National Park Service
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National Capital Region Network

LONG-TERM MONITORING PLAN FOR NATURAL RESOURCES IN THE NATIONAL CAPITAL REGION NETWORK

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EXECUTIVE SUMMARY

Chapter 1 Introduction and Background

National park managers are directed by federal law and National Park Service policies and guidance to determine the status and trends in the condition of natural resources under their stewardship. Inventory and Monitoring Program goals are to develop basic natural resource inventories and implement long-term monitoring of ecosystem health. Information garnered from the monitoring program will be available to evaluate and guide park management efforts. The National Capital Region Network (NCRN) has been funded since 2000 to implement biological inventories and a long-term monitoring program.

The network approach will facilitate collaboration, information sharing, and economies of scale in natural resource monitoring. It will also provide a base infrastructure that can be built upon in the future.

Servicewide goals for vital signs monitoring for the National Park Service are:

- 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.

Chapter 2 Conceptual Models

Conceptual models were used to help identify and prioritize the most appropriate ecological indicators for monitoring ecosystem health in the parks of the NCRN. Of special significance to the Vital Signs Monitoring Program, conceptual models may be useful in the initial development of performance criteria for those stressors that are suspected to be most important to influence environmental conditions. Once monitoring data have been collected, the models can be used as a framework for numerical models to quantify relationships and trends. A hierarchical approach was used to develop the models, beginning with a general overview model that identifies key environmental systems and the anthropogenic stressors that influence those systems.

Chapter 3 Vital Signs

There are 21 priority vital signs identified for the National Capital Region Network. The vital signs framework was developed by a committee representing network and Natural Resources Program Center staff in order to apply a nationally standardized naming convention to the network vital signs. Five vital signs refer to air and climate, two refer to geology and soils, four refer to water, eight refer to biological integrity, and two refer to ecosystem pattern and processes.

Chapter 4 Sampling Design

The overall sampling design for NCRN divides the vital signs monitoring protocols into two groups, terrestrial and aquatic. This division is necessary, as terrestrial monitoring takes place over the entire park area, whereas aquatic monitoring takes place in streams that form linear corridors through parks and cover only a small area. A sampling design has been created for each of the two groups. By unifying terrestrial monitoring under one design and aquatic monitoring under another design, we will maximize our ability to synthesize data collected under different protocols.

Some vital signs, such as air quality and land use change, consist of regional assessments and do not include sampling of specific locations in the parks. Rare, threatened, and endangered species will be monitored where they occur to assess their status. For practical reasons, deer monitoring is restricted to park roadways. These vital signs are not considered in this chapter. Data collection methods for these vital signs are detailed in their individual protocols.

Chapter 5 Sampling Protocols

Chapter 5 provides an overview of the protocols that will be developed, detailed summaries of each protocol are presented in the form of Protocol Development Summaries in appendix N. Each summary provides a brief justification and rationale for selecting the vital sign. In addition, key monitoring questions and objectives are outlined, the principal investigator and National Park Service contacts are identified, and cost of protocol development is provided.

Chapter 6 Introduction to Data Management

Chapter 6 summarizes the NCRN data management strategy, which is more fully presented in the NCRN Data Management Plan. The NCRN Data Management Plan serves as the overarching strategy for achieving the goals noted above. The plan supports Inventory and Monitoring program goals and objectives by ensuring that program data are documented, secure, and remain accessible and useful indefinitely.

Chapter 7 Data Analysis and Reporting

The NCRN strategy towards data analysis and reporting rests upon providing sufficient funding for these activities so that they occur promptly—that is, to report on the previous field season (October–September) by the following March. The NCRN will also focus on producing an annual integrated "State of the Parks" report that effectively communicates the changes and trends observed in each vital sign to our primary audience—the natural resource managers of each park.

Chapter 8 Administration / Implementation of the Monitoring Program

The network has developed a three-year (fiscal year [FY] 2005–2008) plan under which vital sign monitoring will begin, while development of protocols for monitoring of the other vital signs will be initiated. Chapter 8 describes the makeup of the Board of Directors and Technical Committee and the decision-making process of the network; the staffing plan; how network operations are integrated with other park operations; key partnerships; how in-house field work will be carried out; and the periodic review process for the program.

