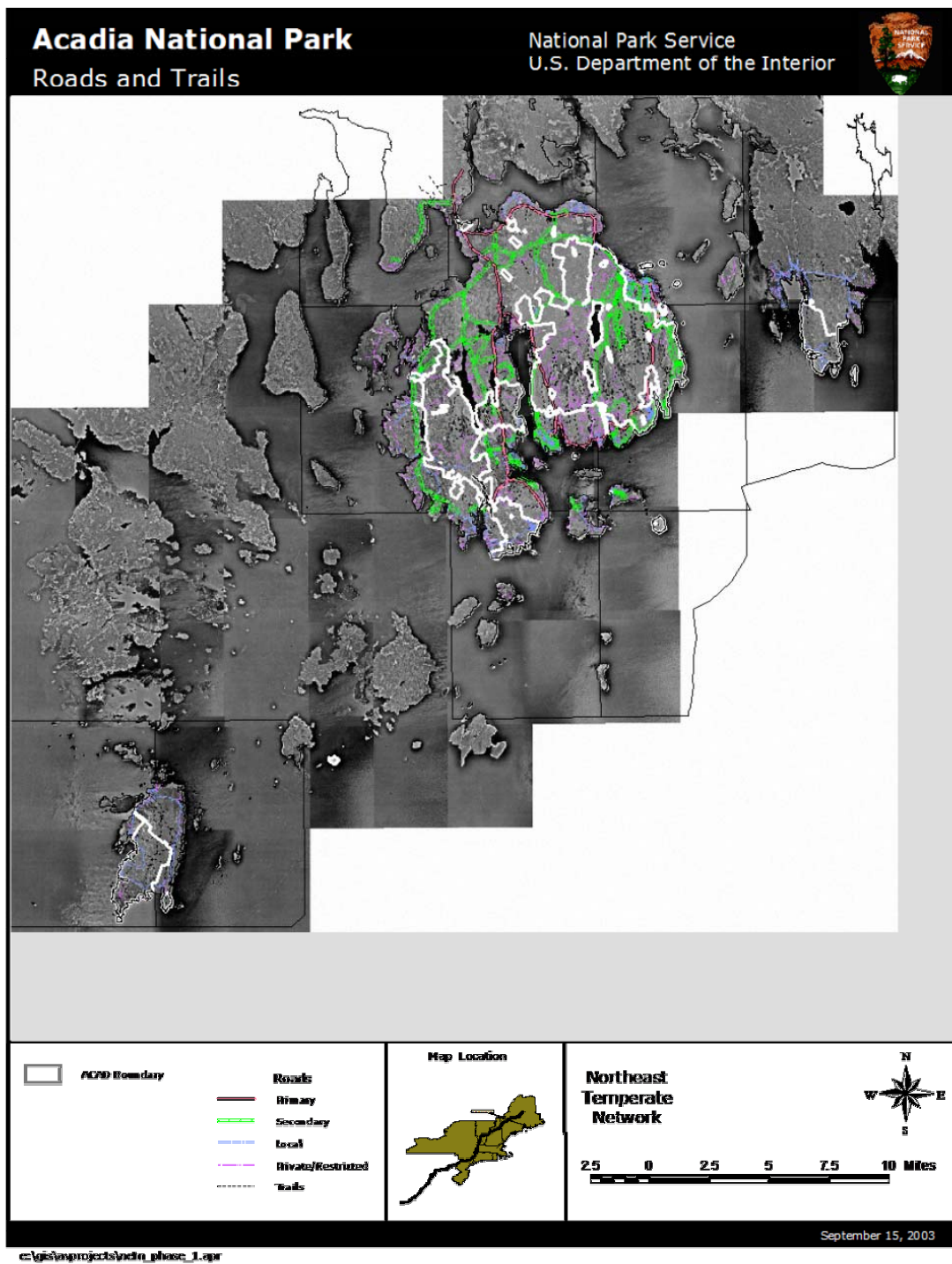


Figure A.1. Boundary map of Acadia National Park showing roads and trails.

APPENDIX B: Summary of parks in the NETN

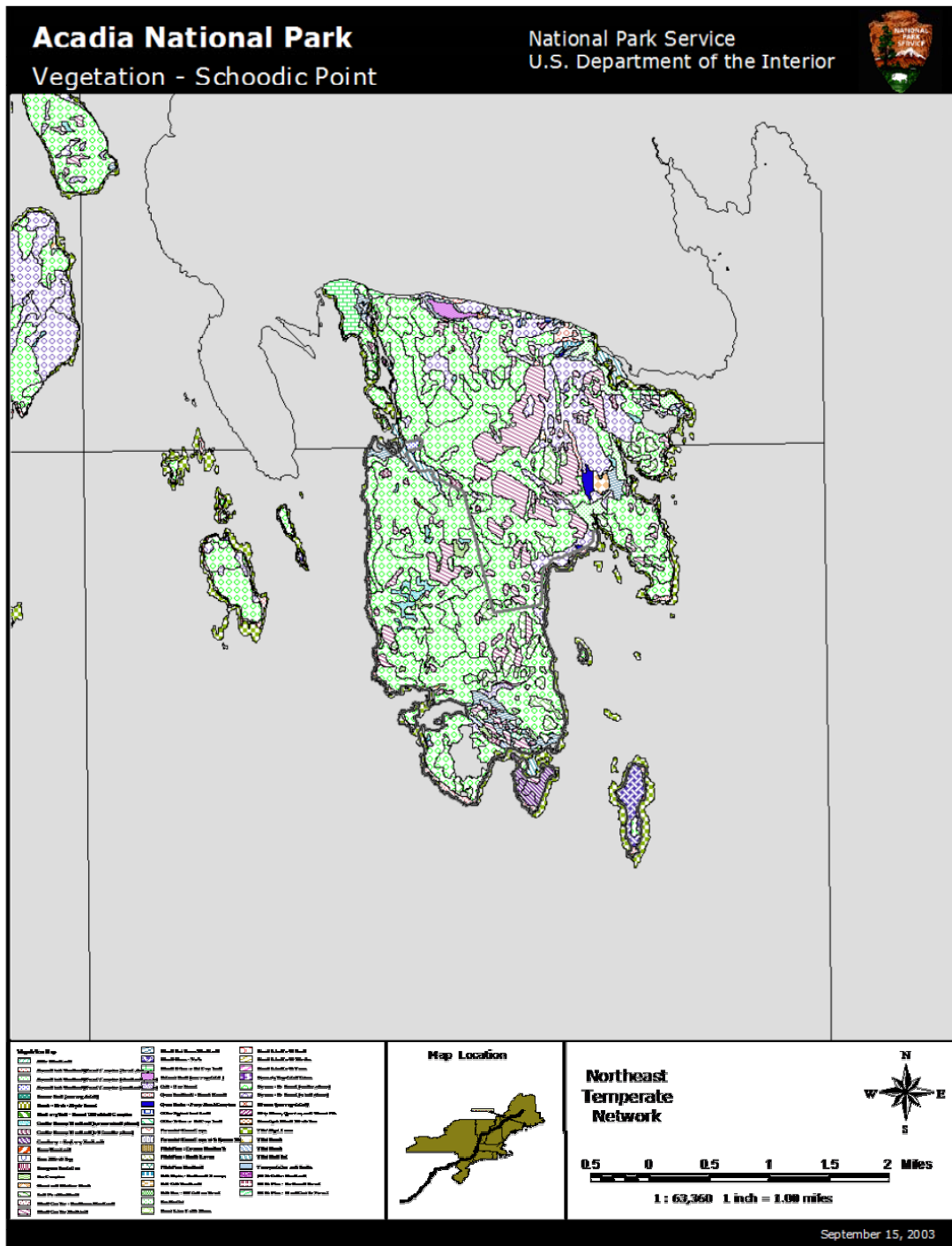


Figure A.2. Vegetation Map of Schoodic Peninsula at Acadia National Park.

APPENDIX B: Summary of parks in the NETN

Appalachian National Scenic Trail (APPA, ME-PA)

Established as the first National Scenic Trail by Congress with passage of the National Trails System Act in 1968 and amendments, the Appalachian National Scenic Trail is a continuous marked footpath extending approximately 2,160 miles across the Appalachian Mountains from the summit of Springer Mountain, Georgia to the summit of Mount Katahdin, Maine. The entire Appalachian National Scenic Trail is a unit of the National Park System, administered broadly by the National Park Service with over 105 agencies and organizations involved in the cooperative management of the trail.

The Northeast Temperate Inventory and Monitoring Network presently includes the Appalachian Trail from Mount Katahdin to the Pennsylvania-Maryland border and will work with other networks, parks, and agencies to develop long-term ecological monitoring priorities for the entire corridor. This section of the trail covers 1,108 miles, includes 155,972 acres of state and federally managed lands, and 1,003 documentations of rare occurrences and exemplary ecological communities (based on Natural Heritage Inventories). The Appalachian Trail traverses 4 ecoregions from ME to MD. From Maine to Pennsylvania the Trail is located in the Northeastern Highlands ecoregion, crossing briefly into the North Central Appalachians before extending through Maryland in the Ridge and Valley ecoregion (Fig. A.3). Ranging from wetlands to alpine vegetation communities, this section of the Appalachian Trail is representative of all terrestrial communities in the Northeast. Including many alpine summits, the Trail contains some of the last remaining old growth forests in the East that are now subjected to high levels of human disturbance including air pollution, land cover change, and invasive species.

Land cover change adjacent to the Trail was identified as a priority resource management issue. Conservation lands within 150 miles of the Trail corridor are patchily distributed (Fig. A.4)

APPENDIX B: Summary of parks in the NETN

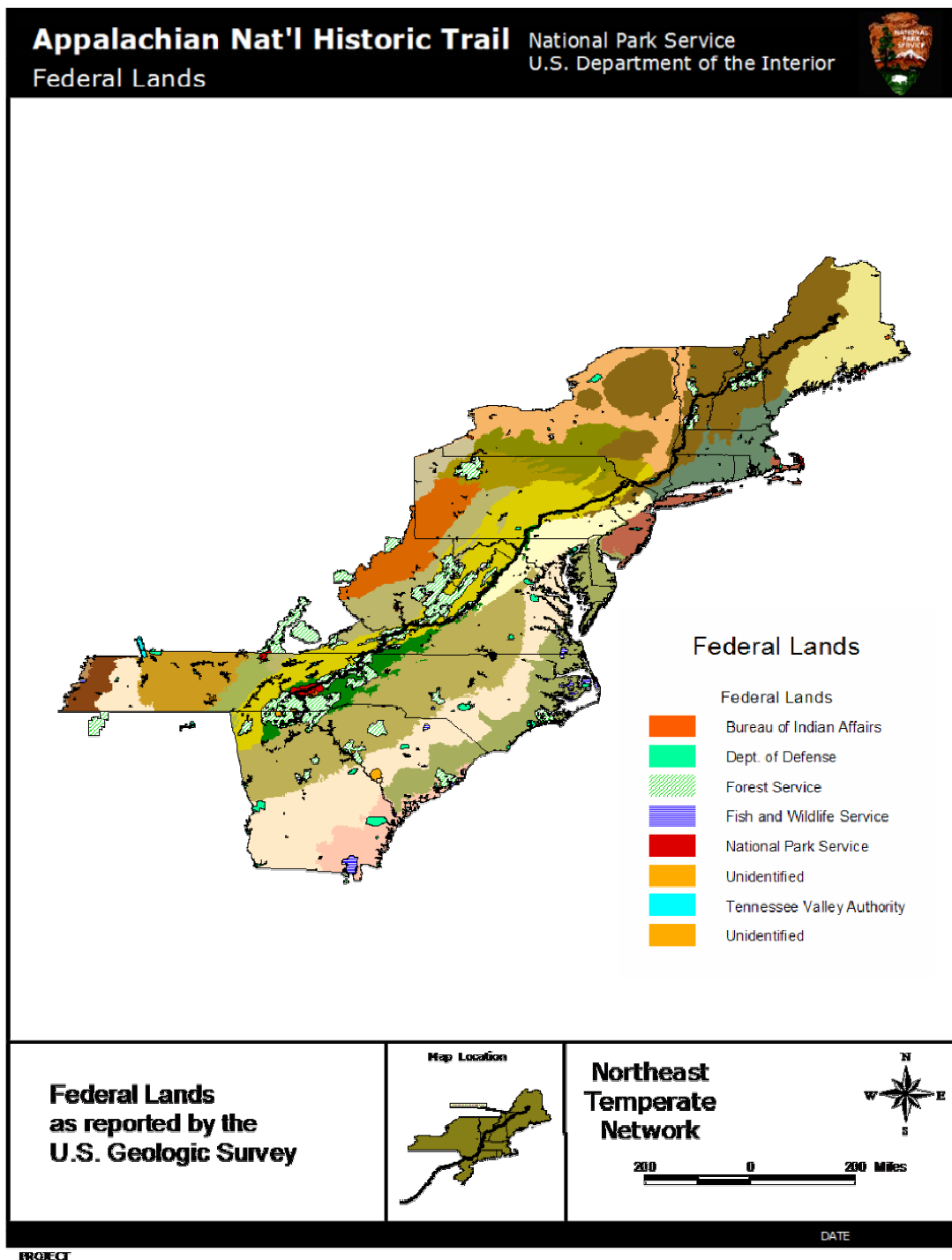


Figure A.3. Ecoregions and federal lands associated with the Appalachian Trail. The AT crosses 6 NPS units, 1 USFWS Refuge, 8 National Forests, and 67 state parks, forests and other lands (not shown).

APPENDIX B: Summary of parks in the NETN

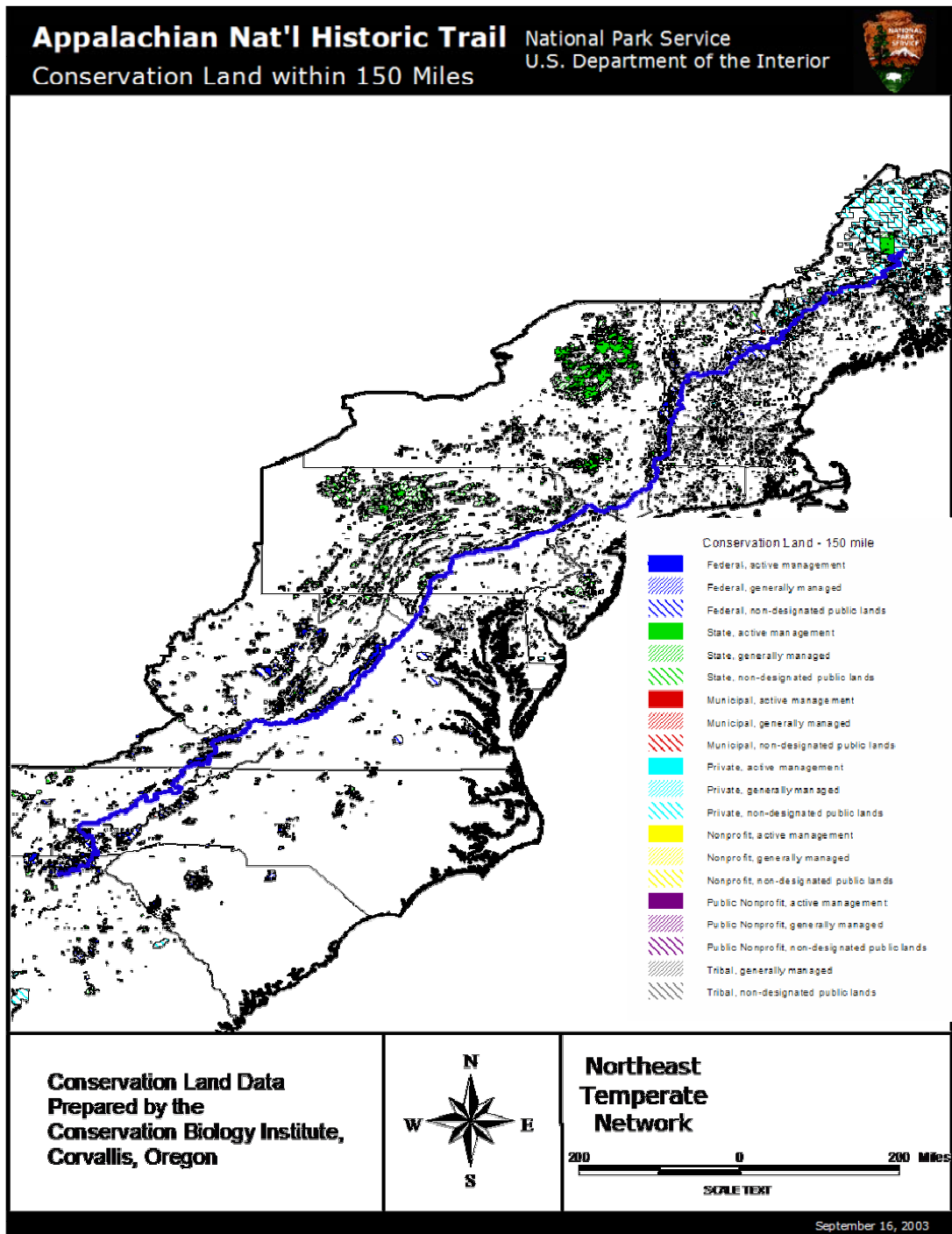


Figure A.4. “Conservation” Land ownership within 150 miles of the Appalachian Trail.

APPENDIX B: Summary of parks in the NETN

Boston Harbor Islands a national park area (BOHA, Massachusetts)

The Boston Harbor Islands became a unit of the National Park System in November 1996 by an act of Congress (Public Law 104-333) that contains several provisions which, in total, make this a national park like no other. 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 land over 50 square miles (Fig. A.5). The Boston Harbor Islands are unique geologically as they 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. 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 succesional vegetation.

APPENDIX B: Summary of parks in the NETN

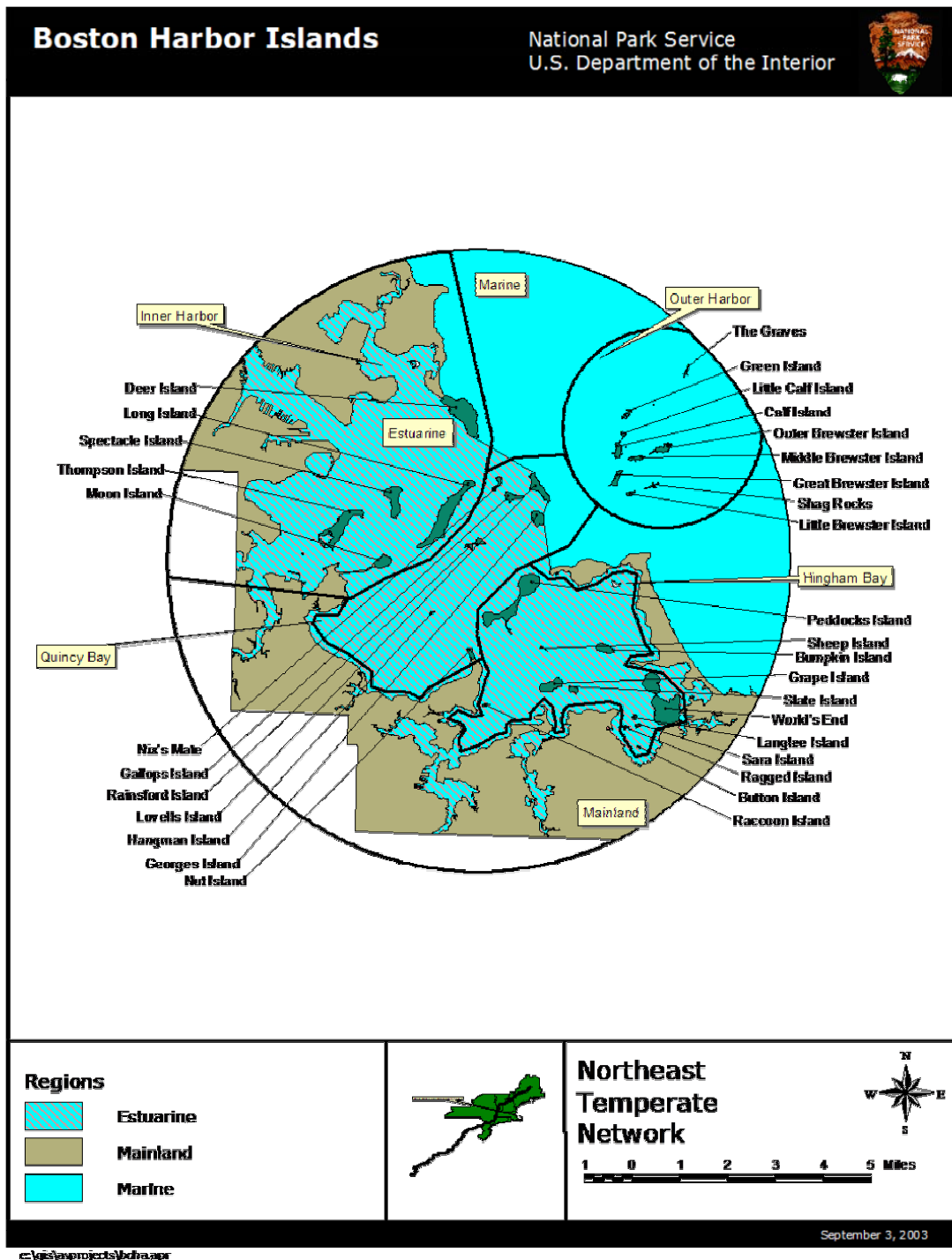


Figure A.5. Location of Boston Harbor Islands.

APPENDIX B: Summary of parks in the NETN

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

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 (Fig. A.6). The park was gifted to the National Park Service by Laurance 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 (Figure A.7). 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 (Fig. A.6). As a unit of the National Park System, the forest will be managed to maintain these unique and distinctive cultural and visual qualities.

