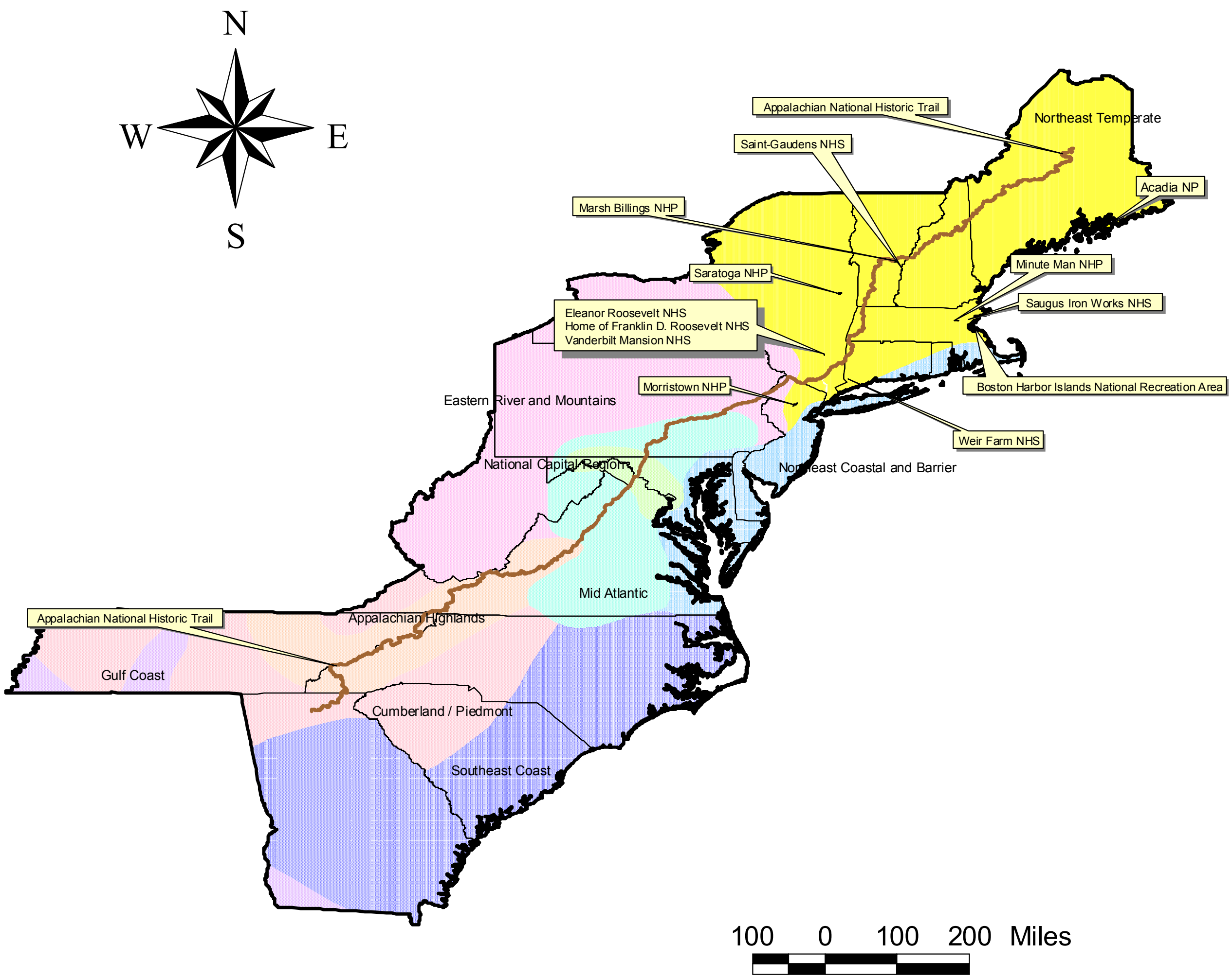
Phase I Vital Signs Monitoring Plan for the Northeast Temperate Network

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.

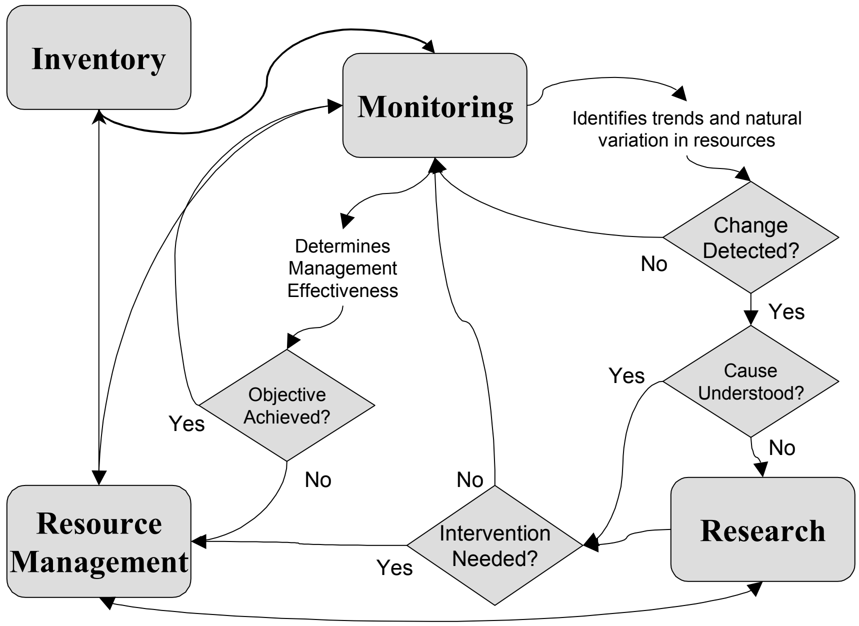

Figure 1.1. Relationships between monitoring, inventories, research, and natural resource management activities in national parks (modifed from Jenkins et al. 2002).