Chapter 9 Monitoring Schedule

This chapter describes the schedule for implementing the NCRN Vital Signs Monitoring program. Key tasks or issues are described for the protocols under development in the next three to five years, including frequency and timing of sampling.

Chapter 10 Budgets

Long-term budget estimates were made through FY 2015 by including annual step increases and expected cost of living increases (2% inflation). Over the 10-year period, personnel costs average 75% and agreements or contracts average 12%. While less funding is available for agreements over the first four years due to increasing personnel costs, additional funding becomes available after two-term data management positions end. The data management positions will end after all known legacy data is entered into the systems and standard data management systems are in place.

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Chapter 1

Introduction and Background

1.1 PURPOSE

As a result of the Natural Resource Challenge, the National Park Service (NPS) is implementing a series of programs designed to bolster the agency's science (Kaiser 2000). The Inventory and Monitoring (I&M) program is one of these programs and is being established at over 270 national parks that are organized into 32 networks sharing physiographic and ecological characteristics.

The purposes of the I&M Program are related directly to the purposes of the National Park System. Program goals are to develop basic natural resource inventories and implement long-term monitoring of ecosystem health. Information garnered from the monitoring program will be available to evaluate and guide park management efforts. The National Capital Region Network (NCRN) has been funded since 2000 to implement biological inventories and a long-term monitoring program.

1.1.1 Institutionalizing the Inventory and Monitoring Program

The NPS strategy to institutionalize inventory and monitoring throughout the agency consists of a framework having 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" I&M programs begun in 1992 to evaluate alternative monitoring designs and strategies; and (3) implementation of operational monitoring of critical parameters (i.e., vital signs) in over 270 national parks with significant natural resources that have been grouped into 32 networks linked by geography and shared natural resource characteristics.

All parks with significant natural resources must possess a minimum of 12 resource inventory data sets to effectively manage resources. The I&M program requires these parks to compile at least:

- A natural resource bibliography
- Base cartographic data
- Geology map
- Soils map
- Weather data
- Air quality data
- Location of air quality monitoring stations
- Water body locations and classifications
- Water quality data
- Vegetation maps
- Documented species list of vertebrates and vascular plants
- Species distributions for and status of vertebrates and vascular plants

The network approach will facilitate collaboration, information sharing, and economies of scale in natural resource monitoring. It will also provide a base infrastructure that can be built upon in the future. Ten of the 32 networks include one or two prototype long-term ecological monitoring programs. The monitoring programs were established as experiments to learn how to design scientifically credible and cost-effective monitoring programs in ecological settings of major importance to a number of NPS units. Because of higher funding and staffing levels, as well as U.S. Geological Survey (USGS) involvement and funding in program design and protocol development, the prototypes serve as "centers of excellence" that are able to do more extensive and in-depth monitoring and continue research and development work to benefit other parks.

1.1.2 Justification for Integrated Natural Resource Monitoring

Knowing the condition of the nation's ecosystems is widely recognized as essential information for making sound management decisions (Heinz Center 2002; EPA 1997; EPA 1994). Similarly, understanding the natural resources in national parks is fundamental to the NPS's ability "to conserve the scenery and the natural and historic objects and the wildlife therin 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" (*NPS Organic Act* 1916). 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 as a basis for making decisions and working with other agencies and the public for the benefit of park resources. For years, managers and scientists have sought ways to characterize and determine trends in the condition of parks and protected areas to assess the efficacy of management practices and restoration efforts and to provide early warning of impending threats. Protecting and managing a park's natural resources requires a multi-agency, ecosystem approach because most parks have threats such as air pollution, water pollution, or invasive species that originate outside of the park's 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.