APPENDIX B: Summary of parks in the NETN

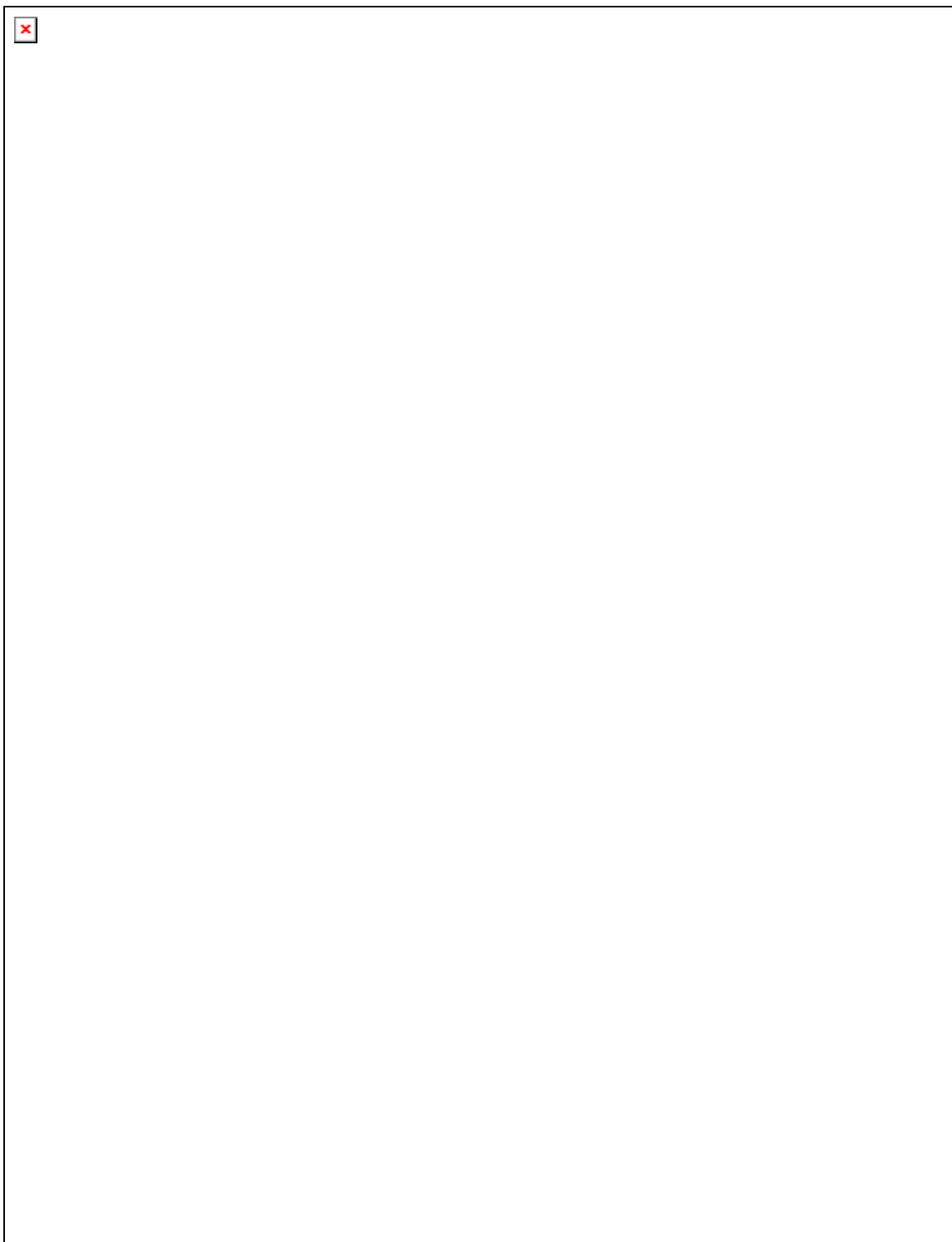


Figure A.6. Hydrography, carriage roads, and vernal pool locations at Marsh-Billings-Rockefeller NHP.

APPENDIX B: Summary of parks in the NETN

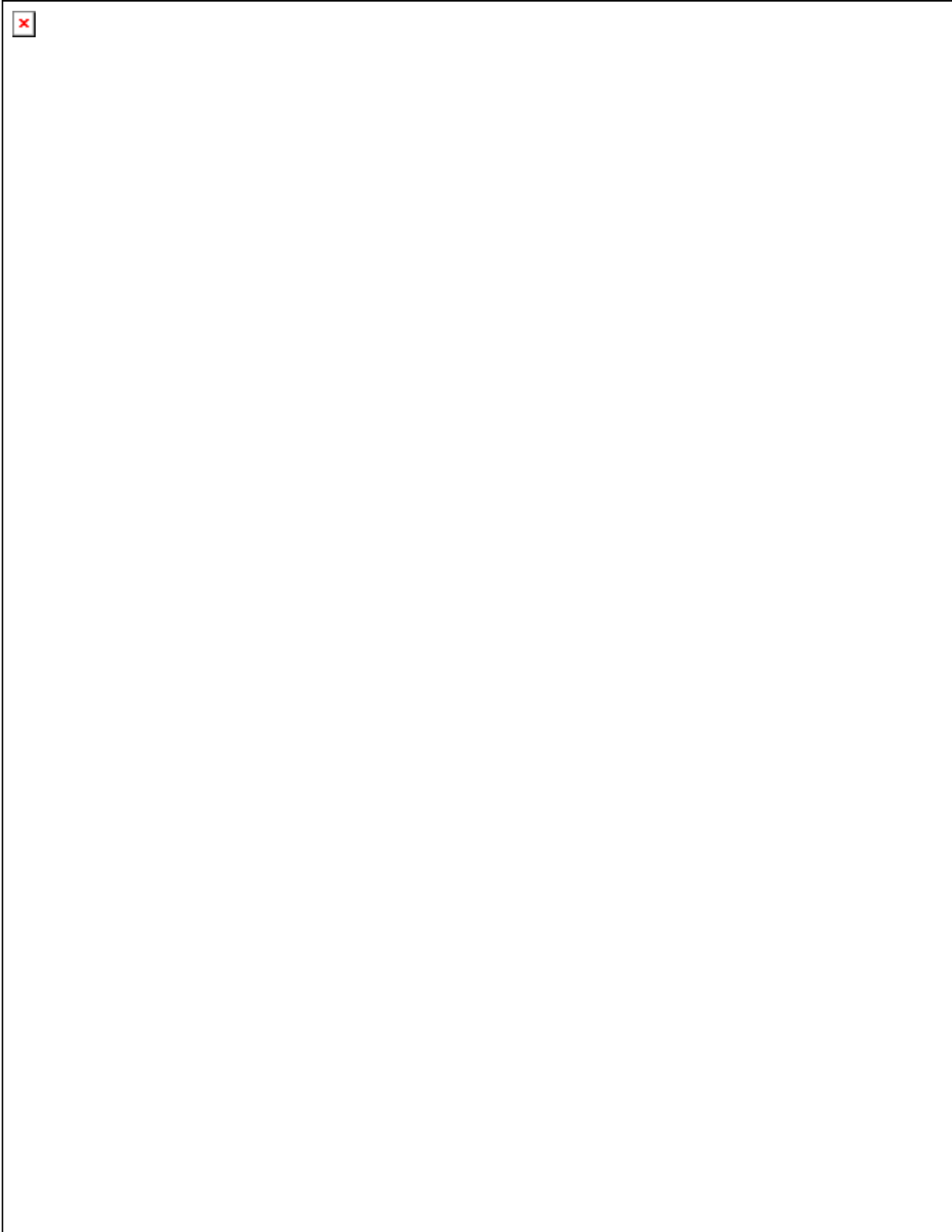


Figure A.7. Land cover types showing plantations and natural stands at Marsh-Billings-Rockefeller NHP.

APPENDIX B: Summary of parks in the NETN

Minute Man National Historical Park (MIMA, Massachusetts)

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 the site of “the shot heard around the world” at the North Bridge (Fig. A.8).

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 (Fig. A.9).

APPENDIX B: Summary of parks in the NETN

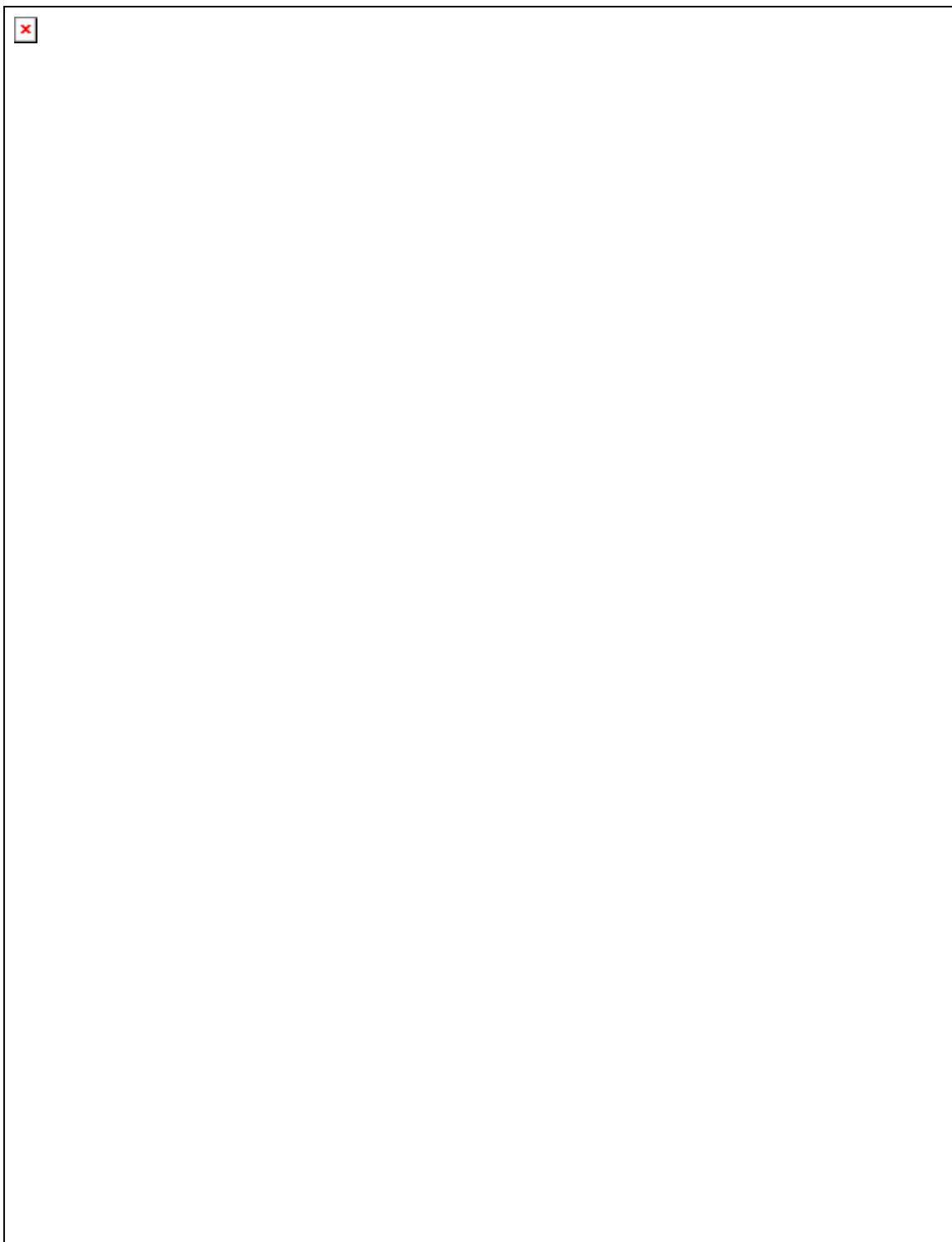


Figure A.8. Hydrography, roads, and the Minute Man NHP boundary.

APPENDIX B: Summary of parks in the NETN

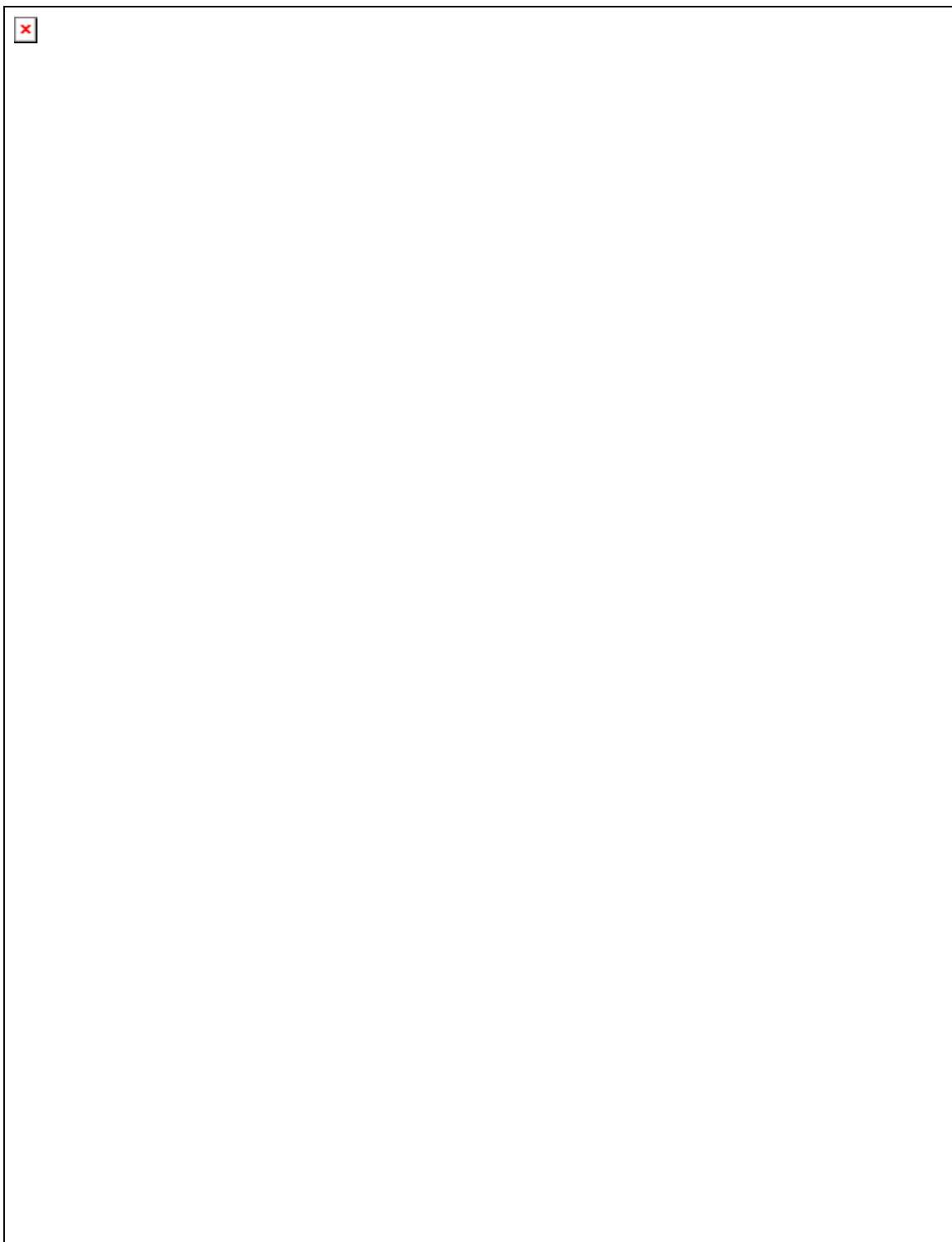


Figure A.9. Invasive plants at the North Bridge Unit of Minute Man NHP.

APPENDIX B: Summary of parks in the NETN

Morristown National Historical Park (MORR, New Jersey)

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 Mifflin 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 Mifflin Unit occupies 35 acres, the Jockey Hollow Encampment, the largest unit, occupies 1,320 acres, and the New Jersey Brigade Unit occupies 321 acres (Fig. A.10). The vegetation of the park is distributed across these units and is dominated by a mix of mowed fields, orchards, planted gardens, and forest stands (Fig. A.11). 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. The park is 80% forest, 10% wetlands and 5% fields.

APPENDIX B: Summary of parks in the NETN

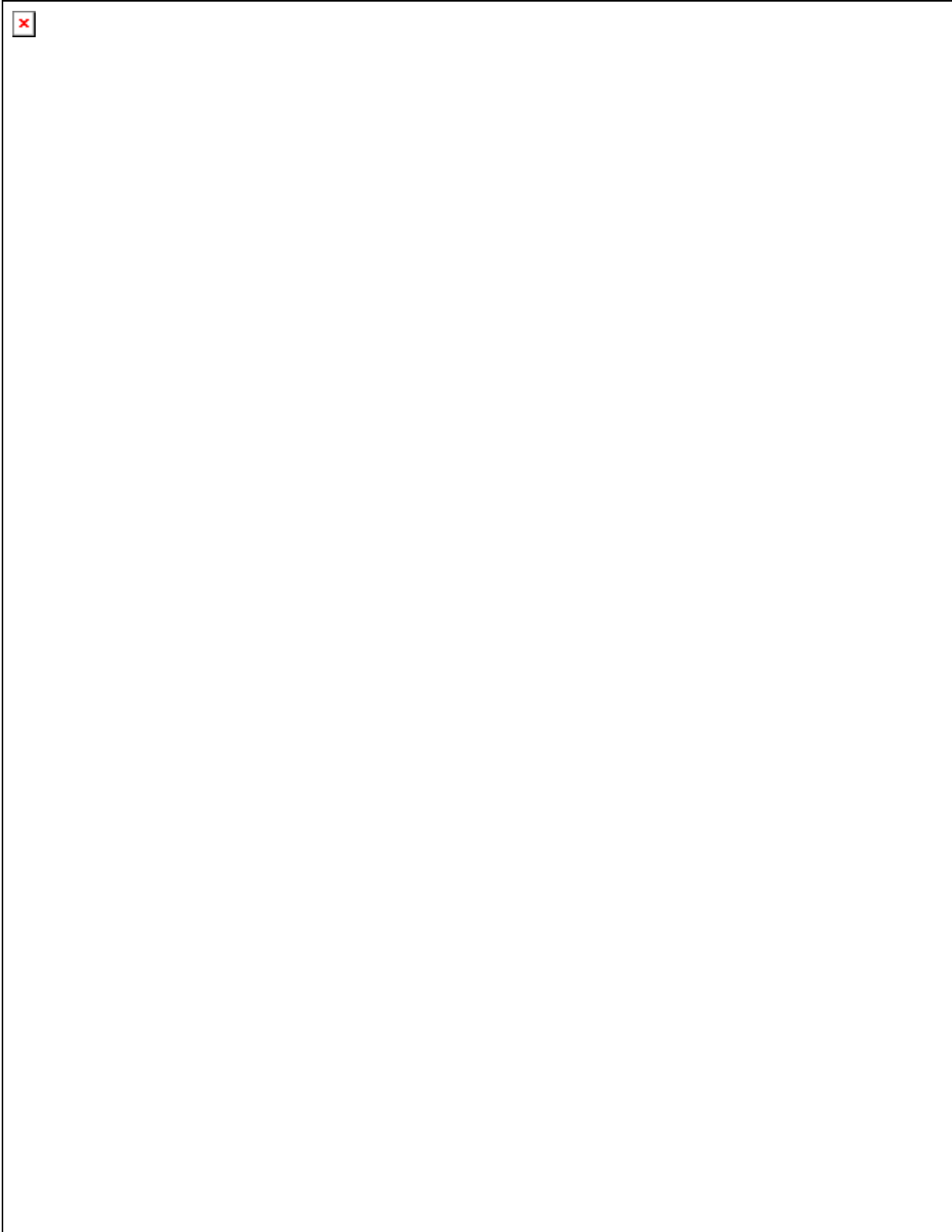


Figure A.10. Hydrography, roads and Morristown NHP boundary (Fort Nonsense Unit not shown)

APPENDIX B: Summary of parks in the NETN

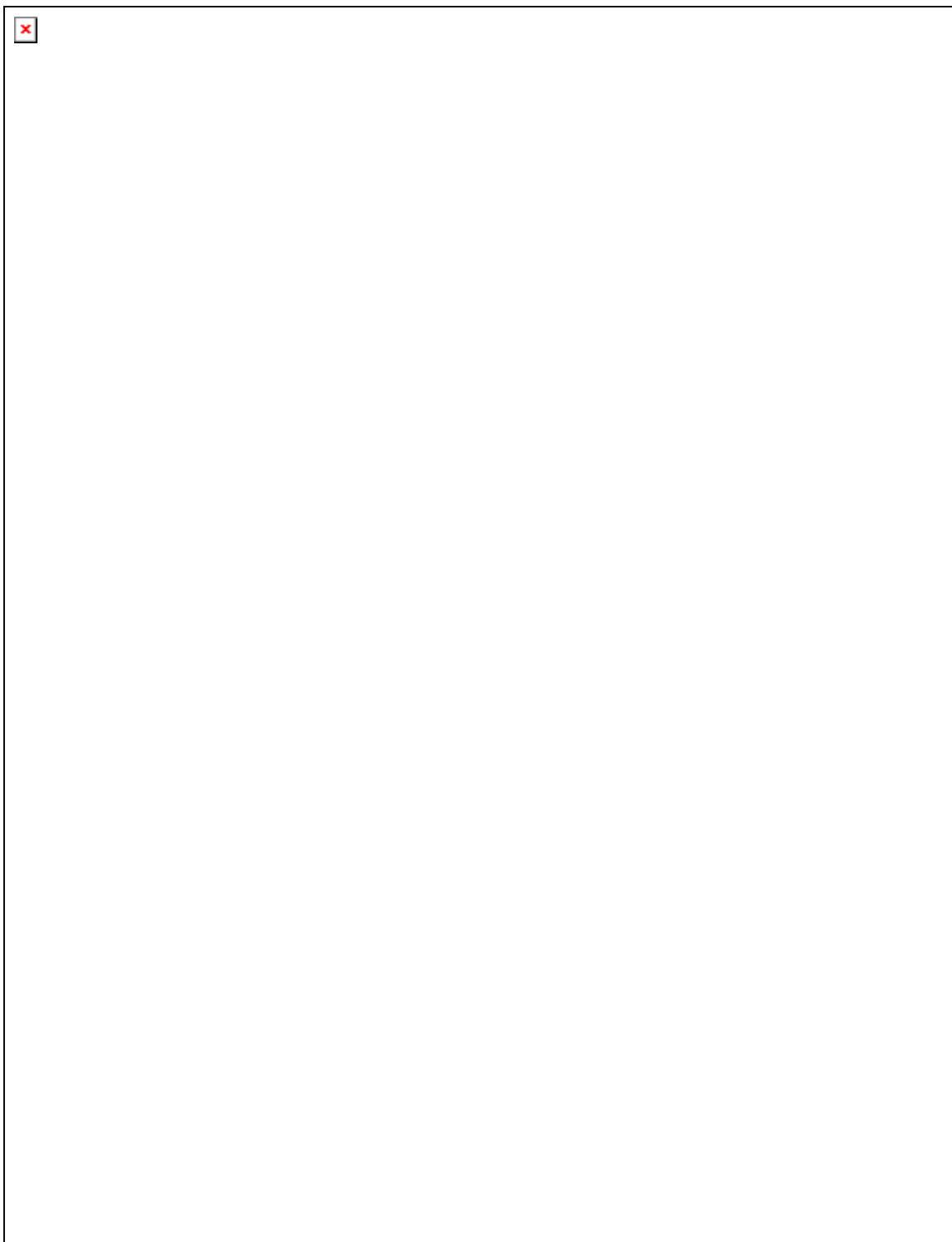


Figure A.11. Basic land cover types for Morristown NHP.

APPENDIX B: Summary of parks in the NETN

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

Roosevelt-Vanderbilt National Historic Sites consists of three sites in Hyde Park, New York, totaling 682 acres. The sites are within three miles of each other, and are located in western Dutchess County in the town of Hyde Park (Fig. A.12). The purposes of the park are to (a) "to explain the significance of these wealthy Americans and the era they represent in the economic, sociological, and cultural history of the United States," (b) "to let present and future generations know what mansion-living was like . . .", and (c) "to illustrate a phase of man's relationship with his environment."

Roosevelt-Vanderbilt NHS hosts a broad array of natural resources located in the Eastern Great Lakes and Hudson Lowlands ecoregion. Both the Home of F.D.R. NHS and Vanderbilt Mansion NHS border on the Hudson River, a freshwater 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 uncommon or lacking in eastern Dutchess County.