1.2.2 Vital Signs Monitoring Goals

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

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

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 conjuction with the U.S. Army Corps of Engineers, South Florida Water Management District, and other partners, may select a completely different set of indicators and sampling protocols appropriate to restoration of the everglades ecosystem.

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

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 Design										
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.

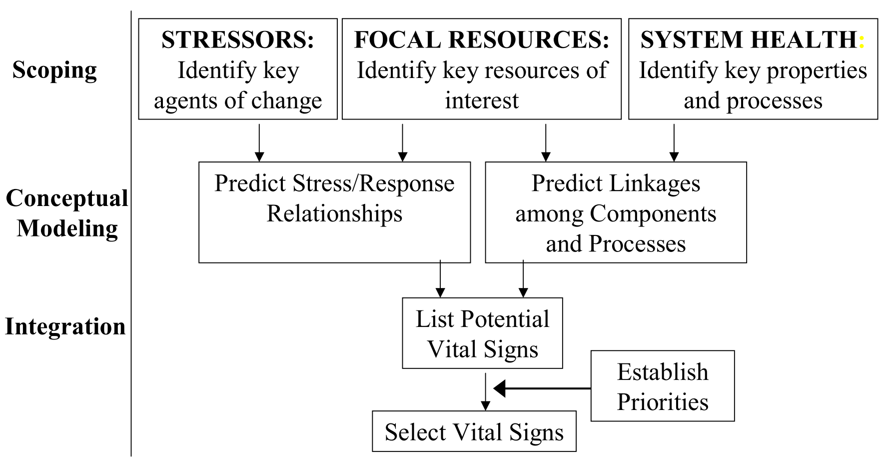

Figure 1.2. Basic approach to identifying and selecting vital signs for integrated monitoring of park resources (source: Kurt Jenkins, USGS Olympic Field Station).

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 initiaitive 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

DATE/PLACE	*PARKS*	*PARTICIPANTS*	*PURPOSE*
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**.

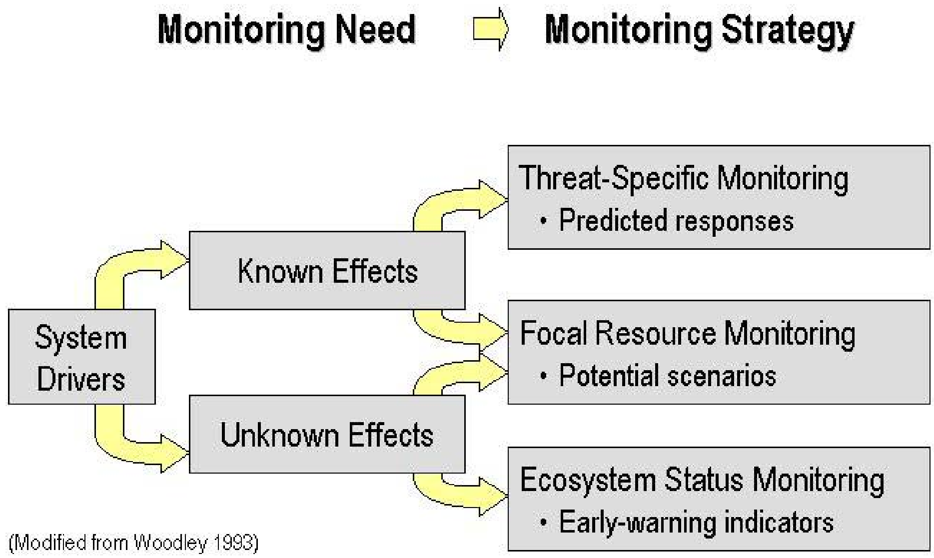

Figure 1.3. Conceptual approach for selecting monitoring indicators.

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.