Natural resource monitoring provides site-specific information needed to identify and understand meaningful change in complex and variable natural systems and to determine whether observed changes are within natural levels of variability or may be indicative of unwanted human influences. 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, known as "vital signs," that are determined to be the most significant indicators of ecological condition of the 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. In situations where natural areas have been so highly altered that physical and biological processes no longer operate (e.g., control of fires and 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.

1.1.3 National Park Service Monitoring Goals

Servicewide goals for vital signs monitoring for the NPS are:

- 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.

In addition to meeting these goals, the NCRN has established the need to:

- Manage, maintain, and analyze regionally common data sets in accessible and usable forms in support of long-term resource preservation, protection, and education.

- Establish collaborative relationships among NPS divisions, educational institutions, partnering agencies, and organizations to gather and share information.

1.2 STRATEGIES FOR DETERMINING WHAT TO MONITOR

Monitoring is a central component of natural resource stewardship in the NPS, and in conjunction with natural resource inventories and research, provides the information needed for effective, science-based resource management decision-making. Inventories may provide baseline information for monitoring or help prioritize monitoring needs based on the resources known to occur in a park. If monitoring detects trends that are unexplained, research can be directed to influence future resource management. However, a review of existing monitoring programs has shown that their desired influence on park management is not always achieved (Bernstein et al. 1993; Pasko 2002; W. Cass, Botanist, Shenandoah National Park, 2000 pers. comm.). Monitoring must inform and be closely tied to resource management. Resource management is not only driven by science but also by a variety of legislation and societal influence (figure 1-1) (National Research Council 2000; Harwell et al. 1999; Woodward et al. 1999). The NPS *Organic Act*, NPS *Management Policies 2001*, and each park's enabling legislation may all influence resource management priorities. Appendix A provides a summary of relevant legislation, NPS policy, and NPS guidance. The *Government Performance and Results Act* (GPRA) helps establish priorities and tracks resource management priorities (OMB 1993).