The parks include almost 500 acres and have about 500,000 visitors per year. The lands are primarily (55%) forested and include almost 30% wetlands (open water, Hudson River and freshwater tidal marshes). Regionally significant herp populations are found there (16 amphibian and 15 reptile species documented including State Threatened Blanding's turtle (*Emydoidea blandingii*); and plants (- Rare northern population of prickly pear cactus -*Opuntia humiifusa*). The landscape at the Vanderbilt site is nationally significant. Significant threats from exotic species are affecting natural and cultural landscapes, especially Japanese barberry, Japanese knotweed, garlic mustard, tree-of heaven, and black locust. The damming of Fall-Kill Creek by the Roosevelt family in 1925 created an extensive wetlands complex at Eleanor Roosevelt NHS, creating important habitat for many wildlife species including the State-threatened Blanding's Turtle. A series of permanent and seasonal woodland ponds also occur on the site, as well as mature second-growth hardwood forest, numerous rock outcrops, a sphagnum swamp, and a wet sedge meadow. Approximately 4.4 miles of streams, 14 acres of permanent ponds, 40 acres of non-tidal wetlands, and numerous small, unmapped vernal pools and intermittent stream are found in the park. A 25 acre tidal marsh lies between the Home of Franklin D. Roosevelt NHS and the Hudson River (Fig. A.13).

APPENDIX B: Summary of parks in the NETN

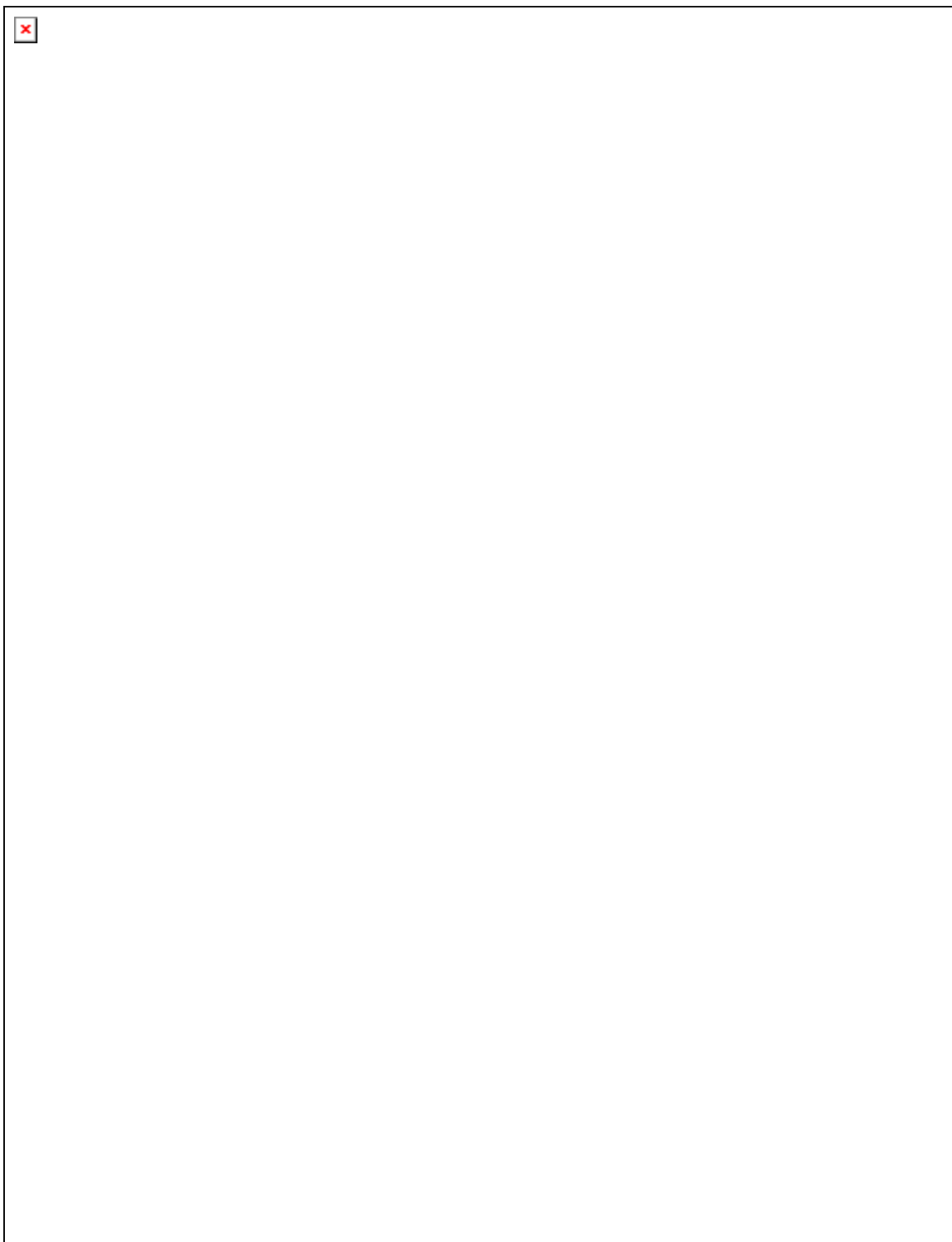


Figure A.12. Road and trails at Roosevelt-Vanderbilt NHS.

APPENDIX B: Summary of parks in the NETN

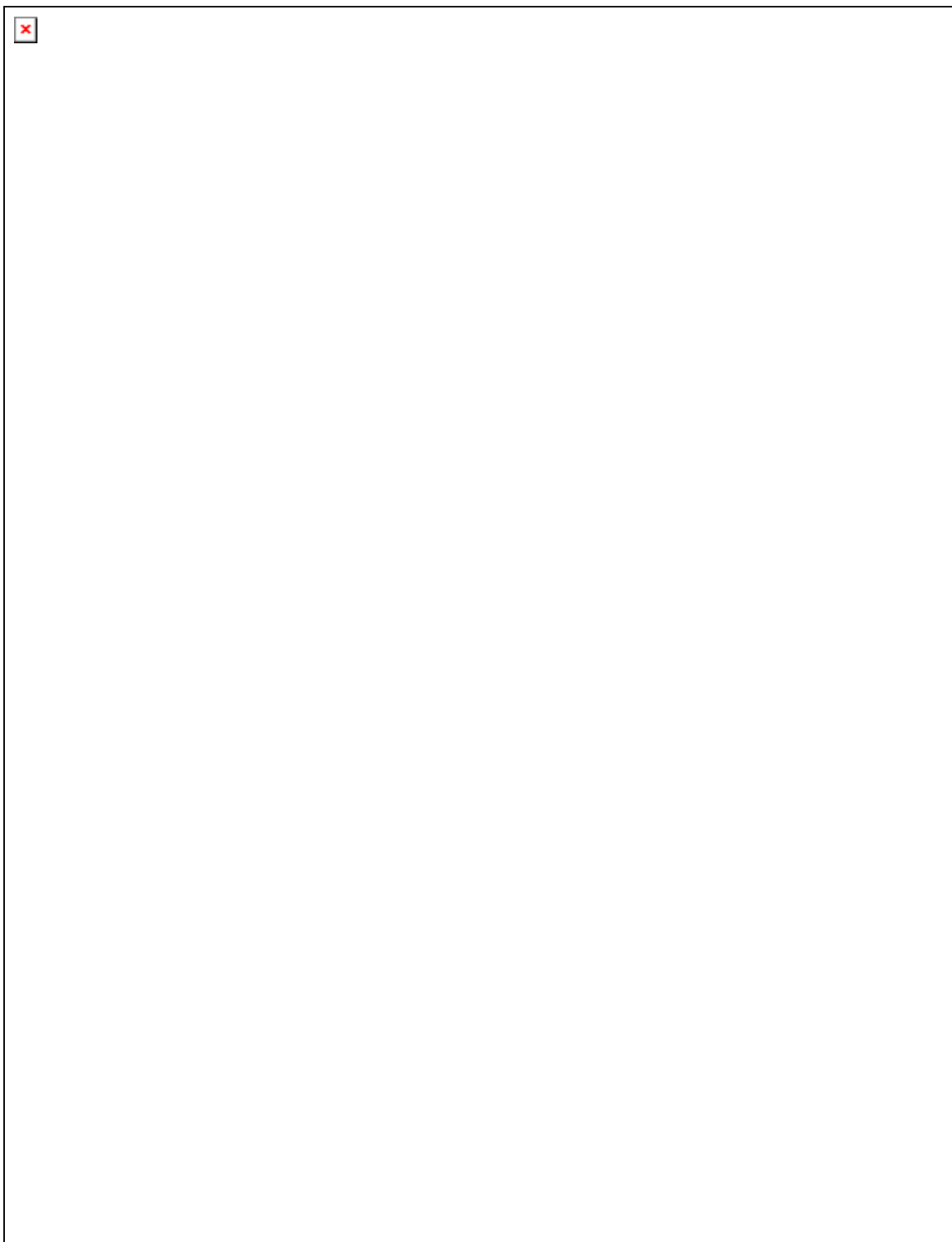


Figure A.13. Vegetation cover for the 3 units of Roosevelt-Vanderbilt NHP.

APPENDIX B: Summary of parks in the NETN

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

Saint-Gaudens National Historic Site consists of 148 acres including 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. Saint-Gaudens National Historic Site was formally established in 1964. Saint-Gaudens lived and worked as an artist in the Cornish Colony from 1885 to 1907 (Cronan, 1981). 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. The terrace slopes 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. Management of the cultural landscape at Saint-Gaudens is an ongoing task and some natural resources may be influenced by such action. 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. Hemlock Woolly Adelgid poses a potential threat to forest resources. There has been encroachment into the forest of exotic tree species. Proliferation of purple loosestrife and potential introduction of other exotics are management concerns with regard to the park's wetlands. The park supports a diverse herp community and is developing long-term monitoring protocols and vernal pool protection strategies.

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 (Figs. A.14 and A.15). 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 up to 7-8 ft by the dam and average 3.8 ft over the pond as a whole

APPENDIX B: Summary of parks in the NETN

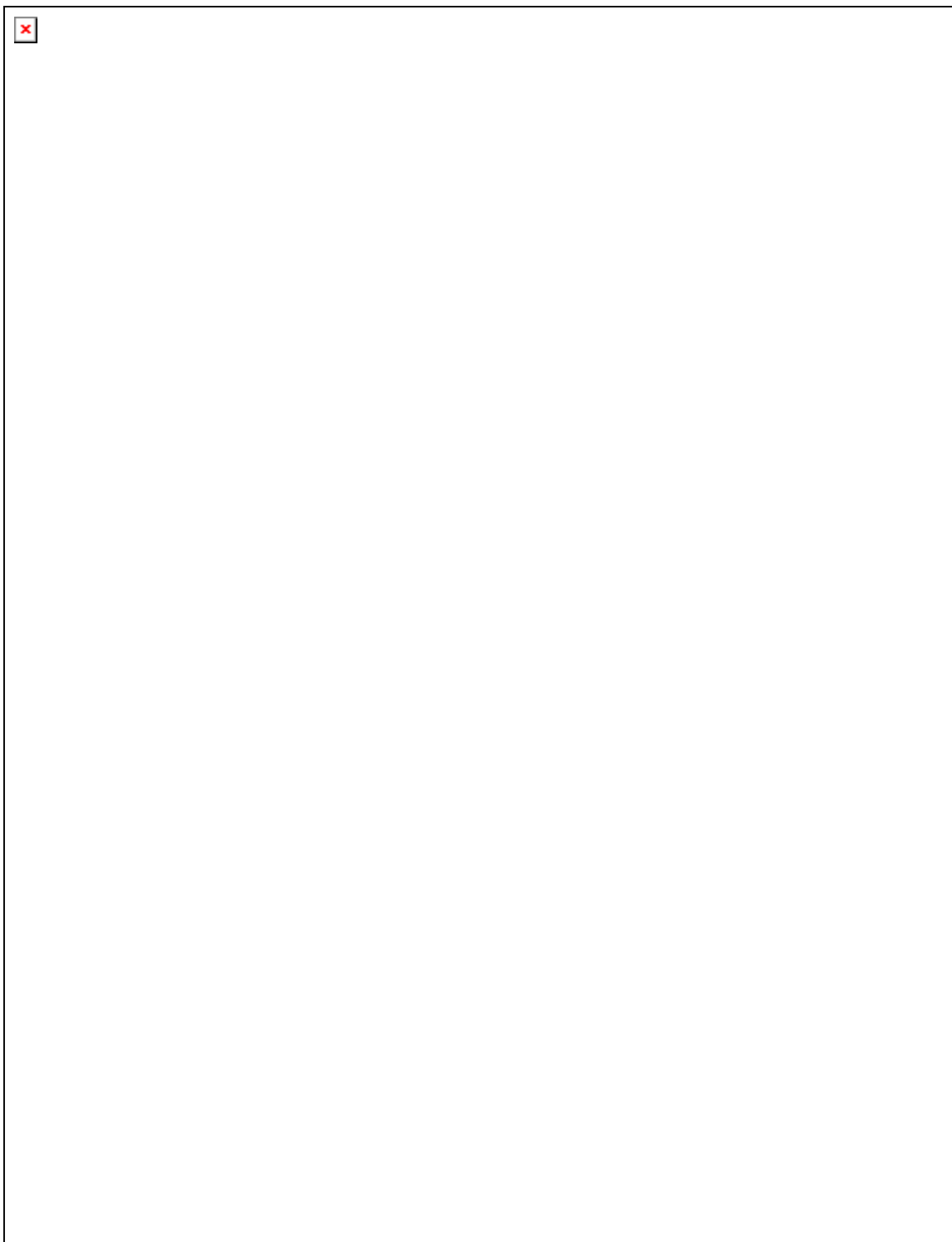


Figure A.14. Surface water, roads, and trails at Saint Gaudens NHP.

APPENDIX B: Summary of parks in the NETN

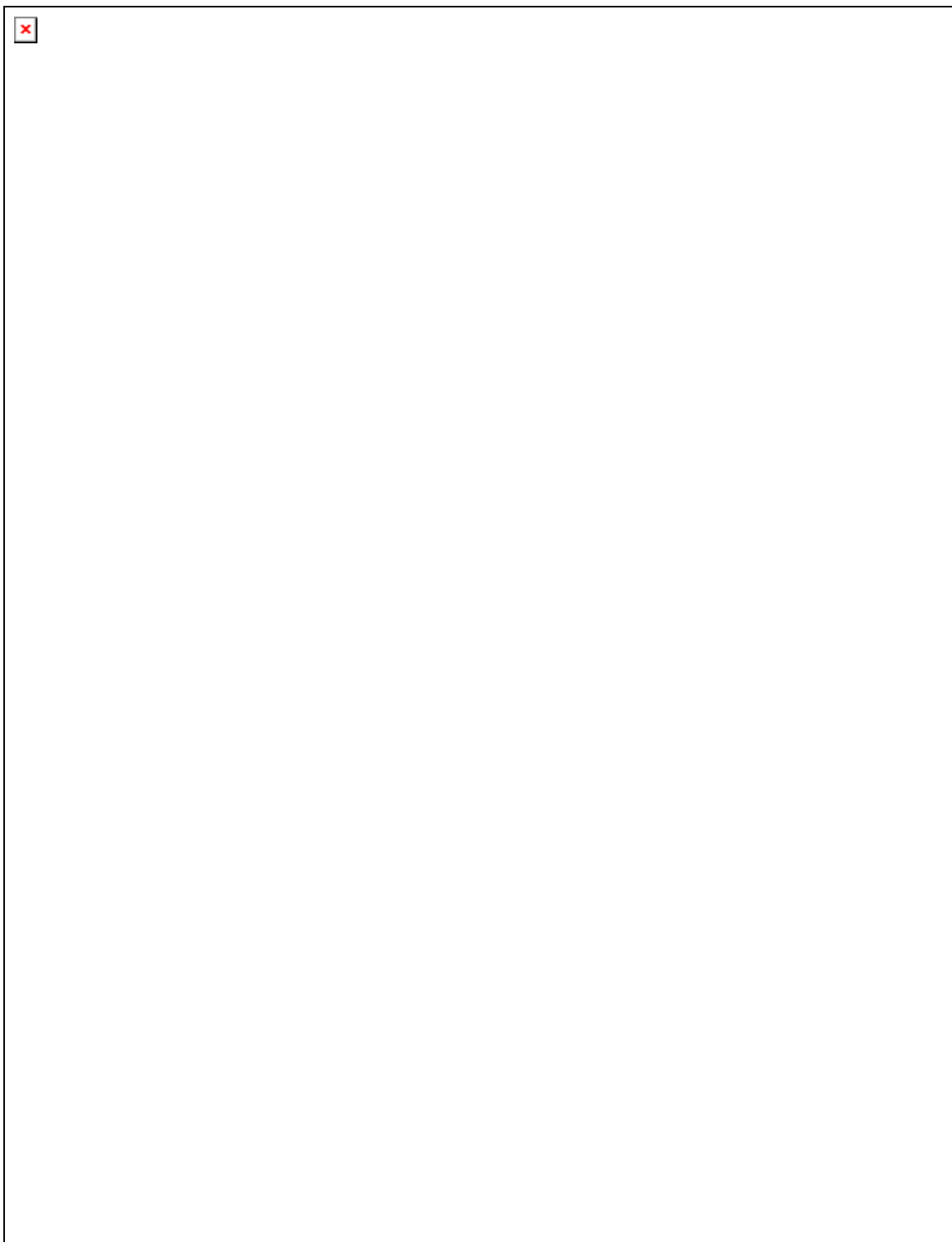


Figure A.15. Wetlands at Saint Gaudens NHP.

APPENDIX B: Summary of parks in the NETN

Saratoga National Historical Park (SARA, New York)

Site of the first significant American military victory during the Revolution, the Battles of Saratoga 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 Americans. The Battlefield was made part of the National Park System in 1938 when Saratoga National Historical Park was authorized. 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 (Fig. A.16), New York, the General Philip Schuyler House eight miles north in Schuylerville and the Saratoga Monument in the nearby village of Victory. Saratoga is near the Adirondack Mountain region where the influence of northern mountain climate is manifested 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 (Fig. A.17). Grasslands comprise 800 acres of the park and are dominated by grasses and forbs and contain the largest number of species in the park (Fig. A.17). These are maintained through prescribed fire and mowing (Stalter et al., 1993) (Fig. A.18). Brush/shrub areas (416 acres) and wetlands (45 acres) make up the rest of the park landscape. The Hudson River floodplain, streams and wet meadows support unique habitats within and around the park. Two sedges are state-listed as threatened species or species of special concern, in addition to an iris (blue-eyed grass), running pine, and woodland agrimoniae. 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 occupy 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. Current vegetation is considered an integral component of the cultural landscape.

APPENDIX B: Summary of parks in the NETN

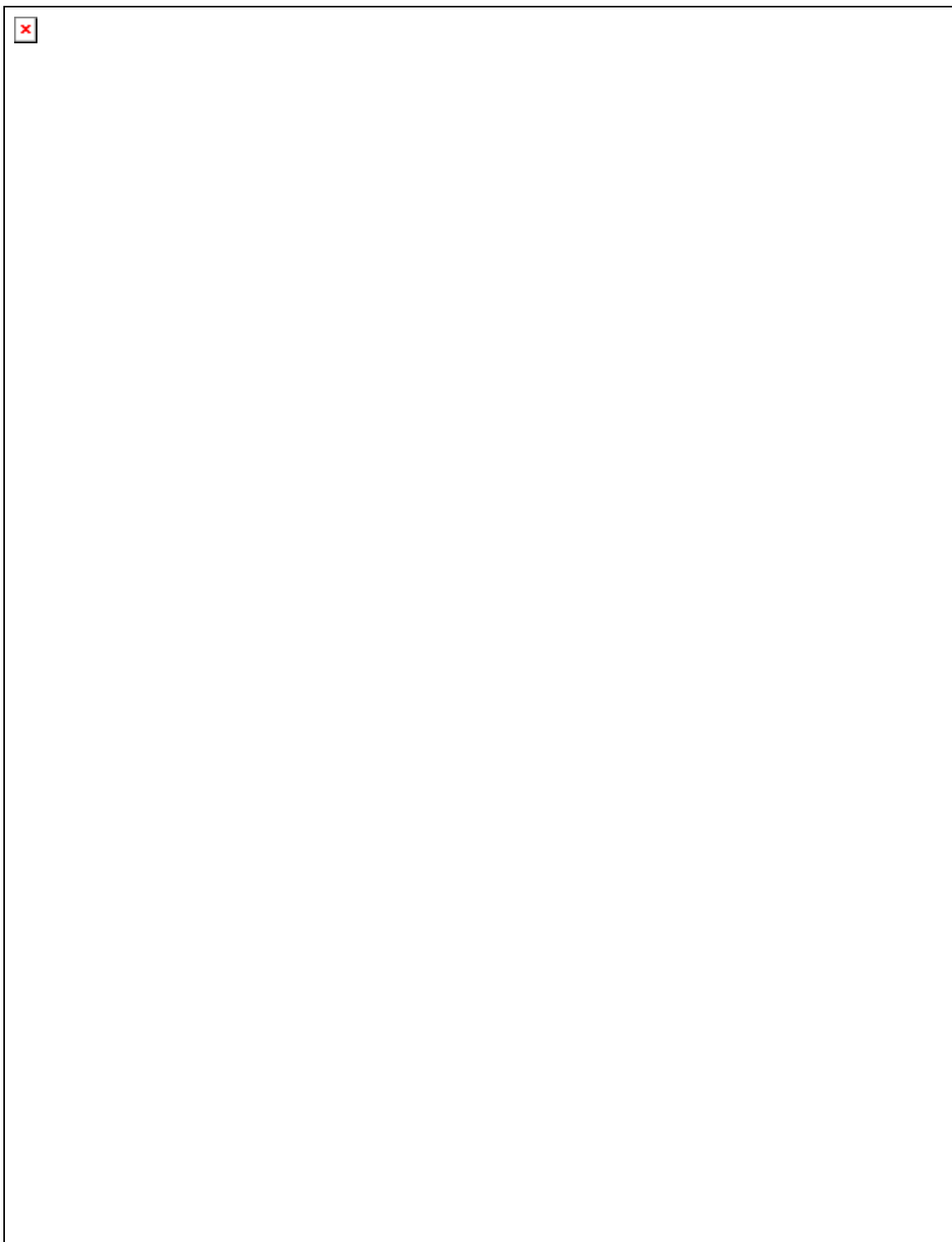


Figure A.16. Surface water and roads at the main battle field unit of Saratoga NHP.