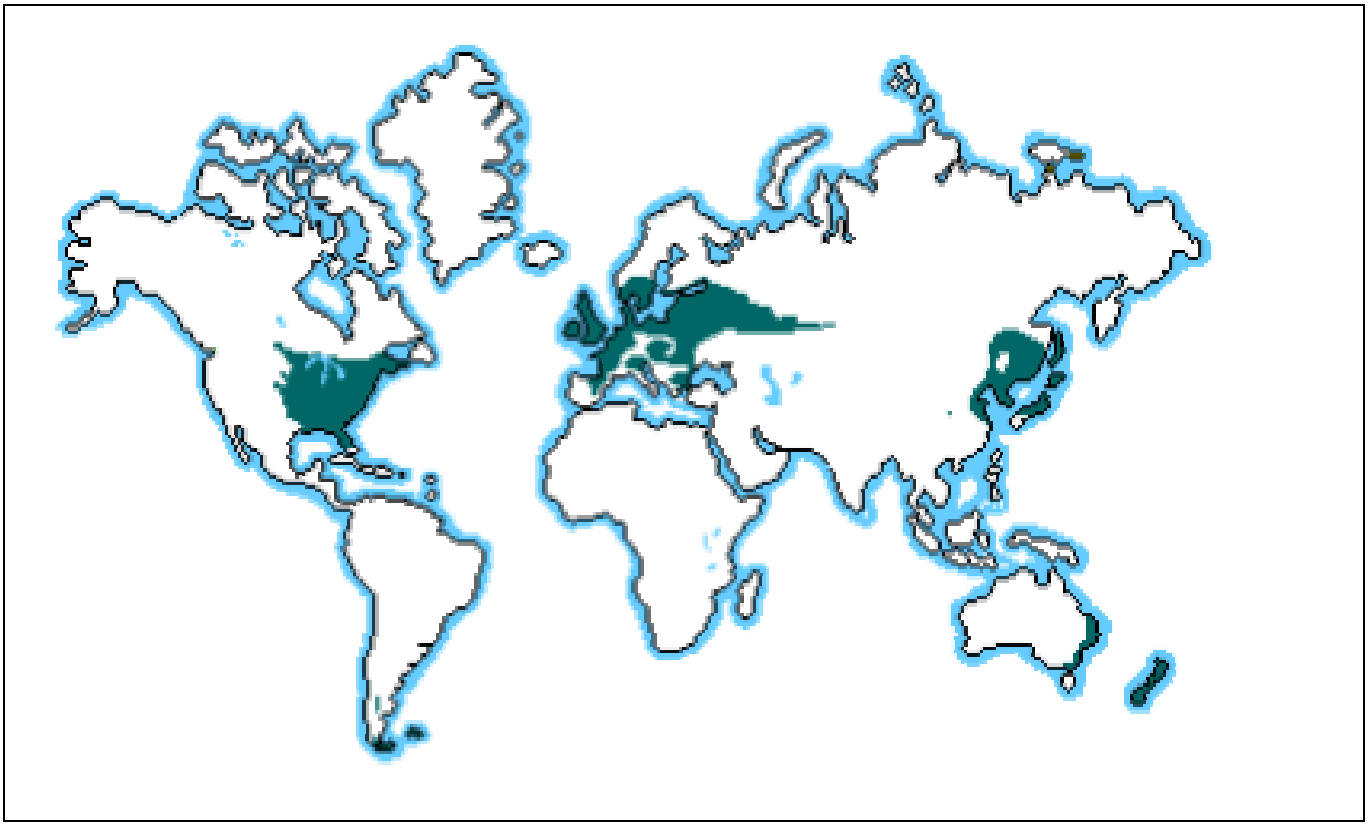

Figure 1.4. Global distribution of broadleaf deciduous forest.