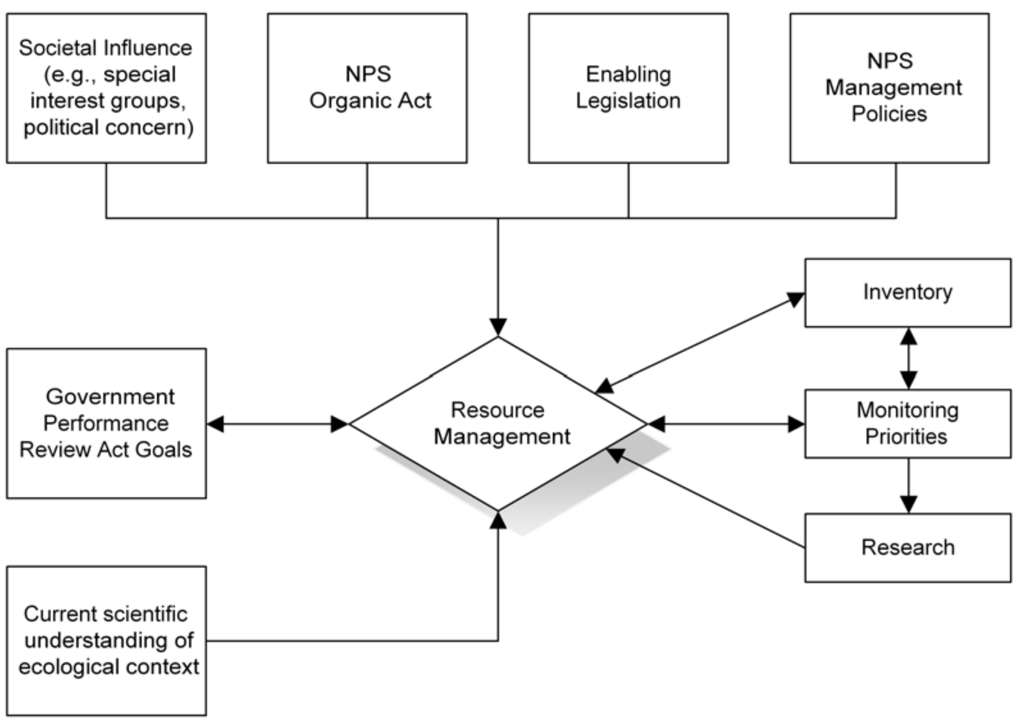


FIGURE 1-1: RELATIONSHIPS BETWEEN LEGAL MANDATES, RESOURCE MANAGEMENT, AND MONITORING PRIORITIES

1.3 THE NATIONAL CAPITAL REGION NETWORK MONITORING PROGRAM

Eleven parks within the District of Columbia, Maryland, Virginia, and West Virginia make up the NCRN (table 1-1): Antietam National Battlefield (ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield (MANA), Monocacy National Battlefield (MONO), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap Farm Park (WOTR). I&M staff supports monitoring efforts at National Mall & Memorial Parks (NACC), which also has a local air quality monitoring station.

1.3.1 Process for Identifying Vital Signs

One of the main challenges for the I&M program is that there are no standard indicators for evaluating ecosystem health (National Research Council 2000; Flather et al. 1999). Indicators must meet a variety of obligations including legal and societal. Appropriate vital signs should also meet rigorous scientific criteria such as those laid out by Dale and Beyeler (2001), Fancy (2002), and the National Research Council (2002):

- are sensitive enough to provide an early warning of change
- have low natural variability
- can be accurately and precisely estimated
- have costs of measurement that are not prohibitive
- have monitoring results that can be interpreted and explained
- are low impact to measure
- have measurable results that are repeatable with different personnel

Early guidance to implementing a long-term I&M program was developed by the NPS (Silsbee and Peterson 1991) and others (Davis 1993) to ensure that both legal mandates and ecological contexts are considered. Fancy (2002) suggested a seven-step implementation process that was adopted by the NCRN (see appendix B for details).

TABLE 1-1: ELEVEN PARKS IN THE NATIONAL CAPITAL REGION NETWORK

Park	Park Code	Size (ha)	Physiographic Province
Antietam National Battlefield	ANTI	1,318	Ridge and Valley
Catoctin Mountain Park	CATO	2,336	Blue Ridge, Ridge and Valley
Chesapeake and Ohio Canal National Historical Park	CHOH	7,788	Coastal plain, Piedmont, Blue Ridge, Ridge and Valley
George Washington Memorial Parkway	GWMP	3,198	Coastal Plain, Piedmont
Harpers Ferry National Historical Park	HAFE	1,500	Ridge and Valley
Manassas National Battlefield Park	MANA	2,064	Piedmont
Monocacy National Battlefield	MONO	667	Piedmont
National Capital Parks – East (conglomerate of parks)	NACE	4,378	Coastal Plain, Piedmont
Prince William Forest Park	PRWI	7,518	Coastal Plain, Piedmont
Rock Creek Park	ROCR	1,100	Coastal Plain, Piedmont
Wolf Trap Farm Park	WOTR	53	Piedmont
Total		**31,346**	

To provide a starting point the NCRN established both a Board of Directors (BOD) and a Science Advisory Committee (SAC) to guide for the planning process. While the BOD (appendix C includes the BOD charter) consisted mostly of superintendents who provide programmatic oversight, the SAC consisted of resource managers along with subject matter experts who provided an overview on the resource management issues and ecological setting.

In the early planning stage, the I&M staff pulled together background information on the region's significant natural resources, legislative mandates, and existing data. The SAC reviewed this information to develop draft conceptual models that highlighted the regions key natural resource, agents of change (e.g., threats), and ecological responses. Work progressed by breaking out into eight working groups based on broadly defined resources found in the NCRN including:

- Air Resources
- Geology
- Invertebrates
- Landscape
- Rare, Threatened and Endangered Species
- Vegetation Communities
- Water Resources
- Wildlife

The draft models were enhanced through a monitoring workshop that brought together additional subject matter experts representing diverse expertise. Participants represented over 20 partner agencies including The Nature Conservancy, NatureServe, USGS, EPA, Department of Defense, U.S. Department of Agriculture Forest Service, the Smithsonian Institution, and other NPS Divisions (Air Resource Division, Water Resource Division, Geology Resource Division, and Natural Resource Information Division).