APPENDIX B: Summary of parks in the NETN

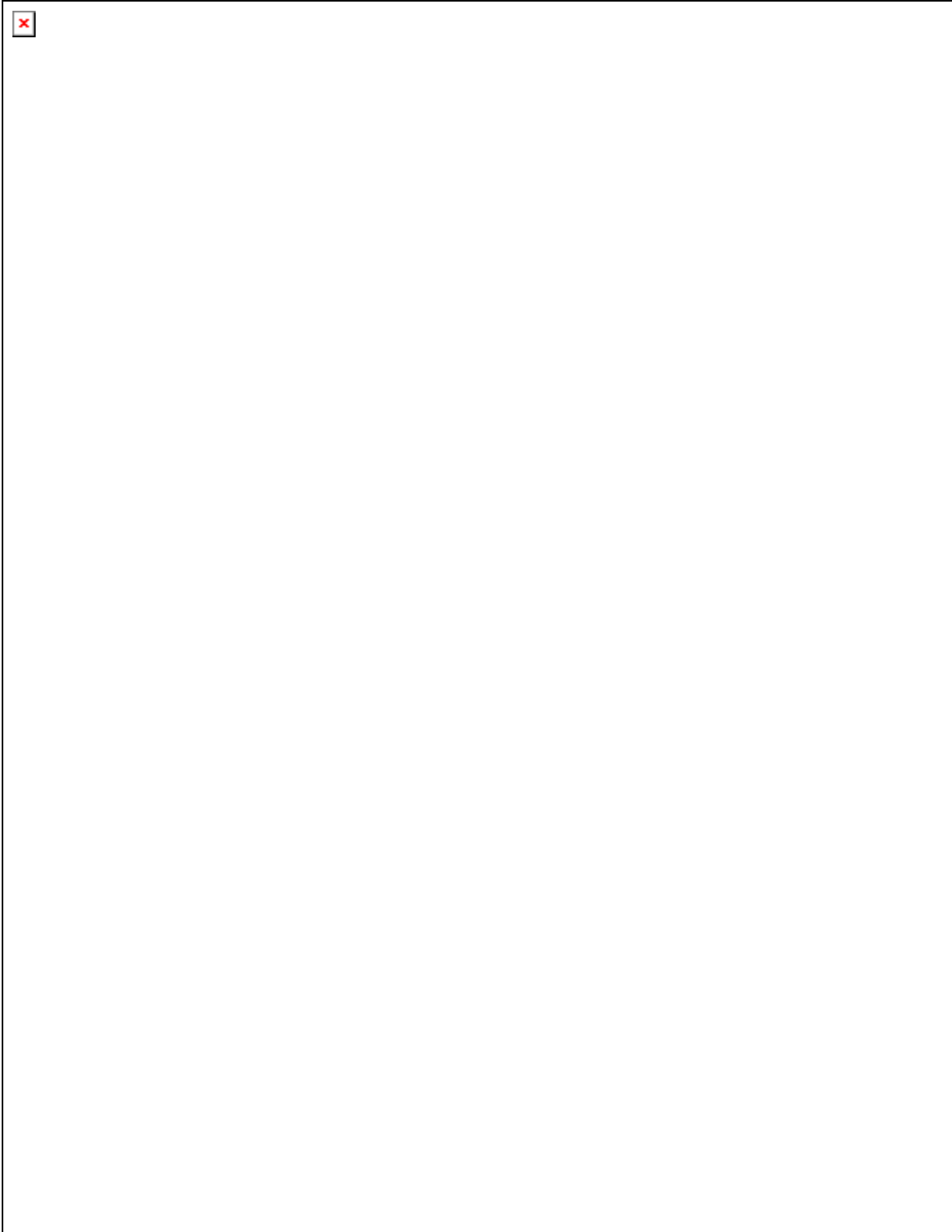


Figure A.17. Vegetation cover at Saratoga NHP.

APPENDIX B: Summary of parks in the NETN

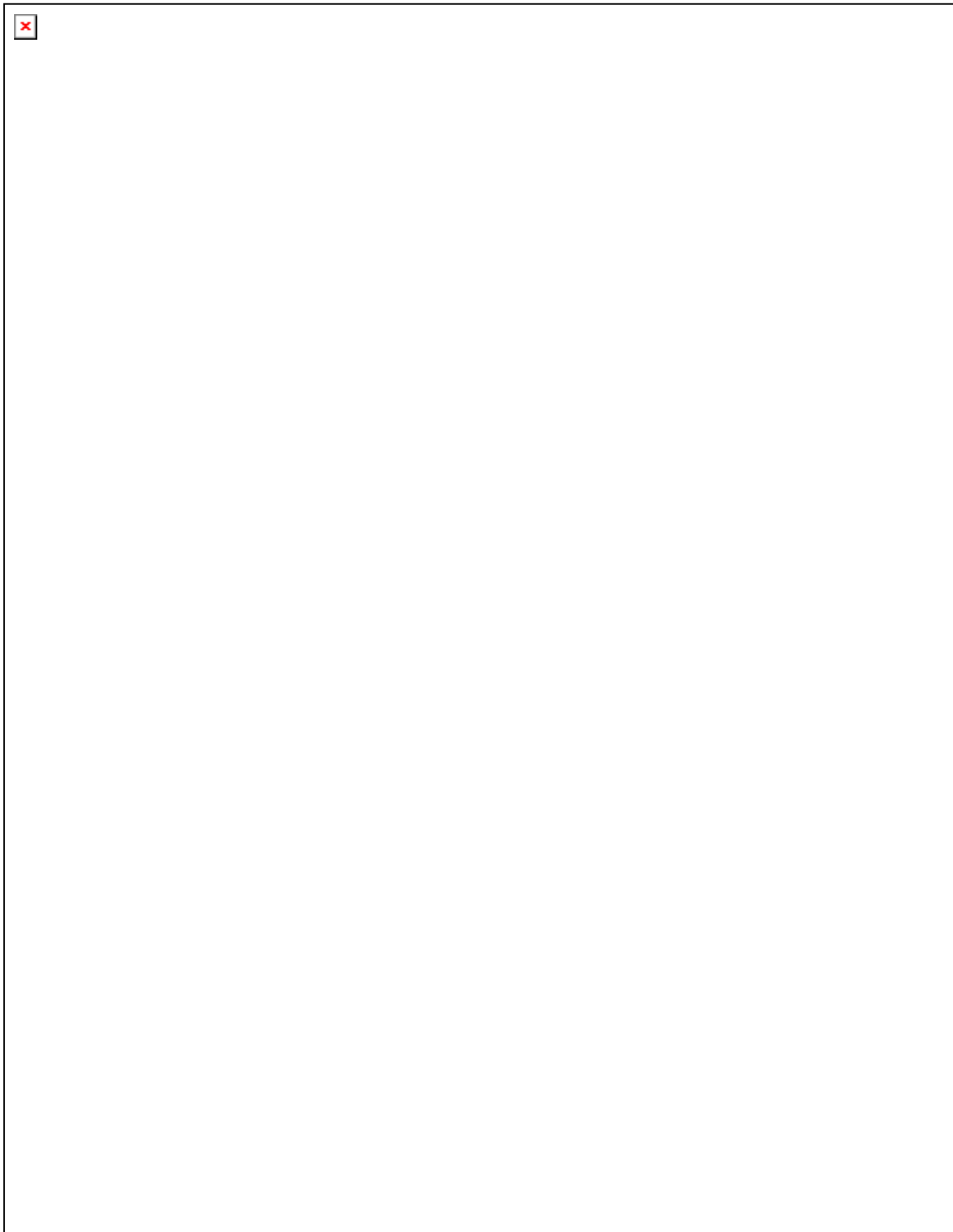


Figure A.18. Prescribed fire management history at Saratoga NHP.

APPENDIX B: Summary of parks in the NETN

Saugus Iron Works National Historic Site (SAIR, Massachusetts)

Saugus Iron Works National Historic Site, established 1968, is 9 acres located on the Saugus River in the Northeastern Coastal Zone ecoregion (Fig. A.19). The Park hosts 25,000 annual visitors. Prominent landscape features were dramatically altered in 1957 when a breached dam caused a massive in-fill of silt to the site's harbor. A wetland marsh, dominated by invasive species, has since grown up around the now channeled river, obscuring the reconstructed harbor and its role in the original iron making operation. Noteworthy natural resources include the floodplain and wetland marsh, the east terrace riparian woodlands and river, the fishery, both smelt and eel are known (Fig. A.20). 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 SAIR's brackish marsh and adjoining areas. The tallest and most invasive 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 a problem.

APPENDIX B: Summary of parks in the NETN

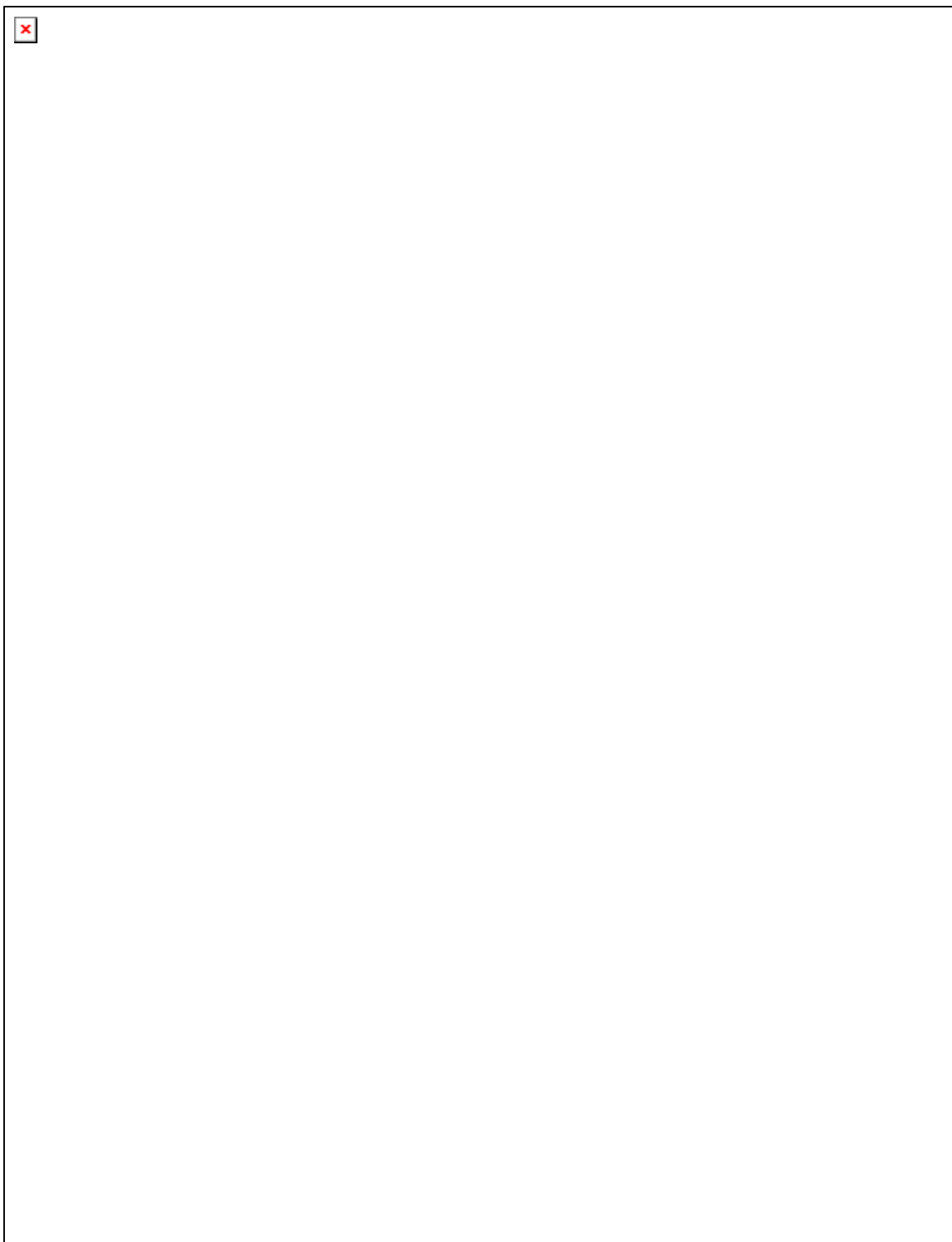


Figure A.19. Boundary, roads, and hydrography of Saugus Iron Works NHP.

APPENDIX B: Summary of parks in the NETN

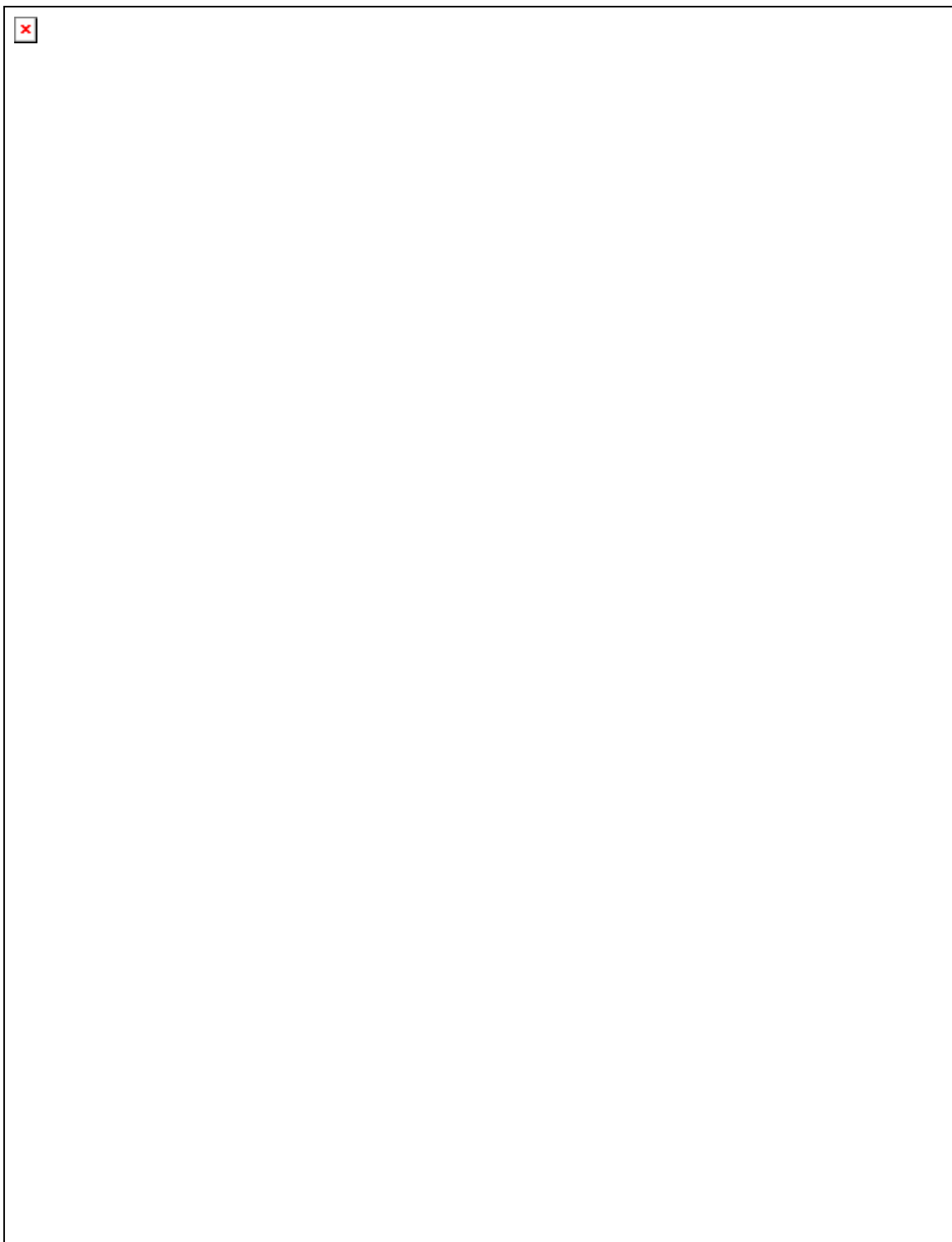


Figure A.20. Basic land cover types of Saugus Iron Works NHP.

APPENDIX B: Summary of parks in the NETN

Weir Farm National Historic Site (WEFA, Connecticut)

Weir Farm National Historical Park, established in 1990, is one of the last intact landscapes associated with American Impressionism (Fig. A.21). It is located in the Northeastern Coastal Zone ecoregion in the southern part of Connecticut. The park is within 25 miles of the Atlantic coast (Long Island Sound). The park contains a number of wetland complexes, mostly defined as palustrine scrub shrub and forested, but a number of intermittent and ephemeral surface streams also occur on the park. Weir Pond, a 3.7 acre, stream and ground water fed, manmade pond is a prominent component of the Parks landscape (Fig. A.22). The Weir Pond Dam, built to create the pond 1896, has become an important management issue in terms of both cultural and natural resources. The most recent inspection of the earthen dam suggests that it may fail if left in its current state (Fox and Zubricki 1995). In 1998, the Brooklyn Botanical Garden located five state listed species of plants at WEFA Farm, but further distribution and abundance information needs to be gathered for these species. A number of invasive species are of some concern as well at the site, including Black Swallowwort (*Vincetoxicum nigrum*), Asiatic bittersweet (*Celastrus orbiculatus*), Japanese Barberry (*Berberis thunbergii*) and Garlic Mustard (*Allaria officinalis*). These species are becoming a serious threat to many natural communities (An ecological Survey of Weir Farm, 1991).

APPENDIX B: Summary of parks in the NETN

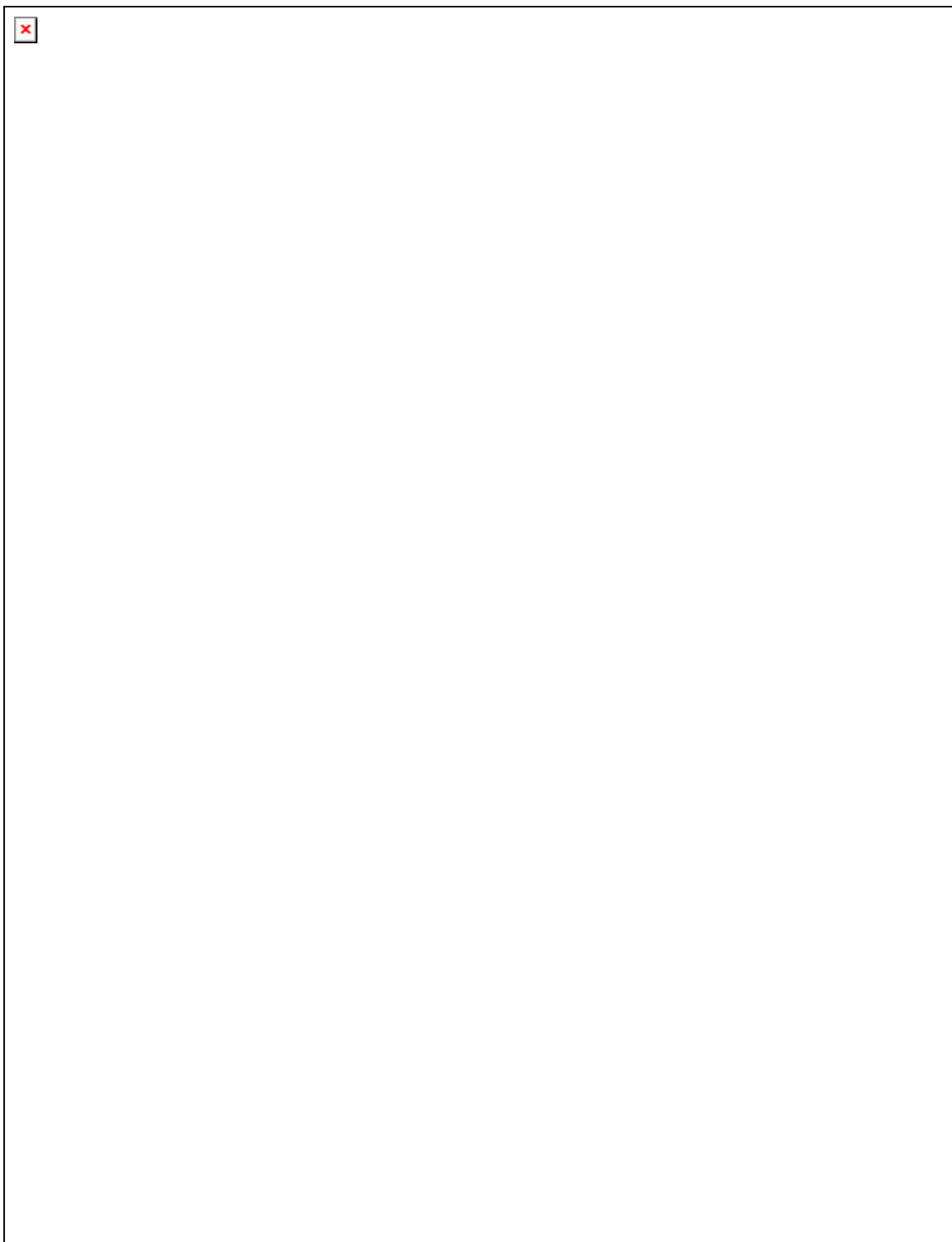


Figure A.21. Boundary, hydrography, and roads at Weir Farm NHP.

APPENDIX B: Summary of parks in the NETN

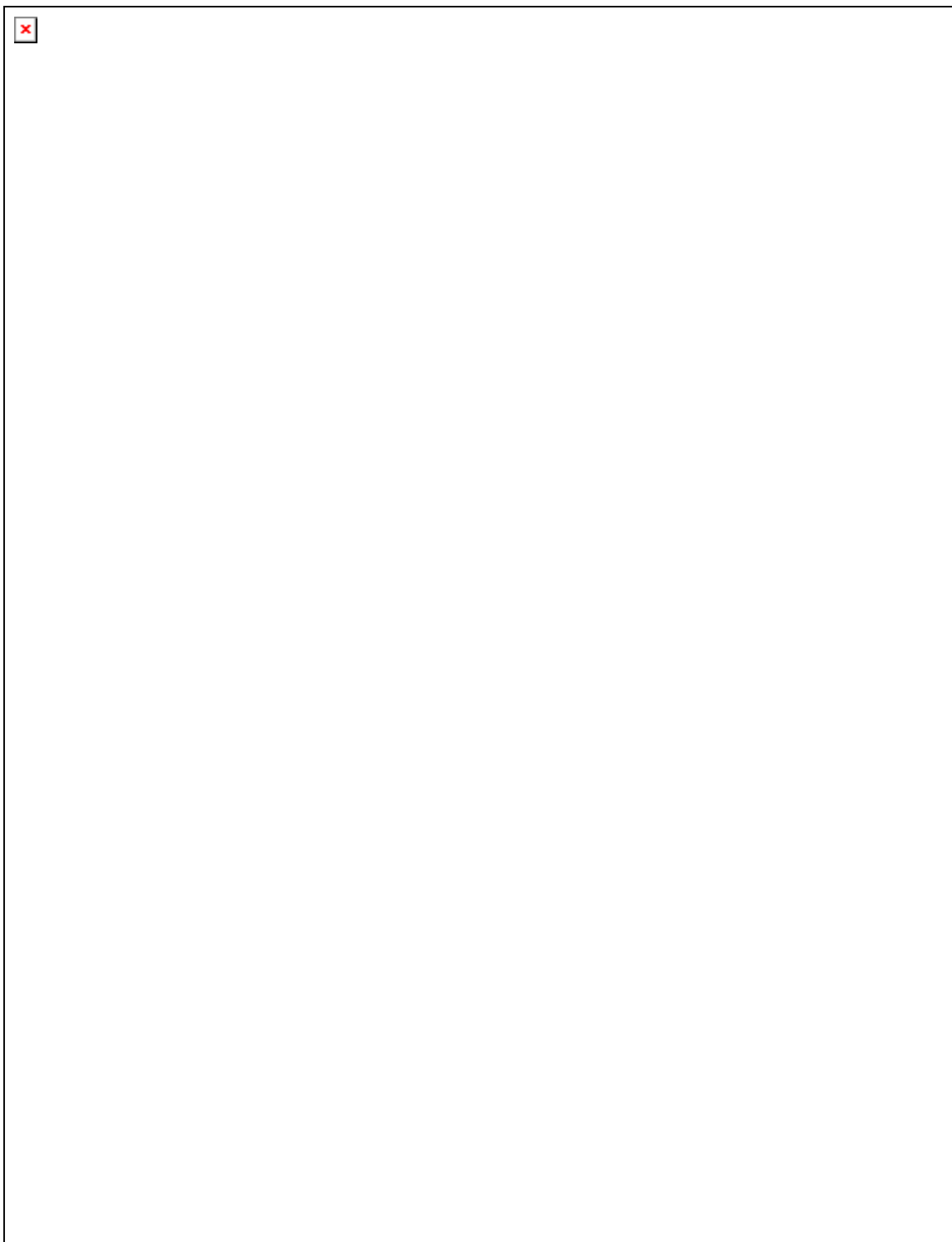


Figure A.22. Basic land cover at Weir Farm NHP.