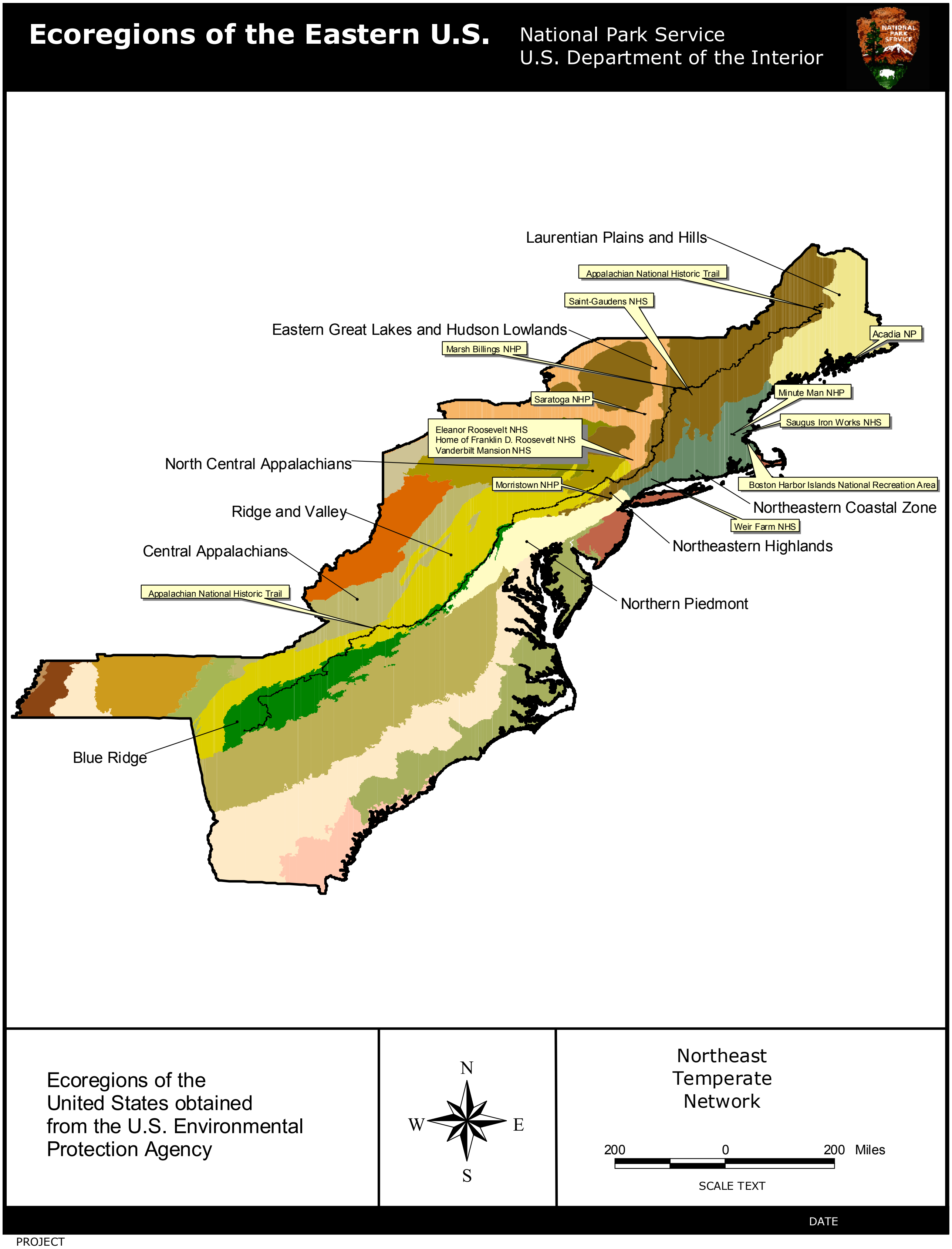

Figure 1.5. Location of NETN parks with respect to the ecoregions of the eastern US.

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 ≈ 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			2	1	0	1	2	2	1	0	0	1	2
		Laurentian-Acadian Acidic Swamp	CES201.574											
		Laurentian-Acadian Alkaline Swamp	CES201.575											
		North-Central Appalachian Acidic Swamp	CES202.604											
		North-Central Interior and Appalachian Rich Swamp	CES202.605											
	floodplain forest			0	1	2	0	2	2	1	0	2	1	0
		Laurentian-Acadian Floodplain Forest	CES201.587											
		Central Appalachian Floodplain	CES202.608											
		Central Appalachian Riparian	CES202.609											
Open/Shrub Wetlands-peatlands														
	peatland			2	1	0	0	1	0	0	0	0	0	0
		Acadian Maritime Bog	CES201.580											
		Laurentian-Acadian Acidic Basin Fen	CES201.583											

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
		Laurentian-Acadian Wet Meadow-Shrub Swamp and Marsh	CES201.577											
Tidal Wetlands														
	rocky shore			2	0	2	0	0	0	1	0	0	0	0
		Acadian-North Atlantic Rocky Coast	CES201.573											
		North Atlantic Rocky Intertidal	CES201.048	2										
	salt marsh			2	0	2	0	0	0	0	0	0	0	0
		Acadian Coastal Salt Marsh	CES201.578											
		Acadian Estuary Marsh	CES201.579	2										
	cobble beach	North Atlantic Cobble Shore	CES201.051	1	0	2	0	0	0	0	0	0	0	0
	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
		Mudflat												
		North Atlantic Tidal Sand Flat	CES201.049											
Upland Forests														
	deciduous forest			2	1	1	2	2	2	2	2	1	2	2
		Boreal Aspen-Birch Forest	CES103.020											
		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											
		Acadian Montane Spruce-Fir-Hardwood Forest	CES201.566											
	hemlock, mixed forest			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 ridgetop shrubland	Laurentian-Acadian Acidic Rocky Outcrop	CES201.571	2	2	0	0	0	0	0	0	0	0	0
	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, *e.g.*, measure of fragmentation/ patchiness, measure of genetic connectivity)	√	√
	condition of the surrounding landscape (*i.e.,* 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 interdemic 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 ≈ 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**
Air Quality											
Acid Deposition	2	2	1	2	1	2	1	2	1	1	1
Ozone	2	2	1	1	2	2	1	2	1	2	1
Visibility	2	2	1	1	1	2	1	1	1	1	1
External Development											
Cell 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	
Visitor Impacts											
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	
Contaminants/Toxics											
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	
Natural Disasters											
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	
Internal Park Development	1	1	1	0	0	0	1	0	1	1	0
Nuisance Wildlife											
Beaver	2	1	0	1	2	0	1	0	0	1	0
Raccoons	2	0	1	0	1	1	1	1	1	1	0
Fox	1	0	1	0	1	0	0	0	0	0	0
Feral cats/dogs	1	0	1							1	
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
Pest Species (parasites/pathogens)											
Asian Long-Horn Beetle	1	1	0	1	1	2	0	2	1	1	2
Gypsy Moth	1	2	0	1	2	2	1	1	1	1	1
Hemlock wooly adelgid	2	2	0	1	2	2	2	2	0	1	2
Lyme Disease	2	2	1	1	2	2	2	1	1	2	2

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	
Water Quality											
Agricultural Runoff	1	1	0	1	1	0	0	2	0	1	0
Eutrophication	2	1	0	1	1	0	1	2	2	1	1
Land use change	2	2	0	0	2	2	2	2	2	2	1
Non-point pollution	2	1	2	1	1	2	2	2	2	1	1
Nutrient Loading	2	1	2	1	1	0	2	2	2	1	1
Point pollution	1	2	2	0	1	2	0	1	2	0	0
Road Runoff	1	1	0	1	1	1	1	2	2	1	1
Sedimentation	1	1	1	2	1	1	1	2	2	1	1
Stream bank erosion	1	1	0	1	1	1	0	2	1	1	1
Wastewater treatment	0	1	1	0	1	0	1	0	2	0	0
Climate Change											
Coastal erosion	1	0	2	0	0	0	0	0	0	0	0
Alpine recession	2	2	0	0	0	0	0	0	0	0	0
Sea level rise		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) the have large scale influences on the attributes of natural systems" (Leibfreid 2003). We have divided ecosystem drivers in to 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).