The I&M staff continued to refine the vital sign selection with significant input from the SAC. The final set of vital signs was approved by the BOD. Details of the planning process are outlined in chapter 3. The general sequence of events is illustrated in table 1-2.

1.4 BACKGROUND INFORMATION

This section summarizes the legal mandates and ecological context that drive resource management and provide the foundation for long-term ecological monitoring.

1.4.1 Federal Legislation, Policy and Guidance

National park managers are directed by federal law and NPS policies and guidance to determine the status and trends in the condition of natural resources under their stewardship. The NPS *Organic Act* signed by President Woodrow Wilson in 1916 established the framework "to conserve the scenery and the natural and historic objects … unimpaired…for the enjoyment of future generations."

Congress strengthened the NPS protective function, and provided language important to recent decisions about resource impairment, when it amended the NPS *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 …"

Recognizing the need to understand the condition of natural resources within the park system, a servicewide I&M program was established (NPS 1995). The I&M program was responsible for determining the nature and status of natural resources under NPS stewardship, and for monitoring changes in the condition of these resources over time. Information from I&M efforts can then be incorporated into NPS planning, management, decision making, posing research questions, evaluating the effects of management activities, determining compliance with emission and discharge standards, and mitigating anthropogenic disturbance (NPS 1995).

TABLE 1-2: SEQUENCE OF EVENTS TO IDENTIFY VITAL SIGNS AND IMPLEMENT MONITORING PROGRAM

	FY00 Oct-Mar	FY00 Jan-Sep	FY01 Oct-Mar	FY01 Jan-Sep	FY02 Oct-Mar	FY02 Jan-Sep	FY03 Oct-Mar	FY03 Jan-Sep	FY04 Oct-Mar	FY04 Jan-Sep	FY05 Oct-Mar	FY05 Jan-Sep	FY06 Oct- Mar
Establish Board, Science Advisory & Committee (SAC)		X											
Gather background information	X	X	X	X	X	X	X	X	X	X	X	X	X
SAC workshops		X	X	X	X	X	X	X		X	X		
Scoping workshop						X							
Vital sign selection						X		X		X	X		
Protocol development									X	X	X	X	X
Monitoring Plan — Draft Phases I–III						X		X			X		
Monitoring Plan completed												X	
Monitoring implemented													X

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 Fiscal Year 2000 appropriations bill by stating that "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." In addition, the bill charged superintendents to "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 NPS *Management Policies 2001* updated the previous policy and specifically directed the NPS 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 (*NPS Management Policies 2001*).

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:

- *Fish and Wildlife Act* (1956)
- *Fish and Wildlife Coordination Acts* (1958 and 1980)
- *Clean Air Act* (1963; amended 1970 and 1990)
- *National Historic Preservation Act* (1966)
- *National Environmental Policy Act* (1969)
- *Clean Water Act* (1972; amended 1977 and 1987)
- *Endangered Species Act* (1973; amended 1982)
- *Migratory Bird Treaty Act* (1974)
- *Forest and Rangeland Renewable Resources Planning Acts* (1974 and 1976)
- *Mining in the Parks Act* (1976)
- *Executive Order 11990 (Protection of Wetlands)* (1977)
- *American Indian Religious Freedom Act* (1978)
- *Archaeological Resources Protection Act* (1979)
- *Federal Cave Resources Protection Act* (1988)

1.4.2 Park Enabling Legislation

In addition to general legislation and NPS policy, management is directed by the specific legislation for each park. Although parks in the NCRN were created largely for their historic and recreational value, the preservation of natural resources is also addressed. Enabling legislation is discussed in appendix D and a summary is presented in table 1-3.

1.4.3 Government Performance and Results Act

The *Government Performance and Results Act* (GPRA; OMB 1993) was established to ensure that daily actions and expenditures are guided by both long-term and short-term goals that are, in turn, consistent with Department of Interior agency missions. The parks are guided by four hierarchical long-term goals:

- Category I goals preserve and protect park resources.