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

ECOLOGICAL SYSTEM DESCRIPTIONS

CES103.020	Boreal Aspen-Birch Forest	2
CES103.021	Boreal White Spruce-Fir-Hardwood Forest.....	2
CES201.565	Acadian Lowland Spruce-Fir-Hardwood Forest.....	3
CES201.566	Acadian Montane Spruce-Fir-Hardwood Forest.....	4
CES201.571	Laurentian-Acadian Acidic Rocky Outcrop	4
CES201.564	Laurentian-Acadian Northern Hardwoods Forest.....	5
CES201.563	Laurentian-Acadian Pine-Hemlock-Hardwood Forest	6
CES201.719	Laurentian-Acadian White Pine-Red Pine Forest.....	7
CES201.567	Acadian Alpine Barrens.....	8
CES201.568	Acadian Subalpine Woodland and Barrens	9
CES201.573	Acadian-North Atlantic Rocky Coast.....	10
CES201.569	Laurentian-Acadian Acidic Cliff and Talus.....	10
CES201.580	Acadian Maritime Bog	11
CES201.583	Laurentian-Acadian Acidic Basin Fen.....	12
CES201.574	Laurentian-Acadian Acidic Swamp.....	13
CES201.585	Laurentian-Acadian Alkaline Fen.....	13
CES201.575	Laurentian-Acadian Alkaline Swamp.....	14
CES201.578	Acadian Coastal Salt Marsh.....	15
CES201.579	Acadian Estuary Marsh.....	16
CES201.577	Laurentian-Acadian Wet Meadow-Shrub Swamp and Marsh	17
CES201.048	North Atlantic Rocky Intertidal	18
CES201.587	Laurentian-Acadian Floodplain Forest	19
CES201.570	Laurentian-Acadian Calcareous Cliff and Talus.....	20
CES201.586	Laurentian-Acadian Rocky Lakeshore	20
CES201.051	North Atlantic Cobble Shore	21
CES201.050	North Atlantic Intertidal Mudflat.....	22
CES201.049	North Atlantic Tidal Sand Flat.....	22
CES202.593	Appalachian Hemlock-Hardwood Forest	22
CES202.591	Central Appalachian Oak and Pine Forest.....	24
CES202.600	Central Appalachian Pine-Oak Rocky Woodland.....	25
CES202.592	Northeastern Interior Dry Oak Forest.....	26
CES202.604	North-Central Appalachian Acidic Swamp	28
CES202.606	North-Central Interior and Appalachian Acid Peatland.....	29
CES202.605	North-Central Interior and Appalachian Rich Swamp.....	30
CES202.608	Central Appalachian Floodplain	31
CES202.609	Central Appalachian Riparian.....	32
CES202.601	North-Central Appalachian Acidic Cliff and Talus	33
CES202.603	North-Central Appalachian Circumneutral Cliff and Talus.....	34

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

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 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, CEG002463)
- *Pinus banksiana* - *Populus tremuloides* / *Diervilla lonicera* Forest (M, G4G5, Jack Pine - Aspen / Bush-honeysuckle Forest, CEG002518)
- *Populus* (*tremuloides*, *balsamifera*) - (*Betula papyrifera*) - *Picea mariana* / *Alnus viridis* Forest (L, G?, Aspen - Birch - Black Spruce / Green Alder Forest, CEG002514)
- *Populus* (*tremuloides*, *grandidentata*) - *Betula* (*populifolia*, *papyrifera*) Woodland (H, G5, Early Successional Woodland/Forest, CEG006303)
- *Populus tremuloides* - *Betula papyrifera* - (*Acer rubrum*, *Populus grandidentata*) Forest (H, G5, Aspen - Birch - Red Maple Forest, CEG002467)
- *Populus tremuloides* - *Betula papyrifera* / (*Abies balsamea*, *Picea glauca*) Forest (L, G5, Aspen - Birch / Boreal Conifer Forest, CEG002466)

SOURCES

References: Eyre 1980

Last updated: 25 Mar 2003

Concept Author: D. Faber-Langendoen

Stakeholders: MCS, ECS, CAN

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 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.

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

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, CEG002474)
- *Picea glauca* - *Abies balsamea* - *Populus tremuloides* / Mixed Herbs Forest (H, G5, Spruce - Fir - Aspen Forest, CEG002475)
- *Picea glauca* - *Abies balsamea* / *Acer spicatum* / *Rubus pubescens* Forest (H, G4G5, Spruce - Fir / Mountain Maple Forest, CEG002446)
- *Picea mariana* - *Populus tremuloides* / Mixed Herbs Forest (M, G4G5, Black Spruce - Aspen Rich Forest, CEG002516)
- *Picea mariana* / *Pleurozium schreberi* Forest (M, G5, Black Spruce / Feathermoss Forest, CEG002447)

SOURCES

Last updated: 25 Mar 2003

Concept Author: D. Faber-Langendoen

Stakeholders: MCS, ECS, CAN

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.

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, CEG002516)
- *Picea mariana* / *Pleurozium schreberi* Forest (L, G5, Black Spruce / Feathermoss Forest, CEG002447)
- *Picea rubens* - *Abies balsamea* - *Betula papyrifera* Forest (H, G?, Low-Elevation Spruce - Fir Forest, CEG006273)
- *Picea rubens* - *Abies balsamea* - *Betula* spp. - *Acer rubrum* Forest (H, G?, Successional Spruce - Fir Forest, CEG006505)
- *Picea rubens* - *Picea glauca* Forest (H, G4G5, Maritime Spruce - Fir Forest, CEG006151)

SOURCES

References: Lorimer 1977

Last updated: 24 Mar 2003

Concept Author: S.C. Gawler

Stakeholders: ECS, MCS

LeadResp: ECS

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

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, CEG006112)
- *Picea rubens* - *Abies balsamea* - *Betula* spp. - *Acer rubrum* Forest (G?, Successional Spruce - Fir Forest, CEG006505)
- *Picea rubens* - *Abies balsamea* / *Sorbus americana* Forest (G3G5, Montane Spruce - Fir Forest, CEG006128)
- *Picea rubens* - *Betula alleghaniensis* / *Dryopteris campyloptera* Forest (G?, Red Spruce - Hardwoods Forest, CEG006267)

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

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

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

CONCEPT

Associations:

- (Pinus strobus, Quercus rubra) / Danthonia spicata Acid Bedrock Wooded Herbaceous Vegetation (G3G4, White Pine - Red Oak Bedrock Glade, CEGLO05101)
- Danthonia spicata - Poa compressa Granite Herbaceous Vegetation (G?, Poverty Grass Granite Barrens, CEGLO05157)
- Juniperus communis - (Quercus rubra) / Juniperus horizontalis - Arctostaphylos uva-ursi Shrubland (G3G4, Common Juniper Rocky Krummholz, CEGLO05065)
- Picea rubens / Vaccinium angustifolium / Sibbaldiopsis tridentata Woodland (G3G5, Spruce - Fir Rocky Ridge, CEGLO06053)
- Pinus banksiana - Pinus strobus - (Quercus rubra) / Cladina spp. Nonvascular Vegetation (M, G3G5, Mixed Pine - (Oak) Igneous - Metamorphic Rock Outcrop, CEGLO02491)
- Pinus banksiana / (Quercus rubra, Quercus ellipsoidalis) Forest (M, G4?, Jack Pine / Scrub Oak Forest, CEGLO02440)
- Pinus banksiana / Kalmia angustifolia - Vaccinium spp. Woodland (G3G5, Jack Pine Heath Barren, CEGLO06041)
- Pinus resinosa / Gaylussacia baccata - Vaccinium angustifolium Woodland (G3G5, Red Pine Woodland, ceglo06010)
- Pinus rigida - Quercus (coccinea, velutina) / Schizachyrium scoparium Woodland (M, G3G5, CEGLO06166)
- Pinus rigida / Corema conradii Woodland (M, G2, Coastal Pitch Pine Rocky Woodland, CEGLO06154)
- Pinus rigida / Photinia melanocarpa / Deschampsia flexuosa - Schizachyrium scoparium Woodland (G?, Pitch Pine Rocky Summit, CEGLO06116)
- Populus tremuloides - (Populus grandidentata) Rocky Woodland (G?, Mixed Aspen Rocky Woodland, CEGLO02487)
- Quercus ellipsoidalis - Quercus macrocarpa - (Pinus banksiana) Rocky Woodland (G?, Boreal Oak - (Pine) Rocky Woodland, CEGLO05246)
- Quercus rubra - (Quercus prinus) / Vaccinium spp. / Deschampsia flexuosa Woodland (G3G5, Appalachian Red Oak Woodland (Northern Type), CEGLO06134)
- Vaccinium angustifolium - Sorbus americana / Sibbaldiopsis tridentata Dwarf-shrubland (G?, Blueberry Granite Barrens, CEGLO05094)

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

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

CONCEPT

Associations:

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

Concept Author: S.C. Gawler

Stakeholders: ECS, MCS

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 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)

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

- *Acer rubrum* - *Nyssa sylvatica* - *Betula alleghaniensis* / *Sphagnum* spp. Forest (G?, Red Maple - Black Gum Basin Swamp, CEG006014)
- *Acer saccharum* - *Pinus strobus* / *Acer pensylvanicum* Forest (G?, Northern Hardwood - White Pine Forest, CEG005005)
- *Betula alleghaniensis* - *Acer rubrum* - (*Tsuga canadensis*, *Abies balsamea*) / *Osmunda cinnamomea* Forest (G4?, Hardwood - Conifer Seepage Forest, CEG006380)
- Clay Seeps Sparse Vegetation (G?, Clay Seeps, CEG005163)
- *Pinus strobus* - (*Pinus resinosa*) - *Quercus rubra* Forest (G4G5, White Pine - Red Oak Forest, CEG002480)
- *Pinus strobus* - *Quercus* (*rubra*, *velutina*) - *Fagus grandifolia* Forest (G5, White Pine - Oak Forest, CEG006293)
- *Pinus strobus* - *Quercus alba* / (*Corylus americana*, *Gaylussacia baccata*) Forest (G3, White Pine - White Oak Sand Forest, CEG002481)
- *Pinus strobus* - *Tsuga canadensis* - *Picea rubens* Forest (G?, White Pine - Hemlock - Red Spruce Forest, CEG006324)
- *Pinus strobus* - *Tsuga canadensis* Great Lakes Forest (G3, Great Lakes White Pine - Hemlock Forest, CEG002590)
- *Pinus strobus* / *Acer spicatum* - *Corylus cornuta* Forest (G3G4, White Pine / Mountain Maple Mesic Forest, CEG002445)
- *Quercus rubra* - *Acer rubrum* - *Betula* spp. - *Pinus strobus* Forest (G?, Northern Oak - Pine Forest, CEG006506)
- *Quercus rubra* - *Acer saccharum* - *Fagus grandifolia* / *Viburnum acerifolium* Forest (G?, Red Oak - Northern Hardwood Forest, CEG006173)
- *Quercus rubra* - *Acer saccharum* - *Liriodendron tulipifera* Forest (G?, High Allegheny Rich Red Oak - Sugar Maple Forest, CEG006125)
- *Quercus rubra* - *Acer saccharum* Forest (G4G5, Northern Red Oak - Sugar Maple Forest, CEG002461)
- *Quercus rubra* - *Quercus alba* - (*Quercus velutina*, *Acer rubrum*) / *Viburnum acerifolium* Forest (G?, Northern Red Oak - White Oak - (Maple) Forest, CEG002462)
- *Symplocarpus foetidus* Herbaceous Vegetation (G4?, Skunk Cabbage Seepage Meadow, CEG002385)
- *Thuja occidentalis* - (*Betula alleghaniensis*, *Tsuga canadensis*) Forest (G3?, White-cedar - (Hemlock) Mesic Forest, CEG002595)
- *Tsuga canadensis* - (*Betula alleghaniensis*) - *Picea rubens* / *Cornus canadensis* Forest (G?, Hemlock - Spruce - Hardwood Forest, CEG006129)
- *Tsuga canadensis* - (*Betula alleghaniensis*) Forest (G3G4, Hemlock Mesic Forest, CEG002598)
- *Tsuga canadensis* - *Acer saccharum* - *Betula alleghaniensis* Forest (G4?, North Central Hemlock - Hardwood Forest, CEG005044)
- *Tsuga canadensis* - *Fagus grandifolia* - (*Acer saccharum*) Great Lakes Forest (G4G5, Great Lakes Hemlock - Beech - Hardwood Forest, CEG005042)
- *Tsuga canadensis* - *Fagus grandifolia* - *Acer saccharum* / (*Hamamelis virginiana*, *Kalmia latifolia*) Forest (G3?, East-central Hemlock Hardwood Forest, CEG005043)

SOURCES

References: Comer and Albert 1997, Comer et al. 1995a, Comer et al. 1998, Whitney 1984

Last updated: 09 Jan 2003

Concept Author: S.C. Gawler

Stakeholders: ECS, MCS

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:

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

CONCEPT

Associations:

- *Pinus resinosa* - *Populus tremuloides* / *Diervilla lonicera* - *Vaccinium* spp. Forest (H, G?, Red Pine - Aspen - Birch Forest, CEG L002520)
- *Pinus resinosa* / *Vaccinium* spp. Forest (H, G3, Red Pine / Blueberry Dry Forest, CEG L002443)
- *Pinus strobus* - *Populus tremuloides* / *Corylus cornuta* Forest (H, G4?, White Pine - Aspen - Birch Forest, CEG L002479)
- *Pinus strobus* - *Tsuga canadensis* - *Picea rubens* Forest (M, G?, White Pine - Hemlock - Red Spruce Forest, CEG L006324)
- *Pinus strobus* / *Acer spicatum* - *Corylus cornuta* Forest (H, G3G4, White Pine / Mountain Maple Mesic Forest, CEG L002445)
- *Pinus strobus* / *Vaccinium* spp. Forest (H, G3G4, White Pine / Blueberry Dry-Mesic Forest, CEG L002444)

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 Gaspé 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 Gaspé.

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, CEG L006081)
- *Diapensia lapponica* Dwarf-shrubland (G2G3, Windswept Alpine Ridge, CEG L006322)
- *Empetrum nigrum* - *Vaccinium uliginosum* - *Vaccinium oxycoccos* / *Rubus chamaemorus* Dwarf-shrubland (G?, Black Crowberry Wet Alpine Bog, CEG L006140)
- *Kalmia angustifolia* - *Chamaedaphne calyculata* / *Rubus chamaemorus* / *Cladina* spp. Dwarf-shrubland (G?, CEG L006425)
- Lichen Fellfield Sparse Vegetation [Provisional] (G?, Lichen Fellfield, CEG L006420)
- *Trichophorum caespitosum* - *Calamagrostis pickeringii* Herbaceous Vegetation (G?, CEG L006423)
- *Trichophorum caespitosum* - *Carex scirpoidea* - *Carex bigelowii* Herbaceous Vegetation (G?, CEG L006424)
- *Trichophorum caespitosum* - *Saxifraga (foliolosa, paniculata, rivularis)* Herbaceous Vegetation (G?, Northern Appalachian Alpine Cliff, CEG L006428)
- *Vaccinium uliginosum* - *Harrimanella hypnoides* - *Loiseleuria procumbens* Dwarf-shrubland (G2G3, Alpine Heath Snowbank, CEG L006155)
- *Vaccinium uliginosum* - *Rhododendron lapponicum* / *Juncus trifidus* Dwarf-shrubland (G2G3, Alpine Heath Meadow, CEG L006298)

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

SOURCES

References: Bliss 1963, Kimball and Weihrauch 2000, Sperduto and Cogbill 1999

Last updated: 09 Jan 2003

Concept Author: S.C. Gawler

Stakeholders: ECS

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 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 Gaspé, 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, CEG006112)
- *Empetrum nigrum* - *Vaccinium uliginosum* - *Vaccinium oxycoccos* / *Rubus chamaemorus* Dwarf-shrubland (G?, Black Crowberry Wet Alpine Bog, CEG006140)
- *Kalmia angustifolia* - *Chamaedaphne calyculata* / *Rubus chamaemorus* / *Cladina* spp. Dwarf-shrubland (G?, CEG006425)
- *Picea mariana* - *Abies balsamea* / *Sibbaldiopsis tridentata* Shrubland (G?, Black Spruce Krummholz, CEG006038)
- *Picea mariana* / *Kalmia angustifolia* Dwarf-shrubland (G?, Subalpine Summit Heath, CEG006031)
- *Picea mariana* / *Ledum groenlandicum* - *Empetrum nigrum* / *Cladina* spp. Dwarf-shrubland (G3G5, Cold Air Talus Heathland, CEG006268)
- *Picea rubens* / *Vaccinium angustifolium* / *Sibbaldiopsis tridentata* Woodland (G3G5, Spruce - Fir Rocky Ridge, CEG006053)

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

SOURCES

References: Sperduto and Cogbill 1999

Last updated: 09 Jan 2003

Concept Author: S.C. Gawler

Stakeholders: ECS

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

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, CEG006106)
- *Morella pensylvanica* - *Empetrum nigrum* Dwarf-shrubland (G?, Crowberry - Bayberry Maritime Shrubland, CEG006510)
- *Morella pensylvanica* - *Prunus maritima* Shrubland (G4, Northern Bayberry Dune Shrubland, CEG006295)
- *Prunus serotina* - *Rhus typhina* Shrubland (G?, Rocky Headland, CEG006399)
- *Solidago sempervirens* - (*Rhodiola rosea*) - *Juniperus horizontalis* Sparse Vegetation (G?, Northern Maritime Rocky Headlands, CEG006529)

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 (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*.

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

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

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)

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

- *Picea mariana* / (*Vaccinium corymbosum*, *Gaylussacia baccata*) / *Sphagnum* sp. Woodland (G3G5, Black Spruce Woodland Bog, CEG L006098)
- *Picea mariana* / *Rubus chamaemorus* / *Sphagnum* spp. Woodland (G3G5, Coastal Black Spruce Woodland Bogs, CEG L006082)
- *Trichophorum caespitosum* - *Gaylussacia dumosa* / *Sphagnum* (*fuscum*, *rubellum*, *magellanicum*) Herbaceous Vegetation (G?, Maritime Peatland Sedge Lawn, CEG L006260)

SOURCES

References: Damman and French 1987

Last updated: 09 Jan 2003

Concept Author: S.C. Gawler

Stakeholders: ECS

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

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, CEG L006524)
- *Carex lasiocarpa* - *Carex oligosperma* / *Sphagnum* spp. Herbaceous Vegetation (G3G4, Northern Sedge Poor Fen, CEG L002265)
- *Carex oligosperma* - *Carex pauciflora* - *Eriophorum vaginatum* / *Sphagnum* spp. Herbaceous Vegetation (G4G5, Open Graminoid / *Sphagnum* Bog, CEG L005256)
- *Chamaedaphne calyculata* / *Carex oligosperma* / *Sphagnum* spp. Poor Fen Dwarf-shrubland (G5, Leatherleaf Poor Fen, CEG L005277)
- *Larix laricina* / *Chamaedaphne calyculata* / *Carex lasiocarpa* Shrubland (G4G5, Tamarack Scrub Poor Fen, CEG L005226)
- *Myrica gale* - *Chamaedaphne calyculata* / *Carex* (*lasiocarpa*, *utriculata*) - *Utricularia* spp. Shrub Herbaceous Vegetation (G4G5, Medium Fen, CEG L006302)
- *Myrica gale* - *Spiraea alba* - *Chamaedaphne calyculata* Shrubland (G?, Sweetgale Mixed Shrub Fen, CEG L006512)
- *Picea mariana* / *Chamaedaphne calyculata* / *Sphagnum* spp. Dwarf-shrubland (G4G5, Black Spruce / Leatherleaf Semi-treed Bog, CEG L005218)
- *Vaccinium corymbosum* / *Sphagnum* spp. Shrubland (G3G5, Highbush Blueberry Bog Thicket, CEG L006190)

SOURCES

References: Damman and French 1987

Last updated: 09 Jan 2003

Concept Author: S.C. Gawler

Stakeholders: ECS, MCS

LeadResp: ECS

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

CES201.574 LAURENTIAN-ACADIAN ACIDIC SWAMP

Division 201, Woody Wetland

Spatial Scale & Pattern: Large Patch

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, CEGLO02071)
- *Acer rubrum* - *Fraxinus* spp. / *Nemopanthus mucronatus* - *Vaccinium corymbosum* Forest (G?, Northern Red Maple - Ash Swamp, CEGLO06220)
- *Acer rubrum* / *Carex stricta* - *Onoclea sensibilis* Woodland (L, G3G5, Red Maple - Tussock Sedge Wooded Marsh, CEGLO06119)
- *Betula alleghaniensis* - *Acer rubrum* - (*Tsuga canadensis*, *Abies balsamea*) / *Osmunda cinnamomea* Forest (G4?, Hardwood - Conifer Seepage Forest, CEGLO06380)
- *Picea mariana* / *Alnus incana* / *Sphagnum* spp. Forest (L, G5, Black Spruce / Alder Swamp, CEGLO02452)
- *Picea rubens* - *Abies balsamea* / *Gaultheria hispidula* / *Osmunda cinnamomea* / *Sphagnum* spp. Forest (G?, Northern Appalachian Spruce - Fir Swamp, CEGLO06312)
- *Picea rubens* - *Acer rubrum* / *Nemopanthus mucronatus* Forest (G?, Red Maple - Conifer Acidic Swamp, CEGLO06198)

SOURCES

References: Comer and Albert 1997, Comer et al. 1995a, Comer et al. 1998

Last updated: 23 Mar 2003

Concept Author: S.C. Gawler

Stakeholders: ECS, MCS

LeadResp: ECS

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

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

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)
- *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

Concept Author: S.C. Gawler

Stakeholders: ECS, MCS

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.