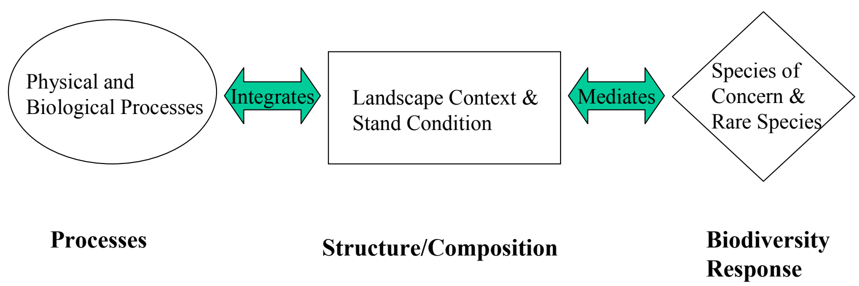

Figure 2.1. Basis for the conceptual models developed for the NETN. The model emphasizes how structural and compositional attributes integrate physical and biological processes/functions (drivers) and mediate the biodiversity response of focal and other species of interest. Adapted from Noon (2003).

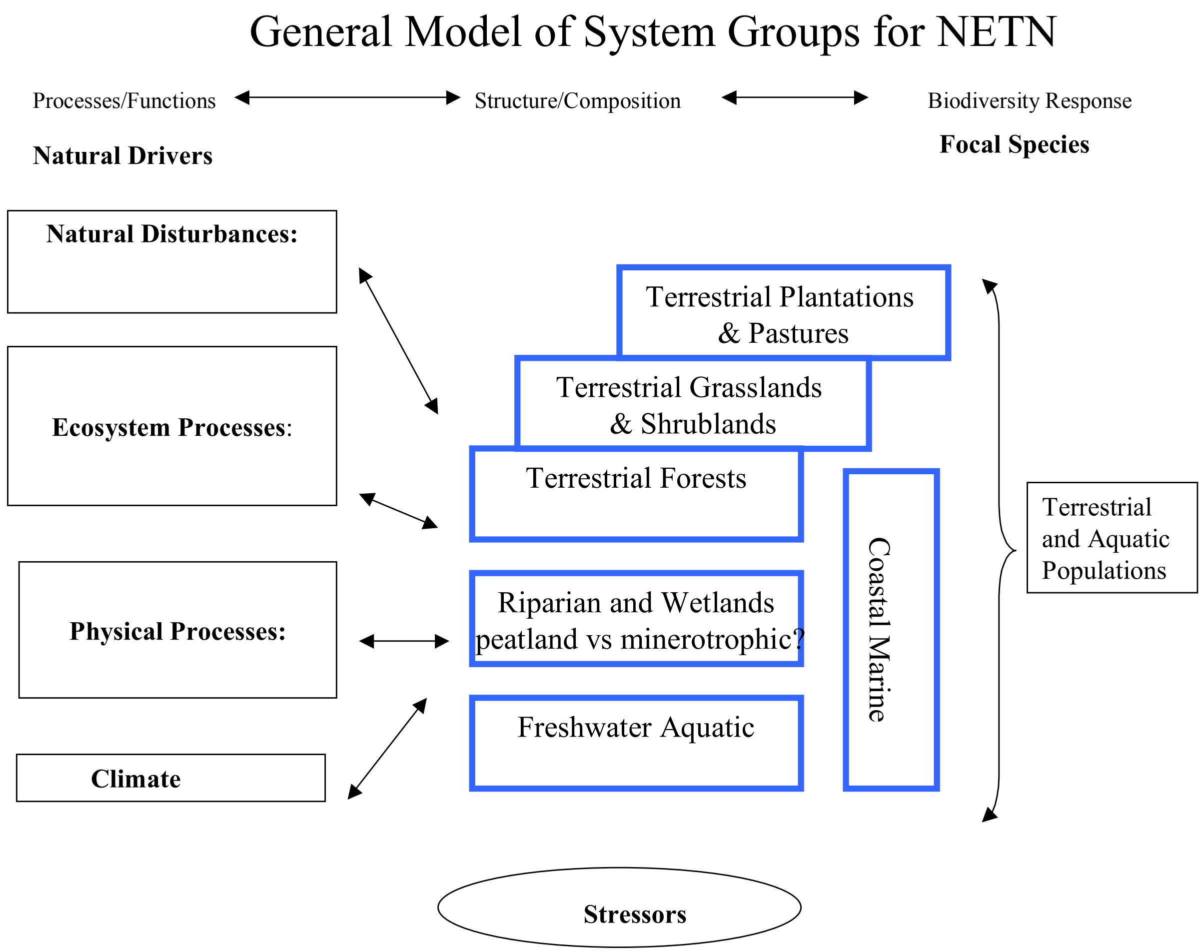

Figure 2.2. Conceptual model for terrestrial ecological systems in the NETN. The model may well emphasizes how structural and compositional attributes integrate physical and biological processes/functions (drivers) and mediate the biodiversity response of focal and other species of interest. Adapted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

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 byNoon (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