- Category II goals provide for the public enjoyment and visitor experience of parks.

- Category III goals strengthen and preserve natural and cultural resources and enhance recreational opportunities managed by partners.

- Category IV goals ensure organizational effectiveness.

Specific and measurable objectives provide the parks with effective means by which to measure progress toward their goals. A five-year strategic plan and an annual work plan outline the strategies for reaching these goals while an annual performance report evaluates the annual progress made toward GPRA goals (NPS 2000).

TABLE 1-3: SUMMARY OF ENABLING LEGISLATION FOR EACH PARK THAT PERTAINS TO CONSERVATION OF NATURAL RESOURCES

	Parks with this Goal										
Enabling Legislation	ANTI	CATO	CHOH	GWMP	HAFE	MANA	MONO	NACE	PRWI	ROCR	WOTR
Animal protection										X	
Conserve all resources		X						X		X	
Forest preservation				X				X		X	
Historical significance	X				X	X	X				
Maintain landscape / viewshed / natural scenery / scenic features	X		X	X				X			
Noise pollution											X
Recreation		X	X	X				X	X	X	
Water quality (prevent water pollution to Anacostia, Potomac, Rock Creek, or South Fork Quantico Creek)				X				X	X	X	

Parks in the NCRN have adapted various GPRA goals (table 1-4). The NCRN Monitoring Plan will identify the monitoring indicators or "vital signs" of the network and develop a strategy for long-term monitoring to detect trends in resource condition (GPRA Goal Ib3a and Goal Ib3b). Once parks identify future desired conditions, vital signs can help track land health goals related to wetland, riparian, and upland areas. Similarly vital signs monitoring will provide essential information for tracking progress towards goals related to species of concern (Ia2X) and water quality (Ia04). In addition, monitoring may contribute to information to help track other natural resources related goals including Ia1A, Ia1B, Ib1, and Ib01.

1.4.4 Ecological Context of NCRN

Besides understanding the program goals and legal justification, one must understand the ecological context of the parks in order to identify appropriate indicators (figure 1-1). Most of the parks in NCRN lie within the Potomac watershed. The only exception is Baltimore and Washington-Parkway of NACE, which is located in the Patuxent watershed. During the last 400 years, significant changes in the natural environment have occurred. Today, about two-thirds (61%) of the landbase is used for agriculture while the rest is forested (28%) or urban (10%). A small portion is wetlands, water, or barren (Dail et al. 1998). Major rivers passing through the region and bordering the parks include the Potomac and Anacostia Rivers.

Park property within the NCRN amounts to approximately 36,000 ha in the District of Columbia, Maryland, Virginia, and West Virginia. The NCRN has 720 km of parkway and primary roads, more than 150 statues, monuments and memorials, and approximately 1,156 km of biking and walking trails. Although NCRN parks only cover 1% of the total NPS lands, the region receives nearly 40 million visitors per year or about 14% of the total NPS visitation (NPS 1999a, NPS and TNC 2001). Most of the parks in the region were established primarily for recreational purposes or the preservation of historic and cultural sites, but many are now recognized for preserving habitat for many species and natural ecosystems. The Potomac Gorge, for example, is known to be one of the most biologically diverse areas of the region (Cohn 2004; NPS and TNC 2001).

1.4.4.1 Regional Climate. Climate throughout the Potomac River Basin is primarily continental with short, moderately cold winters and long, warm summers. Annual temperature is approximately 13°C with an average humidity of 75% and a 173-day growing season. Annual precipitation averages 104 cm, including an average 66 cm of snow. Precipitation is relatively evenly distributed throughout the year, but in any given year some months may

TABLE 1-4: GOVERNMENT PERFORMANCE AND RESULTS ACT GOALS FOR EACH PARK THAT THE INVENTORY AND MONITORING PROGRAM OF THE NATIONAL CAPITAL REGION NETWORK CAN PROVIDE INFORMATION FOR