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

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, CEGLO02071)
- *Fraxinus nigra* - Mixed Hardwoods - Conifers / *Cornus sericea* / *Carex* spp. Forest (G4, Black Ash - Mixed Hardwood Swamp, CEGLO02105)
- *Larix laricina* / *Alnus incana* Forest (G4, Northern Tamarack Rich Swamp, CEGLO02471)
- *Picea mariana* / *Alnus incana* / *Sphagnum* spp. Forest (L, G5, Black Spruce / Alder Swamp, CEGLO02452)
- *Thuja occidentalis* - (*Larix laricina*) Seepage Forest (G3G4, White-cedar Seepage Swamp, CEGLO02455)
- *Thuja occidentalis* - (*Picea mariana*, *Abies balsamea*) / *Alnus incana* Forest (G4, White-cedar - (Mixed Conifer) / Alder Swamp, CEGLO02456)
- *Thuja occidentalis* - *Acer rubrum* / *Cornus sericea* Forest (G?, Northern White-cedar - Red Maple Enriched Swamp, CEGLO06199)
- *Thuja occidentalis* - *Fraxinus nigra* Forest (G?, White-cedar - Black Ash Swamp, CEGLO05165)
- *Thuja occidentalis* - *Larix laricina* / *Sphagnum* spp. Forest (G?, White-cedar - Tamarack Peat Swamp, CEGLO05225)
- *Thuja occidentalis* / *Sphagnum* (*girgensohnii*, *warnstorffii*) Forest (G?, Northern White-cedar Peatland Swamp, CEGLO06007)
- *Tsuga canadensis* - *Betula alleghaniensis* Saturated Forest (L, G3, Hemlock - Yellow Birch Swamp Wet-Mesic Forest, CEGLO05003)

SOURCES

References: Comer and Albert 1997, Comer et al. 1995a, Comer et al. 1998

Last updated: 01 Mar 2303

Concept Author: S.C. Gawler

Stakeholders: ECS, MCS

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

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, CEGLO06341)

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- *Ruppia maritima* Acadian/Virginian Zone Temperate Herbaceous Vegetation (G?, Northern Atlantic Coast Beaked Ditch-grass Bed, CEG006167)
- *Salicornia* (*virginica*, *bigelovii*, *maritima*) - *Spartina alterniflora* Herbaceous Vegetation (G5, Salt Panne, CEG004308)
- *Spartina alterniflora* / (*Ascophyllum nodosum*) Acadian/Virginian Zone Herbaceous Vegetation (G5, *Spartina* Low Salt Marsh, CEG004192)
- *Spartina patens* - *Distichlis spicata* - (*Juncus gerardii*) Herbaceous Vegetation (G5, *Spartina* High Salt Marsh, CEG006006)

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

Associations:

- *Acer rubrum* - *Fraxinus pennsylvanica* / *Polygonum* spp. Woodland (G2, Freshwater Tidal Woodland, CEG006165)
- *Alnus* (*incana* ssp. *rugosa*, *serrulata*) - *Cornus amomum* Shrubland (G?, North Atlantic Fresh Tidal Shrub Swamp, CEG006337)
- *Amaranthus cannabinus* Tidal Herbaceous Vegetation (G3G5, CEG006080)
- *Cladium mariscoides* - *Drosera intermedia* - *Eleocharis rostellata* Herbaceous Vegetation (G1, Sea Level Fen, CEG006310)
- *Eriocaulon parkeri* - *Polygonum punctatum* Herbaceous Vegetation (G2, Estuary Pipewort Brackish Intertidal Flat, CEG006352)
- *Impatiens capensis* - *Peltandra virginica* - *Sagittaria latifolia* - (*Typha angustifolia*) Tidal Herbaceous Vegetation (G?, Freshwater Tidal Mixed Forbs High Marsh, CEG006325)
- *Nuphar lutea* ssp. *advena* Tidal Herbaceous Vegetation (G?, CEG004472)
- *Peltandra virginica* - *Pontederia cordata* Tidal Herbaceous Vegetation (G3G4, CEG004706)
- *Stuckenia pectinata* - *Potamogeton perfoliatus* - (*Zannichellia palustris*) Tidal Herbaceous Vegetation (G3G5, CEG006027)
- *Typha angustifolia* - *Hibiscus moscheutos* Herbaceous Vegetation (G?, Brackish Tidal Marsh (Cattail Type), CEG004201)
- *Zizania aquatica* Tidal Herbaceous Vegetation (G4?, Atlantic Coast Wild Rice Tidal Marsh, CEG004202)

SOURCES

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

Stakeholders: ECS
LeadResp: ECS

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

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

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)
- *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)

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- Potamogeton spp. - Ceratophyllum spp. Midwest Herbaceous Vegetation (G5, Midwest Pondweed Submerged Aquatic Wetland, CEG002282)
- Schoenoplectus (tabernaemontani, acutus) Eastern Herbaceous Vegetation (G?, Bulrush Deepwater Marsh, CEG006275)
- Schoenoplectus acutus - (Schoenoplectus fluviatilis) Freshwater Herbaceous Vegetation (G4G5, Freshwater Bulrush Marsh, CEG002225)
- Schoenoplectus fluviatilis - Schoenoplectus spp. Herbaceous Vegetation (G3G4, River Bulrush Marsh, CEG002221)
- Schoenoplectus tabernaemontani - Typha spp. - (Sparganium spp., Juncus spp.) Herbaceous Vegetation (G4G5, Bulrush - Cattail - Burreed Shallow Marsh, CEG002026)
- Scirpus cyperinus Seasonally Flooded Herbaceous Vegetation (G?, CEG006349)
- Typha (angustifolia, latifolia) - (Schoenoplectus spp.) Eastern Herbaceous Vegetation (G5, Eastern Cattail Marsh, CEG006153)
- Typha latifolia Southern Herbaceous Vegetation (G5, Southern Cattail Marsh, CEG004150)
- Typha spp. - Schoenoplectus acutus - Mixed Herbs Midwest Herbaceous Vegetation (G4?, Midwest Mixed Emergent Deep Marsh, CEG002229)
- Typha spp. Midwest Herbaceous Vegetation (G5, Midwest Cattail Deep Marsh, CEG002233)
- Vallisneria americana - Potamogeton perfoliatus Herbaceous Vegetation (G5, Open Water Marsh with Mixed Submergents/Emergents, CEG006196)
- Zizania (aquatica, palustris) Herbaceous Vegetation (G3G4, Wild Rice Marsh, CEG002382)

SOURCES

References: Comer and Albert 1997

Last updated: 09 Jan 2003

Concept Author: S.C. Gawler, D. Faber-Langendoen

Stakeholders: ECS, MCS

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 nodosum*); hollow stemmed kelp (*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

Concept Author: S. Gawler, P. Comer

Stakeholders: ECS

LeadResp: ECS

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

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 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), CEG006147)
- *Acer saccharinum* - *Ulmus americana* - (*Populus deltoides*) Forest (G4?, Silver Maple - Elm - (Cottonwood) Forest, CEG002586)
- *Acer saccharinum* / *Onoclea sensibilis* - *Boehmeria cylindrica* Forest (G?, Silver Maple Floodplain Bottom Forest (Sensitive Fern Type), CEG006176)
- *Acer saccharum* - *Fraxinus* spp. - *Tilia americana* / *Matteuccia struthiopteris* - *Ageratina altissima* Forest (G?, Terrace Hardwood Floodplain Forest, CEG006114)
- *Alnus incana* Swamp Shrubland (G5?, Speckled Alder Swamp, CEG002381)
- *Calamagrostis canadensis* - *Phalaris arundinacea* Herbaceous Vegetation (G4G5, Bluejoint Wet Meadow, CEG005174)
- *Calamagrostis canadensis* - *Scirpus* spp. - *Dulichium arundinaceum* Herbaceous Vegetation (G?, Seasonally Flooded Mixed Graminoid Meadow, CEG006519)
- *Cephalanthus occidentalis* / *Glyceria canadensis* Shrubland (G?, Buttonbush Shrub Swamp, CEG006069)
- *Fraxinus pennsylvanica* - *Ulmus americana* - (*Acer negundo*, *Tilia americana*) Northern Forest (G3G4, Northern Ash - Elm Floodplain Forest, CEG002089)
- River Mud Flats Sparse Vegetation (G?, River Mud Flats, CEG002314)
- Riverine Sand Flats - Bars Sparse Vegetation (G4G5, Riverine Sand Flats, CEG002049)

SOURCES

Last updated: 09 Jan 2003

Concept Author: S.C. Gawler

Stakeholders: ECS, SCS, MCS

LeadResp: ECS

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

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

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

Concept Author: S.C. Gawler

Stakeholders: ECS, MCS

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]

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.

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

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, CEG002584)
- Igneous - Metamorphic Cobble - Gravel Inland Lake Shore Sparse Vegetation (G4G5, Inland Lake Igneous - Metamorphic Cobble - Gravel Shore, CEG002303)
- Igneous - Metamorphic Cobble - Gravel River Shore Sparse Vegetation (G4G5, Riverine Igneous - Metamorphic Cobble - Gravel Shore, CEG002304)
- Inland Freshwater Strand Beach Sparse Vegetation (G4G5, Inland Freshwater Strand Beach, CEG002310)
- Lake Mud Flats Sparse Vegetation (G?, Lake Mud Flats, CEG002313)
- Sandstone Bedrock River Shore Sparse Vegetation (G?, River Ledge Sandstone Pavement, CEG002302)
- *Spartina pectinata* - *Muhlenbergia richardsonis* - *Sporobolus heterolepis* - *Oligoneuron album* - *Euthamia graminifolia* Sparse Vegetation (G1, River Ledge Limestone Pavement, CEG005233)
- *Spartina pectinata* North Atlantic Coast Herbaceous Vegetation (G?, CEG006095)

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 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

Concept Author: S. Gawler, P. Comer

Stakeholders: ECS

LeadResp: ECS

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

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 silt 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:

- *Zostera marina* Herbaceous Vegetation (G?, Eel-grass Meadow, CEG004336)

SOURCES

References: Brown 1993

Last updated: 18 Apr 2003

Concept Author: S. Gawler, P. Comer

Stakeholders: ECS

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, CEG004336)

SOURCES

References: Brown 1993

Last updated: 18 Apr 2003

Concept Author: S. Gawler, P. Comer

Stakeholders: ECS

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

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

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 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, CEG006014)
- *Acer rubrum* - *Nyssa sylvatica* High Allegheny Plateau, Central Appalachian Forest (G?, Central Appalachian Forested Acid Seep, CEG006132)
- *Acer saccharum* - *Betula alleghaniensis* - *Prunus serotina* Forest (G4, Central Appalachian Northern Hardwood Forest, CEG006045)
- *Acer saccharum* - *Pinus strobus* / *Acer pensylvanicum* Forest (G?, Northern Hardwood - White Pine Forest, CEG005005)
- *Acer saccharum* - *Quercus rubra* / *Hepatica nobilis* var. *obtusata* Forest (G?, CEG006046)
- *Betula alleghaniensis* - (*Tsuga canadensis*) / *Rhododendron maximum* / *Leucothoe fontanesiana* Forest (G3G4Q, Blue Ridge Hemlock - Northern Hardwood Forest, CEG007861)
- *Betula lenta* / *Ilex montana* / *Lycopodium annotinum* Forest (GM, Central Appalachian Northern Hardwood Forest (Sweet Birch / Clubmoss Type), CEG008503)
- *Betula papyrifera* / *Acer saccharum* - Mixed Hardwoods Forest (G4?, Paper Birch / Sugar Maple - Mixed Hardwoods Forest, CEG002464)
- *Chrysosplenium americanum* Herbaceous Vegetation (G3G5, Golden-saxifrage Seep, CEG006193)
- *Deschampsia caespitosa* - *Symplocarpus foetidus* Herbaceous Vegetation (G1, Inland Acidic Seep Community, CEG006101)
- *Liriodendron tulipifera* - *Betula lenta* - *Tsuga canadensis* / *Rhododendron maximum* Forest (G5, Southern Appalachian Acid Cove Forest (Typic Type), CEG007543)
- *Picea rubens* - *Betula alleghaniensis* - *Prunus serotina* Forest (G?, CEG006029)
- *Pinus strobus* - *Tsuga canadensis* / *Acer pensylvanicum* / *Polystichum acrostichoides* Forest (G4?, Central Appalachian White Pine - Eastern Hemlock Forest, CEG006019)
- *Pinus strobus* - *Tsuga canadensis* / *Rhododendron maximum* - (*Leucothoe fontanesiana*) Forest (G4, Southern Appalachian Eastern Hemlock Forest (White Pine Type), CEG007102)
- *Pinus strobus* - *Tsuga canadensis* Lower New England / Northern Piedmont Forest (G5, White Pine - Hemlock Dry-Mesic Coniferous Forest, CEG006328)
- *Pinus strobus* Successional Forest (GD, Eastern White Pine Successional Forest, CEG007944)
- *Quercus bicolor* / *Vaccinium corymbosum* / *Carex stipitata* Forest (G?, Perched Swamp White Oak Swamp, CEG006241)
- *Quercus rubra* - *Acer saccharum* - *Fagus grandifolia* / *Viburnum acerifolium* Forest (G?, Red Oak - Northern Hardwood Forest, CEG006173)
- *Quercus rubra* - *Acer saccharum* - *Liriodendron tulipifera* Forest (G?, High Allegheny Rich Red Oak - Sugar Maple Forest, CEG006125)
- *Rhododendron maximum* Upland Shrubland (G3?Q, Montane *Rhododendron* Thicket, CEG003819)
- *Thuja occidentalis* - *Pinus strobus* - *Tsuga canadensis* / *Carex eburnea* Forest (G1G2, Southern Appalachian Northern White-cedar Slope Forest, CEG008426)
- *Tsuga canadensis* - (*Betula alleghaniensis*, *Quercus rubra*) / *Ilex montana* / *Rhododendron catawbiense* Forest (G1?, Eastern Hemlock / Catawba *Rhododendron* Forest, CEG008513)

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

- *Tsuga canadensis* - (*Fagus grandifolia*, *Tilia americana* var. *heterophylla*) / *Magnolia tripetala* Forest (G4, Cumberland/Appalachian Hemlock - Hardwood Cove Forest, CEG008407)
- *Tsuga canadensis* - *Betula alleghaniensis* - *Prunus serotina* / *Rhododendron maximum* Forest (G?, Central Appalachian Hemlock - Northern Hardwood Forest, CEG006206)
- *Tsuga canadensis* - *Betula alleghaniensis* / *Veratrum viride* - *Carex scabrata* - *Oclemena acuminata* Forest (G2, High-Elevation Hemlock - Yellow Birch Seepage Swamp, CEG008533)
- *Tsuga canadensis* - *Betula alleghaniensis* Lower New England / Northern Piedmont Forest (G4?, Hemlock - Northern Hardwood Forest, CEG006109)
- *Tsuga canadensis* - *Fagus grandifolia* - *Acer saccharum* / (*Hamamelis virginiana*, *Kalmia latifolia*) Forest (G3?, East-central Hemlock Hardwood Forest, CEG005043)
- *Tsuga canadensis* - *Fagus grandifolia* Forest (G4G5, Hemlock - Beech Forest, CEG006088)
- *Tsuga canadensis* - *Quercus prinus* / *Kalmia latifolia* - *Rhododendron* (*catawbiense*, *maximum*) / *Galax urceolata* Forest (G4, Central Appalachian Acidic Cove Forest, CEG008512)
- *Tsuga canadensis* / *Rhododendron maximum* - (*Clethra acuminata*, *Leucothoe fontanesiana*) Forest (G3G4, Southern Appalachian Eastern Hemlock Forest (Typic Type), CEG007136)
- *Tsuga caroliniana* - (*Tsuga canadensis*) / *Rhododendron maximum* Forest (G1G2, Carolina Hemlock Forest (Mesic Type), CEG007138)

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.

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

Concept Author: S.C. Gawler, R. White, R. Evans, M. Pyne

Stakeholders: SCS, MCS, ECS

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

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

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

Associations:

- *Acer rubrum* - *Nyssa sylvatica* High Allegheny Plateau, Central Appalachian Forest (G?, Central Appalachian Forested Acid Seep, CEG L006132)
- *Castanea dentata* - *Quercus prinus* Forest (GH, American Chestnut Forest (Subxeric Type), CEG L007196)
- *Pinus rigida* - *Quercus* (velutina, coccinea, prinus) Forest (G?, CEG L006290)
- *Pinus strobus* - *Pinus resinosa* - *Pinus rigida* Forest (G4G5, CEG L006259)
- *Pinus strobus* - *Quercus* (rubra, velutina) - *Fagus grandifolia* Forest (G5, White Pine - Oak Forest, CEG L006293)
- *Pinus strobus* - *Quercus alba* - *Quercus coccinea* / *Vaccinium stamineum* Forest (G4, Central Appalachian / Piedmont White Pine - Xeric Oak Forest, CEG L008539)
- *Pinus strobus* - *Quercus rubra* - *Liriodendron tulipifera* Forest (G?, CEG L006304)
- *Pinus strobus* / *Vaccinium pallidum* Forest (G?, White Pine - Blueberry Forest of Low-Elevation Slopes and Hills, CEG L007099)
- *Pinus strobus* Successional Forest (GD, Eastern White Pine Successional Forest, CEG L007944)
- *Pinus virginiana* - *Pinus* (rigida, echinata) - (*Quercus prinus*) / *Vaccinium pallidum* Forest (G4?, Appalachian Low-Elevation Mixed Pine / Hillside Blueberry Forest, CEG L007119)
- *Pinus virginiana* - *Quercus* (coccinea, prinus) Forest (G?, Virginia Pine - Oak Forest, CEG L005040)
- *Pinus virginiana* Successional Forest (GD, Virginia Pine Successional Forest, CEG L002591)
- *Quercus* (pinus, coccinea) / *Kalmia latifolia* / (*Galax urceolata*, *Gaultheria procumbens*) Forest (G5, Chestnut Oak Forest (Xeric Ridge Type), CEG L006271)
- *Quercus prinus* - *Quercus* (rubra, velutina) / *Gaylussacia baccata* Forest (G5, Northern Appalachian Dry Oak Forest, CEG L006282)
- *Quercus rubra* - (*Quercus prinus*, *Quercus velutina*) / *Rhododendron periclymenoides* / *Lysimachia quadrifolia* - *Hieracium paniculatum* Forest (G2G3, Mixed Oak / Heath Forest (Northern Red Oak / Mixed Herbs Type), CEG L008523)

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

Concept Author: S.C. Gawler

Stakeholders: ECS, SCS

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

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

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, CEGLO05101)
- *Juniperus virginiana* - *Fraxinus americana* / *Danthonia spicata* - *Poa compressa* Woodland (G2G3, Traprock Ridge, CEGLO06002)
- *Paulownia tomentosa* Woodland (GW, Princess-tree Woodland, CEGLO03687)
- *Photinia melanocarpa* - *Gaylussacia baccata* / *Carex pensylvanica* Shrubland (G1?, High-Elevation Outcrop Barren (Black Chokeberry Igneous / Metamorphic Type), CEGLO08508)
- *Picea rubens* / *Vaccinium angustifolium* High Allegheny Plateau Woodland (G3G5, Central Appalachian Red Spruce Woodland, CEGLO06254)
- *Pinus* (*pungens*, *rigida*) / *Quercus ilicifolia* / *Gaylussacia baccata* Woodland (G4, Central Appalachian Table Mountain Pine - Pitch Pine - Heath Woodland, CEGLO04996)
- *Pinus echinata* - *Quercus prinus* - *Quercus stellata* / *Vaccinium pallidum* / *Pityopsis graminifolia* var. *latifolia* Woodland (G2?, Pine-Oak Virginia Shield Barrens, CEGLO04445)
- *Pinus pungens* - *Pinus rigida* - (*Quercus prinus*) / *Kalmia latifolia* - *Vaccinium pallidum* Woodland (G3, Blue Ridge Table Mountain Pine - Pitch Pine Woodland (Typic Type), CEGLO07097)
- *Pinus rigida* - *Quercus coccinea*, *velutina*) / *Schizachyrium scoparium* Woodland (G3G5, CEGLO06166)
- *Pinus rigida* / *Photinia melanocarpa* / *Deschampsia flexuosa* - *Schizachyrium scoparium* Woodland (G?, Pitch Pine Rocky Summit, CEGLO06116)
- *Pinus rigida* / *Quercus ilicifolia* / *Photinia melanocarpa* Woodland (G4G5, High Allegheny Pine Barrens, CEGLO06323)
- *Quercus ilicifolia* - *Prunus pumila* Shrubland (G?, Ridgetop Scrub Oak Barrens, CEGLO06121)
- *Quercus ilicifolia* Shrubland [Placeholder] (G?, CEGLO03883)
- *Quercus prinus* - *Pinus virginiana* - *Quercus (marilandica, stellata)* / *Dichanthelium depauperatum* Woodland (G2?, Central Appalachian Xeric Sandstone Woodland, CEGLO08540)
- *Quercus prinus* / *Quercus ilicifolia* / *Danthonia spicata* - *Solidago bicolor* Woodland (G3?, Central Appalachian Xeric Shale Woodland (Rock Chestnut Oak / Mixed Herbs Type), CEGLO08526)
- *Quercus rubra* - *Quercus prinus* - *Pinus strobus* / *Penstemon hirsutus* Woodland (G3G5, CEGLO06074)
- *Saxifraga michauxii* Herbaceous Vegetation (G3?, Low-Elevation Rocky Summit (Acidic Type), CEGLO04524)
- *Vaccinium (angustifolium, myrtilloides, pallidum)* High Allegheny Plateau / Central Appalachian Dwarf-shrubland (G?, Central Appalachian Blueberry Shrubland, CEGLO03958)
- *Vaccinium angustifolium* - *Sorbus americana* / *Sibbaldiopsis tridentata* Dwarf-shrubland (G?, Blueberry Granite Barrens, CEGLO05094)