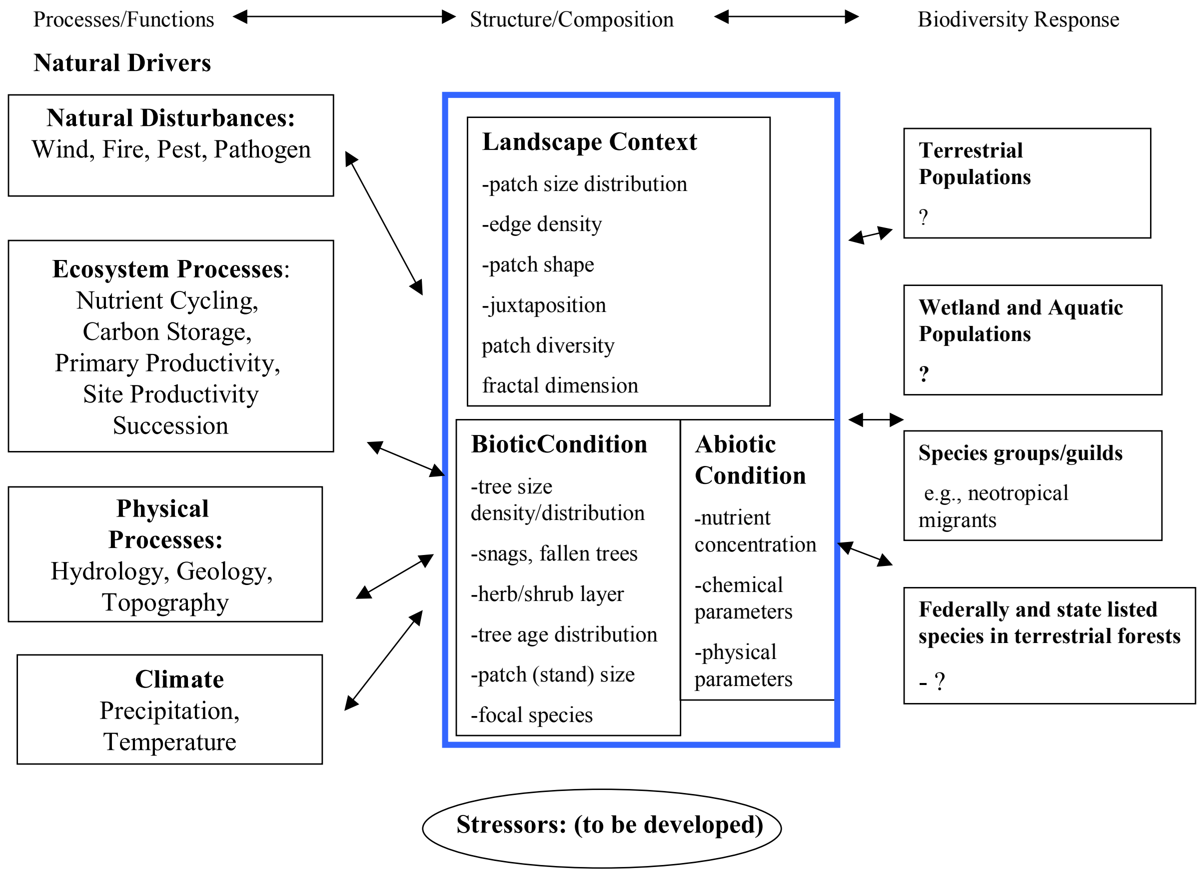

Figure 2.3. Conceptual Model that displays the interaction among individual system models (as displayed in Fig. 2.2).

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 jeffersonianaum*). 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 succesional, 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 decadally 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 the 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 $m^2\ ha^{-1}$ to 60 $m^2\ ha^{-1}$ (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 m^2 ha^{-1} to 25 m^2 ha^{-1} for old growth hemlock-hardwood forests. Basal area above 70 cm dbh ranges from zero to 10 m^2 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 seedings, 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 m^3 ha^{-1} to 300 m^3 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 m^2 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 indictor 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 were 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 (Kizlinski et al. 2002). Therefore, the effects of hemlock wooly 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 *Xylococculus 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).

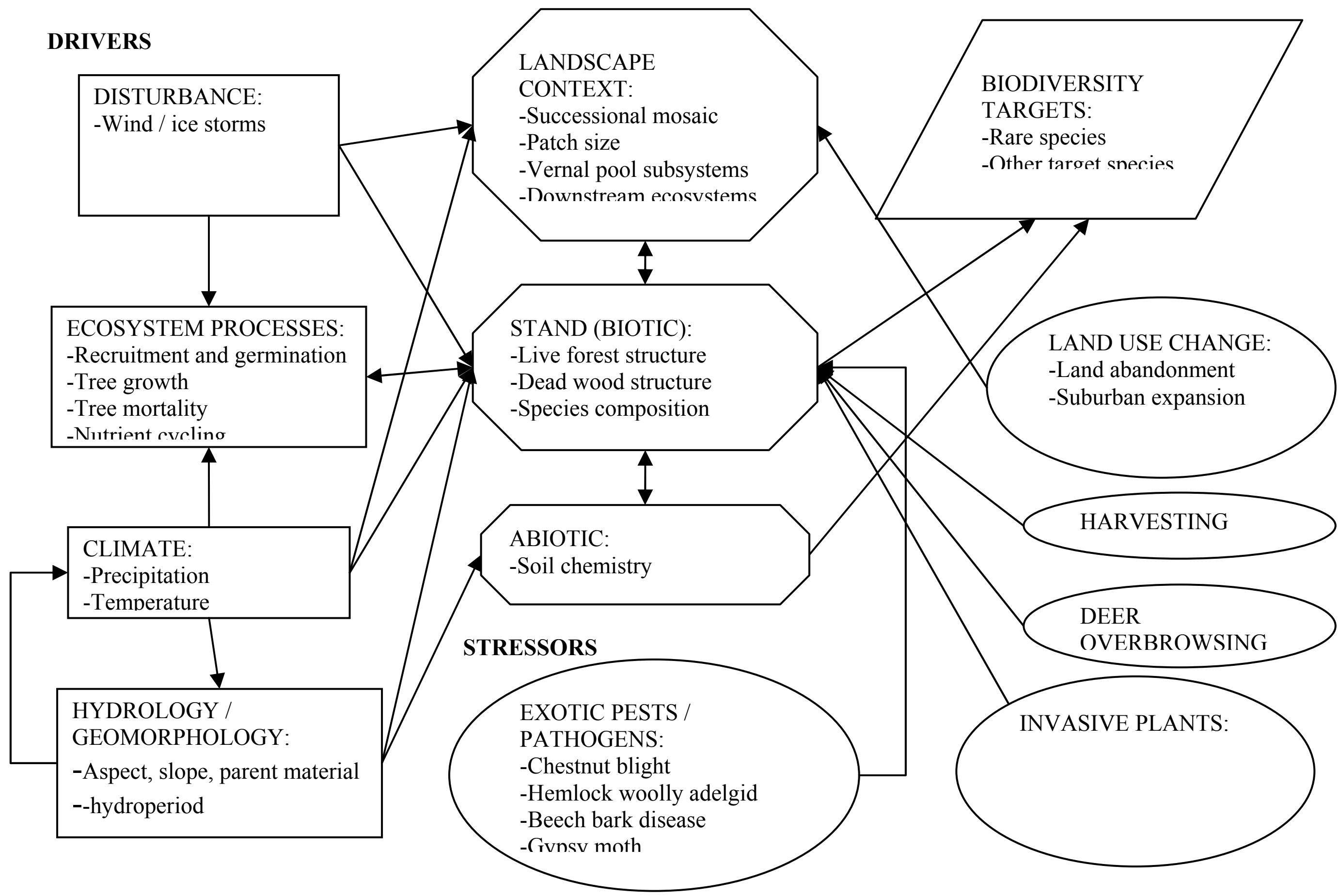

Figure 2.4. Conceptual model of an Eastern-Hemlock-Hardwood ecological community showing natural drivers, stressors, and potential attributes.

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					
		Distance to nearest road					
Biotic Condition	Live forest structure	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					
		Volume of snags					
	Species composition	% 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 m^2 and the range of maximum volume was 6-506 m^3. Hydroperiod was weakly related to pool shape, in that pools greater than 0.5 m in depth and 1,000 m^2 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 a 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 in 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.