SOURCES

Last updated: 09 Jan 2003

Concept Author: S.C. Gawler

Stakeholders: ECS, SCS

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

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

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, CEGLO06014)
- *Acer rubrum* - *Nyssa sylvatica* High Allegheny Plateau, Central Appalachian Forest (G?, Central Appalachian Forested Acid Seep, CEGLO06132)
- *Carya* (glabra, ovata) - *Fraxinus americana* - *Quercus* spp. Forest (G?, CEGLO06236)
- *Castanea dentata* - *Quercus rubra* Forest (GH, American Chestnut Forest (Mesic Montane Type), CEGLO07286)
- *Deschampsia caespitosa* - *Symplocarpus foetidus* Herbaceous Vegetation (G1, Inland Acidic Seep Community, CEGLO06101)
- *Kalmia latifolia* / *Schizachyrium scoparium* / *Cladonia* spp. Shrub Herbaceous Vegetation (G1, Southern Appalachian High-Elevation Mafic Glade (Flatrock Type), CEGLO04238)
- *Pinus strobus* - *Quercus* (rubra, velutina) - *Fagus grandifolia* Forest (G5, White Pine - Oak Forest, CEGLO06293)
- *Pinus strobus* Successional Forest (GD, Eastern White Pine Successional Forest, CEGLO07944)
- *Pinus virginiana* Successional Forest (GD, Virginia Pine Successional Forest, CEGLO02591)
- *Quercus* (alba, rubra, velutina) / *Cornus florida* / *Viburnum acerifolium* Forest (G?, Dry Oak-Hickory Forest, CEGLO06336)
- *Quercus* (velutina, alba) / *Vaccinium pallidum* High Allegheny Plateau, Western Allegheny Plateau Forest (G?, CEGLO06018)
- *Quercus alba* - *Quercus* (rubra, coccinea) - *Carya* (alba, glabra) / *Vaccinium pallidum* Piedmont Dry-Mesic Forest (G5?, Piedmont Dry-Mesic Oak - Hickory Forest, CEGLO08475)
- *Quercus alba* - *Quercus prinus* - *Carya glabra* / *Cornus florida* / *Vaccinium pallidum* / *Carex pensylvanica* Forest (G4?, Central Appalachian Acidic Oak - Hickory Forest, CEGLO08515)
- *Quercus alba* - *Quercus rubra* - *Carya* (alba, ovata) / *Cornus florida* Acid Forest (L, G3, White Oak - Red Oak Dry-Mesic Acid Forest, CEGLO02067)--may be too far west
- *Quercus alba* - *Quercus rubra* - *Carya ovata* Glaciated Forest (L, G4?, Midwestern White Oak - Red Oak Forest, CEGLO02068)--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, CEGLO02059)--may be too far west
- *Quercus bicolor* / *Vaccinium corymbosum* / *Carex stipata* Forest (G?, Perched Swamp White Oak Swamp, CEGLO06241)
- *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), CEGLO08521)
- *Quercus prinus* - *Quercus* (alba, coccinea, velutina) / *Viburnum acerifolium* - (*Kalmia latifolia*) Forest (G4?, Appalachian Oak - (Chestnut) Forest, CEGLO05023)
- *Quercus prinus* - *Quercus rubra* - *Carya* (glabra, alba) / *Gaylussacia baccata* Forest (G5, Central Appalachian Rocky Dry-Mesic Oak Forest, CEGLO06057)
- *Quercus prinus* - *Quercus rubra* - *Carya ovalis* / *Solidago* (ulmifolia, arguta) - *Galium latifolium* Forest (G3G4, Central Appalachian Basic Oak - Hickory Forest (Montane Type), CEGLO08516)
- *Quercus prinus* - *Quercus velutina* / *Oxydendrum arboreum* - *Cornus florida* Forest (G4?, Mixed Oak / Heath Forest (Rock Chestnut Oak - Black Oak Type), CEGLO08522)

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

- *Quercus prinus* / *Rhododendron catawbiense* - *Kalmia latifolia* Forest (G3?, Central Appalachian Rock Chestnut Oak / Catawba *Rhododendron* Forest, CEG L008524)
- *Quercus rubra* - (*Quercus prinus*) / *Vaccinium* spp. / *Deschampsia flexuosa* Woodland (G3G5, Appalachian Red Oak Woodland (Northern Type), CEG L006134)
- *Quercus rubra* - *Acer rubrum* / *Calycanthus floridus* - *Pyrularia pubera* / *Thelypteris noveboracensis* Forest (G4?, Appalachian Montane Oak - Hickory Forest (Red Oak Type), CEG L006192)
- *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), CEG L008520)
- *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), CEG L008518)
- *Quercus rubra* - *Quercus alba* / *Rhododendron prinophyllum* - *Ilex montana* / *Calamagrostis porteri* Forest (G3?, Northern Red Oak Forest (Early Azalea / Porter Reedgrass Type), CEG L008506)
- *Quercus rubra* - *Quercus prinus* / *Deschampsia flexuosa* - *Danthonia compressa* - *Calamagrostis porteri* Woodland (G?, Central Appalachian High-Elevation Red Oak Woodland (Southern Type), CEG L004714)
- *Quercus rubra* / *Ilex montana* - *Menziesia pilosa* / *Dennstaedtia punctilobula* Forest (G3?, Northern Red Oak Forest (Minniebush / Hay-scented Fern Type), CEG L008505)

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 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, CEG L006406)
- *Acer rubrum* - *Nyssa sylvatica* - (*Pinus rigida*) / *Ilex verticillata* / *Osmunda cinnamomea* Forest (G3G4, CEG L007853)
- *Acer rubrum* - *Nyssa sylvatica* - *Betula alleghaniensis* / *Sphagnum* spp. Forest (G?, Red Maple - Black Gum Basin Swamp, CEG L006014)
- *Acer rubrum* - *Nyssa sylvatica* - *Magnolia virginiana* Forest (G3?, Southern Red Maple - Black Gum Swamp Forest, CEG L006238)

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

- *Acer rubrum* - *Nyssa sylvatica* High Allegheny Plateau, Central Appalachian Forest (G?, Central Appalachian Forested Acid Seep, CEG006132)
- *Acer rubrum* / *Rhododendron viscosum* - *Clethra alnifolia* Forest (G?, Southern New England Red Maple - Swamp, CEG006156)
- *Betula alleghaniensis* - *Acer rubrum* - (*Tsuga canadensis*, *Abies balsamea*) / *Osmunda cinnamomea* Forest (G4?, Hardwood - Conifer Seepage Forest, CEG006380)
- *Fraxinus nigra* - *Abies balsamea* / *Rhamnus alnifolia* Forest (G1, Central Appalachian Circumneutral Seepage Swamp, CEG006003)
- *Picea rubens* - (*Tsuga canadensis*) / *Rhododendron maximum* Saturated Forest (G2?, Swamp Forest - Bog Complex (Spruce Type), CEG006277)
- *Picea rubens* - *Abies balsamea* / *Sphagnum magellanicum* Forest (G?, Lower New England Spruce - Fir Swamp, CEG006311)
- *Quercus bicolor* / *Vaccinium corymbosum* / *Carex stipata* Forest (G?, Perched Swamp White Oak Swamp, CEG006241)
- *Tsuga canadensis* - *Betula alleghaniensis* / *Ilex verticillata* / *Sphagnum* spp. Forest (G5, Hemlock - Hardwood Swamp, CEG006226)
- *Tsuga canadensis* / *Rhododendron maximum* / *Sphagnum* spp. Forest (G?, Eastern Hemlock - Great Laurel Swamp, CEG006279)

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

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, CEG005279)
- *Carex oligosperma* - *Carex pauciflora* - *Eriophorum vaginatum* / *Sphagnum* spp. Herbaceous Vegetation (G4G5, Open Graminoid / *Sphagnum* Bog, CEG005256)
- *Chamaecyparis thyoides* / *Chamaedaphne calyculata* Woodland (G3G4, CEG006321)

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

- *Chamaedaphne calyculata* - (*Gaylussacia dumosa*) - *Decodon verticillatus* / *Woodwardia virginica* Dwarf-shrubland (G5, Southern New England Bog, CEG006008)
- *Chamaedaphne calyculata* / *Carex oligosperma* - *Eriophorum virginicum* Dwarf-shrubland (G3G4, Leatherleaf Kettle Bog, CEG005092)
- *Larix laricina* / *Photinia melanocarpa* / *Sphagnum* spp. Forest (G4?, Central Tamarack Poor Swamp, CEG002472)
- *Myrica gale* - *Chamaedaphne calyculata* / *Carex (lasiocarpa, utriculata)* - *Utricularia* spp. Shrub Herbaceous Vegetation (G4G5, Medium Fen, CEG006302)
- *Myrica gale* - *Chamaedaphne calyculata* / *Carex exilis* Shrub Herbaceous Vegetation (G?, Coastal Plain Poor Fen, CEG006392)
- *Myrica gale* - *Dasiphora fruticosa* ssp. *floribunda* / *Carex lasiocarpa* - *Cladium mariscoides* Shrub Herbaceous Vegetation (G2G3, CEG006068)
- *Picea mariana* / (*Vaccinium corymbosum*, *Gaylussacia baccata*) / *Sphagnum* sp. Woodland (G3G5, Black Spruce Woodland Bog, CEG006098)
- *Pinus rigida* / *Chamaedaphne calyculata* / *Sphagnum* spp. Woodland (G3G5, CEG006194)
- *Sphagnum (rubellum, cuspidatum, torreyanum)* - *Vaccinium (oxycoccus, macrocarpon)* Nonvascular Vegetation (G?, Peatland Moss Lawn, CEG006394)
- *Vaccinium corymbosum* - *Gaylussacia baccata* - *Photinia melanocarpa* / *Calla palustris* Shrubland (G2G3, Highbush Blueberry Poor Fen, CEG005085)
- *Vaccinium corymbosum* / *Sphagnum* spp. Shrubland (G3G5, Highbush Blueberry Bog Thicket, CEG006190)

SOURCES

References: Damman and French 1987

Last updated: 23 Mar 2003

Concept Author: S.C. Gawler

Stakeholders: ECS, MCS, SCS

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.

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, CEG005038)
- *Acer rubrum* - *Larix laricina* / *Rhamnus alnifolia* Woodland (G3G5, Red Maple - Larch Wooded Fen, CEG006118)
- *Fraxinus nigra* - *Acer rubrum* - (*Larix laricina*) / *Rhamnus alnifolia* Forest (G?, Rich Red Maple - Black Ash Swamp, CEG006009)
- *Fraxinus nigra* - *Acer rubrum* / *Carex leptalea* Saturated Forest (G?, Red Maple - Black Ash Swamp, CEG007441)

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

- *Fraxinus nigra* - *Liriodendron tulipifera* - *Acer rubrum* / *Caltha palustris* - *Carex bromoides* Forest (G3, Montane Black Ash Seepage Swamp, CEG008416)
- *Larix laricina* - *Acer rubrum* / (*Rhamnus alnifolia*, *Vaccinium corymbosum*) Forest (G2G3, Central Tamarack - Red Maple Rich Swamp, CEG005232)

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)).

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, CEG005033)
- *Acer rubrum* - *Fraxinus pennsylvanica* / *Boehmeria cylindrica* Forest [Provisional] (G?, Red Maple - Green Ash Forested Swamp, CEG006548)
- *Acer saccharinum* - (*Populus deltoides*) / *Matteuccia struthiopteris* Forest (G?, Silver Maple Floodplain Levee Forest (Ostrich Fern Type), CEG006147)
- *Acer saccharinum* - *Ulmus americana* - (*Populus deltoides*) Forest (G4?, Silver Maple - Elm - (Cottonwood) Forest, CEG002586)
- *Acer saccharinum* - *Ulmus americana* / *Onoclea sensibilis* Forest (G?, Silver Maple - Elm Floodplain Forest, CEG006001)
- *Acer saccharinum* - *Ulmus americana* / *Physocarpus opulifolius* Forest (G?, CEG006042)
- *Acer saccharinum* / *Onoclea sensibilis* - *Boehmeria cylindrica* Forest (G?, Silver Maple Floodplain Bottom Forest (Sensitive Fern Type), CEG006176)
- *Acer saccharum* - *Fraxinus* spp. - *Tilia americana* / *Matteuccia struthiopteris* - *Ageratina altissima* Forest (G?, Terrace Hardwood Floodplain Forest, CEG006114)
- *Alnus serrulata* - *Physocarpus opulifolius* Shrubland (G5, Allegheny Floodplain Alder Thicket, CEG006251)
- *Alnus serrulata* Eastern Shrubland (G4G5, Smooth Alder Swamp, CEG005082)
- *Arundinaria gigantea* ssp. *gigantea* Shrubland (G2?, Floodplain Canebrake, CEG003836)
- *Betula nigra* - *Platanus occidentalis* / *Impatiens pallida* Forest (G?, CEG006184)
- *Betula nigra* - *Platanus occidentalis* Forest (G5, River Birch - Sycamore Forest, CEG002086)
- *Carex torta* Herbaceous Vegetation (G3G4, Rocky Bar and Shore (Twisted Sedge Type), CEG004103)
- *Cephalanthus occidentalis* / *Carex* spp. - *Lemna* spp. Southern Shrubland (G4, Southern Buttonbush Pond, CEG002191)

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

- *Fagus grandifolia* - *Quercus* spp. - *Acer rubrum* - *Juglans nigra* Forest (G2G3, Beech - Mixed Hardwood Floodplain Forest, CEG L005014)
- *Fraxinus pennsylvanica* - *Ulmus* spp. - *Celtis occidentalis* Forest (G3G5, Central Green Ash - Elm - Hackberry Forest, CEG L002014)
- *Justicia americana* Herbaceous Vegetation (G4G5, Water-willow Rocky Bar and Shore, CEG L004286)
- *Liriodendron tulipifera* - *Pinus strobus* - (*Tsuga canadensis*) / *Carpinus caroliniana* / *Amphicarpaea bracteata* Forest (G3, Central Appalachian Small-Stream Montane Floodplain Forest, CEG L008405)
- *Peltandra virginica* - *Saururus cernuus* - *Carex crinita* / *Climacium americanum* Herbaceous Vegetation (G2?, Floodplain Pool, CEG L007696)
- *Platanus occidentalis* - *Acer saccharinum* - *Juglans nigra* - *Ulmus rubra* Forest (G4, Sycamore - Silver Maple Calcareous Floodplain Forest, CEG L007334)
- *Platanus occidentalis* - *Liquidambar styraciflua* / *Asimina triloba* Forest (G5, Sycamore - Sweetgum Piedmont Swamp Forest, CEG L007340)
- *Quercus* (palustris, phellos) - *Acer rubrum* / *Cinna arundinacea* Forest (G?, CEG L006605)
- *Quercus bicolor* - *Acer rubrum* / *Carpinus caroliniana* Forest (G?, Swamp White Oak Floodplain Forest, CEG L006386)
- *Quercus palustris* - *Acer rubrum* / *Carex grayi* - *Geum canadense* Forest (G?, CEG L006185)
- *Tilia americana* - *Acer saccharum* - *Acer nigrum* / *Laportea canadensis* Forest (G?, Rich Floodplain Forest, CEG L006405)

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, CEG L006251)
- *Andropogon gerardii* - *Campanula rotundifolia* - *Solidago simplex* Herbaceous Vegetation (G2, Northern Riverside Rock Outcrop, CEG L006284)
- *Andropogon gerardii* - *Panicum virgatum* - *Baptisia australis* Herbaceous Vegetation (G2G3, Fall-Line Riverwash Bedrock Prairie, CEG L006283)
- *Andropogon gerardii* - *Phlox subulata* - *Solidago simplex* var. *racemosa* - *Packera paupercula* Herbaceous Vegetation (G2?, Potomac River Basalt Outcrop Scour Prairie, CEG L004284)
- *Betula nigra* - *Salix interior* Shrubland (G4G5, Birch - Willow Riverbank Shrubland, CEG L003896)
- *Carex torta* Herbaceous Vegetation (G3G4, Rocky Bar and Shore (Twisted Sedge Type), CEG L004103)

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

- *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
Concept Author: S.C. Gawler

Stakeholders: ECS, MCS, SCS
LeadResp: ECS
LeadResp: 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.

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

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

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*.

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?, CEG006020)
- *Acer saccharum* - *Quercus muehlenbergii* Forest (G?, Sugar Maple - Chinquapin Oak Forest, CEG005010)
- *Acer saccharum* - *Tilia americana* - *Fraxinus americana* / *Ostrya virginiana* / *Geranium robertianum* Woodland (G3G5, Rich Northern Hardwood Woodland, CEG005058)
- *Asplenium ruta-muraria* - *Pellaea atropurpurea* Sparse Vegetation (G3G4, Montane Cliff (Calcareous Type), CEG004476)
- *Thuja occidentalis* / *Carex eburnea* - *Pellaea atropurpurea* Woodland (G2G3, Appalachian Cliff White-cedar Woodland, CEG002596)
- *Tilia americana* - *Fraxinus americana* / *Acer pensylvanicum* - *Ostrya virginiana* / *Parthenocissus quinquefolia* - *Impatiens pallida* Woodland (G3, Central Appalachian Basic Boulderfield Forest (Montane Basswood - White Ash Type), CEG008528)
- *Tilia americana* - *Fraxinus americana* / *Cornus florida* Woodland (G3G5, CEG006054)
- *Toxicodendron radicans* / *Heuchera americana* - (*Dichanthelium depauperatum*, *Woodsia obtusa*) Herbaceous Vegetation (G?, Appalachian Mafic Cliff (Low-Elevation Type), CEG004395)

SOURCES

Last updated: 09 Jan 2003

Concept Author: S.C. Gawler

Stakeholders: ECS, MCS, SCS

LeadResp: ECS

APPENDIX D: Invasive plant species known to occur within Northeast temperate Network Parks

List of invasive plant species (n = 65) known to occur within NETN parks, September 2003. Not all species are listed, especially for APPA and BOHA.

<i>Scientific Name</i>	<i>Vernacular Name</i>	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
<i>Acer plantanoides</i>	Norway Maple	X	X	X	X	X	X	X	X	X	X	
<i>Aegopodium podagraria</i>	Goutweed				X							
<i>Ailanthus altissima</i>	tree-of-heaven			X					X	X		
<i>Alliaria petiolata</i>	garlic mustard	X	X	X	X	X	X	X	X		X	X
<i>Allium vineale</i>	Wild Garlic			X	X							
<i>Anthriscus sylvestris</i>	Wild Chervil				X							
<i>Artemisia vulgaris</i>	mugwort/common wormwood			X						X	X	
<i>Berberis altissimus</i>										X		
<i>Berberis japonicus</i>						X						
<i>Berberis secalinus</i>										X		
<i>Berberis tectorum</i>										X		
<i>Berberis thunbergii</i>	Japanese barberry	X	X	X	X	X	X	X	X	X	X	X
<i>Berberis vulgaris</i>	Common Barberry			X								
<i>Berberis x ottawensi</i>		X										
<i>Bromus inermis</i>	smooth brome/awnless brome	X		X						X		
<i>Celastrus orbiculatus</i>	oriental bittersweet	X	X		X	X	X	X	X	X		X
<i>Centaurea biebersteinii</i>	spotted knapweed	X				X	X		X		X	X
<i>Centaurea jacea</i>	brown knapweed										X	
<i>Centaurea maculosa</i>	spotted knapweed			X							X	
<i>Chelidonium majus</i>	Celandine			X	X	X						
<i>Cirsium arvense</i>	Canadian thistle	X									X	
<i>Dactylis glomerata</i>	cocksfoot/orchardgrass	X		X							X	
<i>Elaeagnus umbellata</i>	Autumn Olive	X	X	X	X	X	X		X		X	X
<i>Euonymus alata</i>	winged euonymus	X	X		X	X	X	X	X			X
<i>Euonymus fortunei</i>	Creeping Euonymus					X						

APPENDIX D: Invasive plant species known to occur within Northeast temperate Network Parks

<i>Scientific Name</i>	<i>Vernacular Name</i>	ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
<i>Euphorbia esula</i>	leafy spurge			X						X	X	
<i>Frangula alnus</i>	glossy buckthorn	X	X		X	X			X		X	
<i>Glechoma hederacea</i>	Gill-over-the-ground			X		X						
<i>Hedera helix</i>	English Ivy					X						
<i>Hesperis matronalis</i>	dame's rocket			X		X				X		
<i>Hieracium pratense</i>	Yellow Hawk Weed			X		X						
<i>Iris pseudacorus</i>	yellow flag			X		X			X		X	
<i>Ligustrum spp.</i>	Privet					X						
<i>Liniria vulgaris</i>	Toad Flax			X		X						
<i>Lonicera canadensis</i>	American fly honeysuckle										X	
<i>Lonicera dioica</i>	limber honeysuckle										X	
<i>Lonicera japonica</i>	Japanese honeysuckle			X	X				X			
<i>Lonicera morrowii</i>	Morrow's honeysuckle	X	X	X	X	X	X	X	X		X	X
<i>Lonicera tartarica</i>				X							X	
<i>Lonicera x bella</i>	Bell's honeysuckle	X			X	X			X			X
<i>Lythrum salicaria</i>	purple loosestrife	X	X	X	X	X		X	X	X	X	X
<i>Microstegium vimineum</i>	Japanese stiltgrass						X	?	X		X	
<i>Myriophyllum heterophyllum</i>	two-leaf water-milfoil								X			
<i>Myriophyllum spicatum</i>	Eurasian water-milfoil								X			
<i>Phalaris arundinacea</i>	reed canarygrass					X						
<i>Phragmites australis</i>	common reed								X	X	X	
<i>Polygonum aviculare</i>	prostrate/yard knotweed			X							X	
<i>Polygonum cuspidatum</i>	Japanese knotweed			X	X				X	X	X	
<i>Polygonum erectum</i>	erect knotweed				X				X	X	X	
<i>Polygonum prolificum</i>		X							X		X	
<i>Potamogeton crispus</i>	curly-leaved pondweed									X	X	
<i>Rhamnus cathartica</i>	common buckthorn			X	X				X		X	

APPENDIX D: Invasive plant species known to occur within Northeast temperate Network Parks

		ACAD	APPA	BOHA	MABI	MIMA	MORR	ROVA	SAGA	SAIR	SARA	WEFA
<i>Scientific Name</i>	<i>Vernacular Name</i>											
<i>Rhamnus frangula</i>	columnar buckthorn			X						X		
<i>Robinia pseudoacacia</i>	yellow/black locust			X					X			
<i>Rosa multiflora</i>	multiflora rose	X	X	X	X	X	X	X	X	X	X	X
<i>Rumex acetosella</i>	Field Sorrel			X		X						
<i>Solanum dulcemara</i>	bittersweet	X		X							X	
<i>Sonchus arvensis</i>	sow-thistle	X		X								
<i>Syringa reticulate</i>	Japanese tree lilac								X			
<i>Trapa natans</i>	water chestnut								X		X	
<i>Tussilago farfara</i>	colts foot	X		X							X	
<i>Verbascum thapsus</i>	flannel mullein/velvet dock			X						X	X	
<i>Viburnum sieboldi</i>							X					
<i>Vinca minor</i>	Periwinkle				X	X						
<i>Vincetoxicum nigrum</i>	black swallow-wort				X	X			X		X	

APPENDIX E: 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.

APPENDIX D: Air Quality Monitoring Summary for NETN

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

APPENDIX D: Air Quality Monitoring Summary for NETN

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.

APPENDIX D: Air Quality Monitoring Summary for NETN

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

APPENDIX D: Air Quality Monitoring Summary for NETN

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, New 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,

APPENDIX D: Air Quality Monitoring Summary for NETN

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

APPENDIX D: Air Quality Monitoring Summary for NETN

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

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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

APPENDIX D: Air Quality Monitoring Summary for NETN

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 to 12 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 to 1999 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.