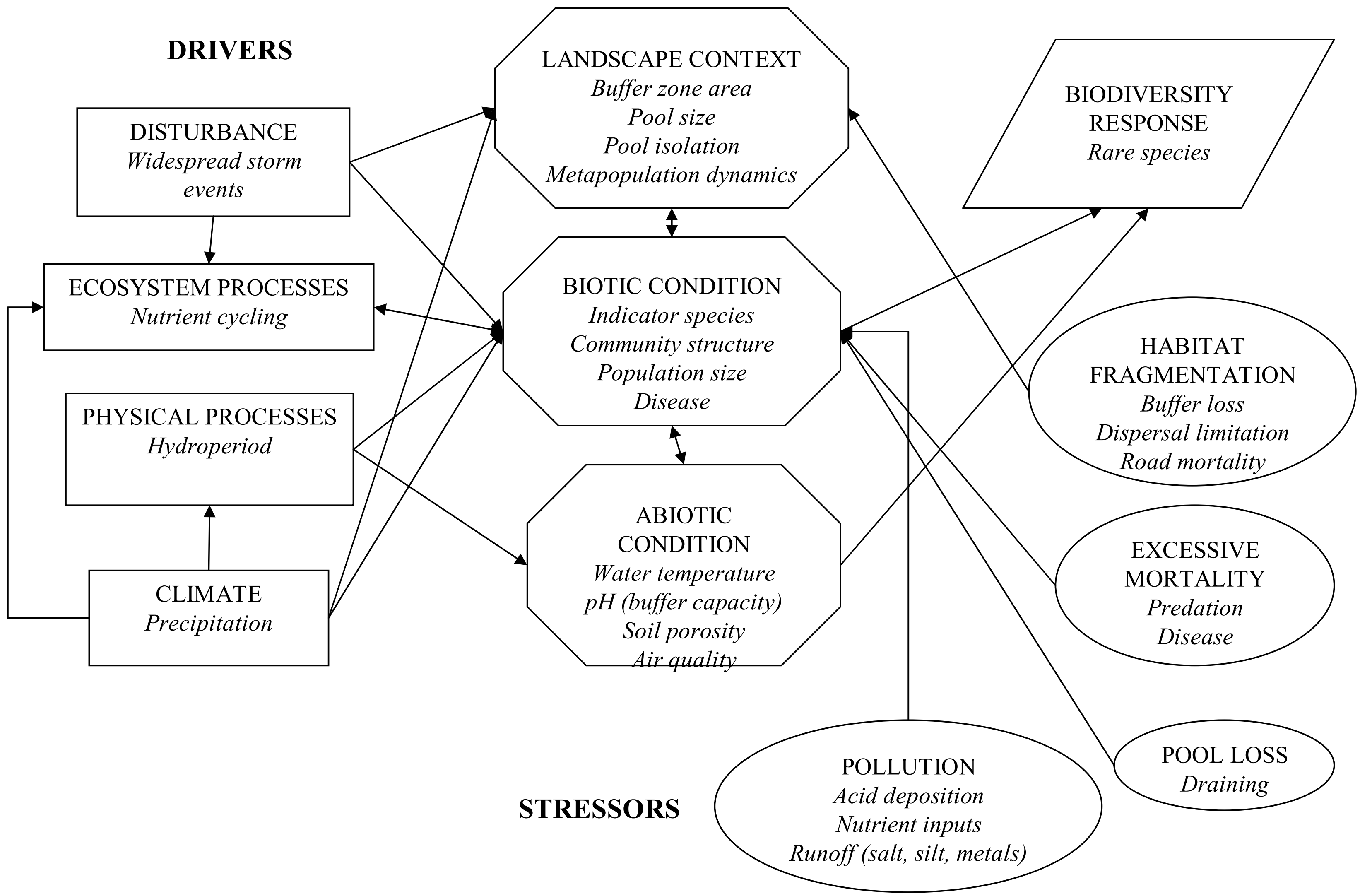

Figure 2.5. Conceptual model of a vernal pool sub-system with natural drivers, stressors, and attributes.

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	*Ambystoma 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 systems[1]

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	*Ambystoma laterale*
Spotted salamander	*Ambystoma maculatum*
Jefferson salamander	*Ambystoma jeffersonianum*
Marbled salamander	*Ambystoma opacum*
Wood frog	*Rana sylvatica*
Eastern spadefoot toad	*Scaphiopus holbrooki*
Fairy shrimp	Anostraca: *Eubranchipus spp.*

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	*Bufo americanus*
Fowler's toad	*Bufo woodhousii*
Four-toed salamander	*Hemidactylium scutatum*
Gray treefrog	*Hyla versicolor*
Spring peeper	*Pseudacris crucifer*
Green frog	*Rana clamitans melanota*
Pickerel frog	*Rana palustris*
Leopard frog	*Rana pipiens*
Red-spotted Newt	*Notophthalmus v. viridescens*
Snapping turtle	*Chelydra serpentina*
Spotted turtle	*Clemmys guttata*
Wood turtle	*Clemmys insculpta*
Painted turtle	*Chrysemys p. pictata*
Blanding's turtle	*Emydoidea blandingii*
Amphibious, air-breathing snails	Basommatophora
Dobsonfly larvae	Corydalidae
Predaceous diving beetle larvae	Dytiscidae
Whirligig beetle larvae	Gyrinidae
Leeches	Hirundinea
Dragonfly larvae	Odonata: *Anisoptera spp.*
Damselfly larvae	Odonata: *Zygoptera spp.*
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 Sudy 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 in 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

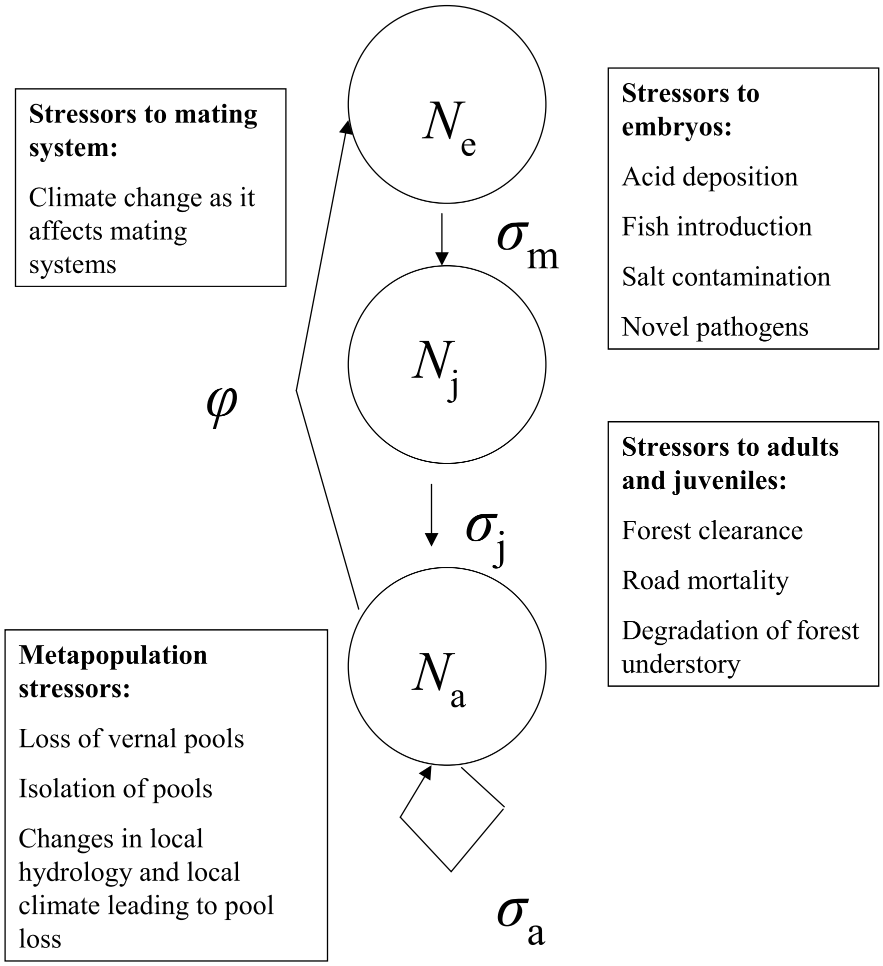

Figure 2.6. Life cycle diagram for Jefferson's salamander, where (N_e) = number of embryos, (N_j) = number of juveniles, and (N_a) = number of adults in a population and σ_a = adult annual survival rate, φ= average eggs produced per reproductive individual, σ_m= survival rate from egg to metamorphosis, 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 D*ata 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).

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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).