APPENDIX D: Air Quality Monitoring Summary for NETN

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/>

APPENDIX E: Air Quality Monitoring Summary for NETN

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 miles S of Mt. Moosilauke, NH	NH02	Howland, ME 45 miles E of Monson, ME	HOW132	Bridgton, ME 30 miles S of Goose Eye Mountain, ME	BRME1	Mt. Greylock, MA within 5 miles	250034002
	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

APPENDIX D: Air Quality Monitoring Summary for NETN

PARK	NADP/NTN		CASTNet		IMPROVE		OZONE	
APPA	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
							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		

APPENDIX D: Air Quality Monitoring Summary for NETN

PARK	NADP/NTN		CASTNet		IMPROVE		OZONE	
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		
					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				

APPENDIX D: Air Quality Monitoring Summary for NETN

PARK	NADP/NTN		CASTNet		IMPROVE		OZONE	
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		
					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

APPENDIX F: Monitoring programs adjacent to Northeast Temperate Network Parks

Park Organization Program Names

Acadia National Park

GoMoos
Pine Shoot Beetle (*Tomicus piniperda*)

Audubon

North American Breeding Bird Survey

Casco Bay Estuary Project

Casco Bay Lobster Tissue Analysis
Casco Bay Wildlife Areas/Protected Lands Mapping
Eel Grass Project
Mussel Tissue Analysis
Sediment Sampling
Waterbird Survey

CSCOR/Coastal Ocean Program

ECOHAB Ecology and Oceanography of Harmful Algal Blooms
U.S. Global Ocean Ecosystem Dynamics (GLOBEC)

DIVISION OF ENVIRONMENTAL ASSESSMENT (ME DEC)

SURFACE WATER AMBIENT TOXIC

Forest Inventory and Analysis

Forest Health Monitoring

FYI Canadian alliance

ST. CROIX ESTUARY PROJECT

Gulf of Maine Council on the Marine Environment

Gulfwatch

Institute for Bird Populations

Monitoring Avian Productivity and Survivorship

Maine Department of Marine Resources (MDMR)

Finfish Aquaculture Monitoring Program

Maine Shore Stewards

BEACH PROFILING PROJECT
Clean Water/Partners in Monitoring
Coastal Swim BEACH Monitoring
ME Phytoplankton Monitoring
Shellfish Sanitation Program
Stream Team Program

Mass Water Resources Authority

Boston Harbor Project

ME Audubon

IBA
Least Terns and Piping Plover
Loons
Maine Amphibian Monitoring Project

APPENDIX F: Monitoring programs adjacent to Northeast Temperate Network Parks

<i>Park</i>	<i>Organization</i>	<i>Program Names</i>
		ME Owl Survey Program
		Owl Survey
		Project Puffin
		Saw-whet Owl
		Vernal Pools
	<i>ME DEP</i>	Partners in Flight
		SWAT-Biological Monitoring of Lakes
		SWAT-Biological Monitoring of Loons
		SWAT-Biological Monitoring of Marine and Estuarine
		SWAT-Biological Monitoring of Rivers and Streams
		SWAT-Caged Mussel Study
	<i>ME Department of Inland Fisheries and Wildlife</i>	[Calling] Amphibian Monitoring
		Bald Eagle
		Black Bears
		Black Tern
		Blandings and Spotted Turtles
		Canada Lynx
		Clayton's Copper
		Coyote/Wolf
		Ecoregional Survey
		Freshwater Mussels
		Golden Eagle
		Grasshopper Sparrows
		Least Tern
		Marshbird Surveys
		Marten
		ME Amphibian and Reptile Atlas Project
		ME Colonial Waterbird Inventory: 19 species
		ME Partners in Flight
		Migratory Shorebird Surveys
		Moose
		New England Cottontail
		Partners in Amphibian and Reptile Conservation
		Penobscot Meadow Vole
		Perigrine Falcon
		Piping Plover
		Rare Butterflies
		Rare Dragonflies
		Roseate Tern
		Ruffed Grouse
		Rusty Blackbird
		Sharp-tailed Sparrows
		Tomah Mayfly

APPENDIX F: Monitoring programs adjacent to Northeast Temperate Network Parks

<i>Park</i>	<i>Organization</i>	<i>Program Names</i>
		Turkey
		Vernal Pools
		Waterfowl: 15+ species
		Whitetail Deer
		Wood Cock
		Wood Turtles
	<i>ME Forest Service Forest Health/ Monitoring Div.</i>	Hemlock Woolly Adelgid
	<i>ME NAP</i>	Aquatic Vegetation Surveys of Selected ME Lakes
		Furbish Louswort
		Management of Invasive Non-native Plants in Maine
		Natural Community
		Volunteer Lake Monitoring Program
	<i>ME Tribal Community</i>	Penobscot FOREST MANAGEMENT
		Penobscot Water Quality Program
	<i>ME Tribal Community (w/US EPA)</i>	Penobscot Air Program
	<i>MERI</i>	Toxic Chemicals in Gulf of Maine Seals
	<i>NADP</i>	MDN
		NADP/NTN
	<i>NESCAUM-ME</i>	Northeast States for Coordinated Air Use Management
	<i>NHP ME</i>	Aquatic Vegetation Surveys of Selected Maine Lakes
		Aquatic Vegetation Surveys: mussels
		Management of Invasive Non-native Plants in Maine
		Vegetation Mapping of Acadia NF Internal
	<i>NOAA - National Status and Trends Program</i>	Mussel Watch
	<i>NOAA @ Narragansett</i>	MARMAP
	<i>NOAA National Estuarine Research Reserve System</i>	NERR Wells Bay
		System-wide Monitoring Program
	<i>NOAA NS&T</i>	National Benthic Surveillance Project
	<i>Sea Grant ME</i>	Paralytic Shellfish Poisoning Monitoring Program
	<i>The Lobster Conservancy</i>	Intertidal Lobster Monitoring Program
	<i>U.S. Forest Service Forest Pest Management</i>	

APPENDIX F: Monitoring programs adjacent to Northeast Temperate Network Parks

<i>Park</i>	<i>Organization</i>	<i>Program Names</i>
		Forest Insect and Disease Conditions in the United States
	<i>USACOE New England District</i>	DAMOS
	<i>USDA-NRCS</i>	National Resources Inventory
	<i>USFWS</i>	Atlantic Salmon Watersheds, Maine: Habitat Identification and Protection Project Casco Bay, Maine: Habitat Identification and Protection Project Coastal Nesting Islands, Maine Habitat Identification and Protection Gulf of Maine Watershed Habitat Analysis Habitat Restoration in Maine National Wetlands Inventory: Gulf of Maine Rivers Ecosystem Team
	<i>USGS ARMI</i>	Stream Salamanders Vernal Pools
	<i>USGS Mapping Division</i>	National Land Use and Land Cover Mapping Program
Appalachian National Scenic Trail		
	<i>Baxter State Park</i>	Monitoring Bicknell's Thrush
	<i>DIVISION OF ENVIRONMENTAL ASSESSMENT (ME DEC)</i>	SURFACE WATER AMBIENT TOXIC
	<i>Forest Inventory and Analysis</i>	Forest Health Monitoring
	<i>Institute for Bird Populations</i>	Monitoring Avian Productivity and Survivorship
	<i>Maine Shore Stewards</i>	Clean Water/Partners in Monitoring Stream Team Program
	<i>ME Audubon</i>	IBA Loons Maine Amphibian Monitoring Project ME Owl Survey Program Owl Survey Saw-whet Owl Vernal Pools
	<i>ME DEP</i>	Partners in Flight SWAT-Biological Monitoring of Lakes SWAT-Biological Monitoring of Loons SWAT-Biological Monitoring of Rivers and Streams SWAT-Caged Mussel Study
	<i>ME Department of Inland Fisheries and Wildlife</i>	[Calling] Amphibian Monitoring

APPENDIX F: Monitoring programs adjacent to Northeast Temperate Network Parks

<i>Park</i>	<i>Organization</i>	<i>Program Names</i>
		Bald Eagle
		Black Bears
		Blandings and Spotted Turtles
		Canada Lynx
		Clayton's Copper
		Coyote/Wolf
		Ecoregional Survey
		Freshwater Mussels
		Golden Eagle
		Grasshopper Sparrows
		Marshbird Surveys
		Marten
		ME Amphibian and Reptile Atlas Project
		ME Partners in Flight
		Moose
		New England Cottontail
		Partners in Amphibian and Reptile Conservation
		Penobscot Meadow Vole
		Perigrine Falcon
		Rare Butterflies
		Rare Dragonflies
		Ruffed Grouse
		Rusty Blackbird
		Sharp-tailed Sparrows
		Tomah Mayfly
		Turkey
		Vernal Pools
		Waterfowl: 15+ species
		Whitetail Deer
		Wood Cock
		Wood Turtles
	<i>ME Forest Service Forest Health/ Monitoring Div.</i>	Hemlock Woolly Adelgid
		Pine Shoot Beetle (<i>Tomicus piniperda</i>)
	<i>ME NAP</i>	Aquatic Vegetation Surveys of Selected ME Lakes
		Management of Invasive Non-native Plants in Maine
		Natural Community
		Small-whorled Pogonia
		Volunteer Lake Monitoring Program
	<i>ME Tribal Community</i>	Penobscot FOREST MANAGEMENT
		Penobscot Water Quality Program
	<i>ME Tribal Community (w/US EPA)</i>	Penobscot Air Program

APPENDIX F: Monitoring programs adjacent to Northeast Temperate Network Parks

Park Organization Program Names

NADP

AIRMoN
MDN
NADP/NTN

NESCAUM-Regional

Northeast States for Coordinated Air Use Management

NHP CT

Butterfly Atlas-Via Peabody Museum: Of Interest?
Rare Animal Species
Rare Plant Species
Whip-poor-Will and Nighthawk Survey

NHP MA

Natural Communities
Natural Heritage & Endangered Species Program Rare Invertebrates
Natural Heritage & Endangered Species Program Rare Plant Species
Natural Heritage & Endangered Species Program: Rare Vertebrate Species
Natural Heritage & Endangered Species Program: Vernal Pools
Rare Animal Species
Rare Plant Species
Vernal Pools

NHP MD

Ancient xeric sand dunes
Appalachian Plateau wetlands
Bald Eagle Nest
Bog Turtle
Butterflies
Circumneutral seepage wetlands
Colonial Waterbirds
Delmarva Fox Squirrel
Dragonflies
Freshwater Mussels
Ground Water Fauna
Herps
Limestone glades and woodlands
Mixed-mesophytic forests
Nanticoke River watershed communities
Northern Piedmont bogs
Peregrine Falcon Nest
Potomac drainage floodplain forests
Rare Freshwater Fish
Rare Plants
River scour communities
Sandstone glades
Shale barren habitats
Small Mammals

APPENDIX F: Monitoring programs adjacent to Northeast Temperate Network Parks

<i>Park</i>	<i>Organization</i>	<i>Program Names</i>
	<i>NHP ME</i>	Aquatic Vegetation Surveys of Selected Maine Lakes Aquatic Vegetation Surveys: mussels Management of Invasive Non-native Plants in Maine Three EcoReserves ???
	<i>NHP NH</i>	Natural Communities Rare Animal Species Rare Plant Species
	<i>NHP NJ</i>	
		Rare Plants and Animals
	<i>NHP NY</i>	
		Herp Atlas: Static? Natural Communities Rare Animal Species Rare Plant Species
	<i>NHP VA</i>	
		Invasive Plants Natural Communities Rare Animals Rare Plants
	<i>NHP VT</i>	
		Natural Communities Rare Animal Species Rare Plant Species
	<i>U.S. Forest Service Forest Pest Management</i>	Forest Insect and Disease Conditions in the United States
	<i>USDA-NRCS</i>	
		National Resources Inventory
	<i>USFWS</i>	
		Gulf of Maine Watershed Habitat Analysis
	<i>USGS ARMI</i>	
		Stream Salamanders The Great Smoky Mountains National Park Inventory and Monitoring Project Vernal Pools
	<i>Vermont Department of Environmental Conservation</i>	
		Ambient Air Toxics Monitoring
	<i>Vermont Monitoring Cooperative</i>	
		FOREST BIRD MONITORING Several
	<i>VT Institute of Natural Science</i>	
		Vermont Butterfly Survey
Boston Harbor Islands National Recreation Area		
	<i>CSCOR/Coastal Ocean Program</i>	
		ECOHAB Ecology and Oceanography of Harmful Algal Blooms

APPENDIX F: Monitoring programs adjacent to Northeast Temperate Network Parks

<i>Park</i>	<i>Organization</i>	<i>Program Names</i>
		U.S. Global Ocean Ecosystem Dynamics (GLOBEC)
		<i>Forest Inventory and Analysis</i>
		Forest Health Monitoring
		<i>Gulf of Maine Council on the Marine Environment</i>
		Mussel Analysis
		<i>Institute for Bird Populations</i>
		Monitoring Avian Productivity and Survivorship
		<i>MA Audubon</i>
		IBA
		<i>MA DEP</i>
		Wetlands Conservancy Program
		<i>MA DEP Wetlands Conservancy Program</i>
		Eelgrass Mapping
		<i>MA Office of Coastal Zone Management</i>
		1999-2004: Cape Cod Salt Marsh Assessment Project
		Coastal 2000 - Comprehensive Marine Monitoring Program
		Massachusetts Historic Shoreline Change Project
		North Shore Wetland Assessment Project
		The Coastal Nonpoint Source Pollution Control Program
		Wetland Ecological Integrity: An Assessment Approach
		Wetland Ecology and Assessment
		<i>NADP</i>
		NADP/NTN
		<i>NESCAUM-MA</i>
		Northeast States for Coordinated Air Use Management
		<i>NHP MA</i>
		Natural Communities
		Natural Heritage & Endangered Species Program Rare Invertebrates
		Natural Heritage & Endangered Species Program Rare Plant Species
		Natural Heritage & Endangered Species Program: Natural Communities
		Natural Heritage & Endangered Species Program: Rare Vertebrate Species
		Natural Heritage & Endangered Species Program: Vernal Pools
		Rare Animal Species
		Rare Plant Species
		Vernal Pools
		<i>NOAA - National Status and Trends Program</i>
		Mussel Watch
		<i>NOAA National Estuarine Research Reserve System</i>
		NERR Narragansett Bay
		NERR Waquoit Bay
		System-wide Monitoring Program
		<i>NOAA NS&T</i>
		National Benthic Surveillance Project
		<i>Sea Grant MA</i>
		Paralytic Shellfish Poisoning Monitoring Program

APPENDIX F: Monitoring programs adjacent to Northeast Temperate Network Parks

Park	Organization	Program Names
	<i>U.S. Forest Service</i>	<i>Forest Pest Management</i> Forest Insect and Disease Conditions in the United States
	<i>USACOE New England District</i>	DAMOS
	<i>USDA-NRCS</i>	National Resources Inventory
	<i>USFWS</i>	Gulf of Maine Watershed Habitat Analysis
	<i>USGS ARMI</i>	Stream Salamanders Vernal Pools
	<i>USGS National Water Quality Assessment Program</i>	river quality
Marsh-Billings-Rockefeller National Historical Park		
	<i>Audubon</i>	North American Breeding Bird Survey
	<i>Forest Inventory and Analysis</i>	Forest Health Monitoring
	<i>Institute for Bird Populations</i>	Monitoring Avian Productivity and Survivorship
	<i>NADP</i>	AIRMoN NADP/NTN
	<i>NESCAUM-VT</i>	Northeast States for Coordinated Air Use Management
	<i>NHP VT</i>	Natural Communities Rare Animal Species Rare Plant Species
	<i>U.S. Forest Service</i>	<i>Forest Pest Management</i> Forest Insect and Disease Conditions in the United States
	<i>USDA</i>	National Resources Inventory
	<i>USGS ARMI</i>	Stream Salamanders Vernal Pools
	<i>Vermont Department of Environmental Conservation</i>	Ambient Air Toxics Monitoring
	<i>Vermont Monitoring Cooperative</i>	FOREST BIRD MONITORING Several
	<i>VT Audubon</i>	IBA
	<i>VT Institute of Natural Science</i>	Vermont Butterfly Survey

APPENDIX F: Monitoring programs adjacent to Northeast Temperate Network Parks

Park Organization Program Names

Minute Man National Historical Park

Audubon

North American Breeding Bird Survey

Forest Inventory and Analysis

Forest Health Monitoring

Institute for Bird Populations

Monitoring Avian Productivity and Survivorship

MA Audubon

IBA

MA DEP

Wetlands Conservancy Program

NADP

NADP/NTN

NESCAUM-MA

Northeast States for Coordinated Air Use Management

NHP MA

Natural Communities

Natural Heritage & Endangered Species Program Rare Invertebrates

Natural Heritage & Endangered Species Program Rare Plant Species

Natural Heritage & Endangered Species Program: Natural Communities

Natural Heritage & Endangered Species Program: Rare Vertebrate Species

Natural Heritage & Endangered Species Program: Vernal Pools

Rare Animal Species

Rare Plant Species

Vernal Pools

U.S. Forest Service Forest Pest Management

Forest Insect and Disease Conditions in the United States

USDA-NRCS

National Resources Inventory

USFWS

Gulf of Maine Watershed Habitat Analysis

USGS ARMI

Stream Salamanders

Vernal Pools

Morristown National Historical Park

Forest Inventory and Analysis

Forest Health Monitoring-Not Started

Institute for Bird Populations

Monitoring Avian Productivity and Survivorship

NADP

NADP/NTN

NESCAUM-NJ

Northeast States for Coordinated Air Use Management

NHP NJ

APPENDIX F: Monitoring programs adjacent to Northeast Temperate Network Parks

<i>Park</i>	<i>Organization</i>	<i>Program Names</i>
		Rare Plants and Animals
	<i>NJ Audubon</i>	
		IBA
	<i>U.S. Forest Service</i>	<i>Forest Pest Management</i>
		Forest Insect and Disease Conditions in the United States
	<i>USDA-NRCS</i>	
		National Resources Inventory
	<i>USGS ARMI</i>	
		Stream Salamanders
		Vernal Pools

Roosevelt-Vanderbilt National Historic Sites

	<i>Forest Inventory and Analysis</i>	Forest Health Monitoring
	<i>Institute for Bird Populations</i>	Monitoring Avian Productivity and Survivorship
	<i>NADP</i>	
		AIRMoN
		MDN
		NADP/NTN
	<i>NESCAUM-NY</i>	
		Northeast States for Coordinated Air Use Management
	<i>NHP NY</i>	
		Herp Atlas: Static?
		Natural Communities
		Rare Animal Species
		Rare Plant Species
	<i>NY Audubon</i>	
		IBA
	<i>U.S. Forest Service</i>	<i>Forest Pest Management</i>
		Forest Insect and Disease Conditions in the United States
	<i>USDA-NRCS</i>	
		National Resources Inventory
	<i>USGS ARMI</i>	
		Stream Salamanders
		Vernal Pools

Saint-Gaudens National Historic Site

	<i>Audubon</i>	North American Breeding Bird Survey
	<i>Forest Inventory and Analysis</i>	Forest Health Monitoring
	<i>Institute for Bird Populations</i>	Monitoring Avian Productivity and Survivorship
	<i>NADP</i>	
		NADP/NTN

APPENDIX F: Monitoring programs adjacent to Northeast Temperate Network Parks

<i>Park</i>	<i>Organization</i>	<i>Program Names</i>
	<i>NESCAUM-NH</i>	Northeast States for Coordinated Air Use Management
	<i>NH Audubon</i>	IBA
	<i>NHP NH</i>	Natural Communities Rare Animal Species Rare Plant Species
	<i>U.S. Forest Service</i>	<i>Forest Pest Management</i> Forest Insect and Disease Conditions in the United States
	<i>USDA-NRCS</i>	National Resources Inventory
	<i>USFWS</i>	Gulf of Maine Watershed Habitat Analysis
	<i>USGS ARMI</i>	Stream Salamanders Vernal Pools
	<i>Vermont Department of Environmental Conservation</i>	Ambient Air Toxics Monitoring
	<i>Vermont Monitoring Cooperative</i>	FOREST BIRD MONITORING
	<i>VT Institute of Natural Science</i>	Vermont Butterfly Survey
Saugus Iron Works National Historic Site		
	<i>Audubon</i>	North American Breeding Bird Survey
	<i>Forest Inventory and Analysis</i>	Forest Health Monitoring
	<i>Institute for Bird Populations</i>	Monitoring Avian Productivity and Survivorship
	<i>MA Audubon</i>	IBA
	<i>MA DEP</i>	Wetlands Conservancy Program
	<i>NADP</i>	NADP/NTN
	<i>NESCAUM-MA</i>	Northeast States for Coordinated Air Use Management
	<i>NHP MA</i>	Natural Communities Natural Heritage & Endangered Species Program Rare Invertebrates Natural Heritage & Endangered Species Program Rare Plant Species Natural Heritage & Endangered Species Program: Natural Communities Natural Heritage & Endangered Species Program: Rare Vertebrate Species Natural Heritage & Endangered Species Program: Vernal Pools

APPENDIX F: Monitoring programs adjacent to Northeast Temperate Network Parks

<i>Park</i>	<i>Organization</i>	<i>Program Names</i>
		Rare Animal Species
		Rare Plant Species
		Vernal Pools
	<i>U.S. Forest Service</i>	<i>Forest Pest Management</i>
		Forest Insect and Disease Conditions in the United States
	<i>USACOE New England District</i>	DAMOS
	<i>USDA-NRCS</i>	
		National Resources Inventory
	<i>USFWS</i>	
		Gulf of Maine Watershed Habitat Analysis
	<i>USGS ARMI</i>	
		Stream Salamanders
		Vernal Pools

Saratoga National Historical Park

	<i>Forest Inventory and Analysis</i>	Forest Health Monitoring
	<i>Institute for Bird Populations</i>	Monitoring Avian Productivity and Survivorship
	<i>NADP</i>	
		AIRMoN
		MDN
		NADP/NTN
	<i>NESCAUM-NY</i>	
		Northeast States for Coordinated Air Use Management
	<i>NHP NY</i>	
		Herp Atlas: Static?
		Natural Communities
		Rare Animal Species
		Rare Plant Species
	<i>NY Audubon</i>	
		IBA
	<i>U.S. Forest Service</i>	<i>Forest Pest Management</i>
		Forest Insect and Disease Conditions in the United States
	<i>USDA-NRCS</i>	
		National Resources Inventory
	<i>USGS ARMI</i>	
		Stream Salamanders
		Vernal Pools

Weir Farm National Historic Site

	<i>CT Audubon</i>	IBA
	<i>CT DEC / USEPA</i>	
		Air Toxics in New England: Ambient Air Monitoring Special Projects

APPENDIX F: Monitoring programs adjacent to Northeast Temperate Network Parks

<i>Park</i>	<i>Organization</i>	<i>Program Names</i>
		Air Toxics in New England: Dioxin Monitoring
		Air Toxics in New England: Photochemical Assessment Monitoring
		Air Toxics in New England: Stack Monitoring
		Air Toxics in New England:Mercury Monitoring
		<i>Forest Inventory and Analysis</i>
		Forest Health Monitoring
		<i>Institute for Bird Populations</i>
		Monitoring Avian Productivity and Survivorship
		<i>MA DEP / USEPA</i>
		Air Toxics in New England
		<i>NADP</i>
		NADP/NTN
		<i>NESCAUM-CT</i>
		Northeast States for Coordinated Air Use Management
		<i>NHP CT</i>
		Butterfly Atlas-Via Peabody Museum: Of Interest?
		Rare Animal Species
		Rare Plant Species
		Whip-poor-Will and Nighthawk Survey
		<i>U.S. Forest Service Forest Pest Management</i>
		Forest Insect and Disease Conditions in the United States
		<i>USACOE New England District</i>
		DAMOS
		<i>USDA-NRCS</i>
		National Resources Inventory
		<i>USGS ARMI</i>
		Stream Salamanders
		Vernal Pools