GPRA Goal	Goal #	Parks with this goal										
		ANTI	CATO	CHOH	GWMP	HAFE	MANA	MONO	NACE	PRWI	ROCR	WOTR
Land Health Goals	TBA											
- Wetland Areas	TBA											
- Riparian and Stream Areas	TBA											
- Upland Areas	TBA											
Disturbed lands restored	Ia1A	X	X	X	X		X		X			
Disturbed lands (other)	Ia01A										X	
Exotic vegetation contained	Ia1B	X	X		X	X	X	X	X	X	X	X
Species of concern populations have improved status	Ia2X								X			
Natural resource inventories	Ib1	X	X	X	X	X	X	X	X	X	X	X
Natural resource inventories (park based)	Ib01	X		X	X			X	X			X
Vital signs for natural resource monitoring identified	Ib3	X	X	X	X	X	X	X	X	X	X	
Water quality improvement	Ia04		X							X		

have very little rain while others may greatly exceed the average. Winds are generally from the northeast in the winter, and southwest in the summer (Dail et al. 1998).

1.4.4.2 Physiographic Regions. Parks within the NCRN span four physiographic regions: Coastal Plain, Piedmont, Blue Ridge, and Ridge and Valley.

Atlantic Coastal Plain Province—The Atlantic Coast is a broad terraced plain rising inland up to an elevation less than 150 m (Hunt 1967; William and Mary 2000). The province was formed by sediments eroding from the Atlantic Highland areas to the west, fluctuating sea levels, and the continual erosive action of waves along the coastline. Coastal Plain surface soils are commonly sandy or sandy-loams that are well drained, low in organic carbon content, and contain soluble elements such as iron, calcium, and magnesium. Large streams and rivers in the Coastal Plain province are often influenced by tides. Within the NCRN, the following parks are located (all or in part) within the Coastal Plain Province: CHOH, GWMP, NACE, PRWI, and ROCR.

Piedmont Plateau—The Fall Line marks a transitional zone where the softer/erosion-prone sedimentary rock of the Coastal Plain to the east intersects the more resilient metamorphic rock of the Piedmont Plateau to the west. The transition zone forms an area of waterfalls and rapids that act as a barrier to dispersal for many aquatic and terrestrial organisms. This often creates localities of high biological diversity such as at the Potomac Gorge (Cohn 1994, NPS and TNC 2001). Soils in the Piedmont Plateau are highly weathered and generally well drained. A majority of parks of the NCRN are located completely or partially within the Piedmont Plateau Province, including: CHOH, GWMP, MANA, MONO, NACE, PRWI, ROCR, and WOTR.

Blue Ridge—The Blue Ridge Province is located on the eastern edge of the Appalachian Mountains. Ancient igneous and metamorphic rocks were uplifted to form the steep terrain. Fast flowing streams have resulted in the northern section of the Blue Ridge Mountains narrowing into a thin band of steep ridges, climbing to approximately 1,200 m in elevation. The Blue Ridge province is characterized by steep terrain covered by thin/shallow soils, resulting in rapid runoff and low ground water recharge rates. Within the NCRN, only a small section of the CHOH is located within the Blue Ridge Province.

Ridge and Valley—The landscape of the Ridge and Valley physiographic province is characterized by long, parallel ridges interspersed with valleys that formed where resistant sandstone ridges border erodable carbonate formations in the valleys. Areas dominated by carbonate formations exhibit karst topography - landscapes dotted by sinkholes, caves, and caverns. Fertile limestone soils in the Ridge and Valley Province are ideal for agriculture, while other areas are predominantly forested. Within the NCRN, the following parks are completely or partially located within the Ridge and Valley physiographic province: ANTI, CATO, CHOH, and HAFE.

1.4.4.3 Water Resources. The major rivers in the area include the Potomac and its major tributaries, including the Monocacy River and the Anacostia River. Though adjacent to several parks (GWMP, CHOH, HAFE), the parks do not manage the waters of the Potomac. The waters of the Potomac River are owned by the state of Maryland. The river bottom running through the District of Columbia, however, is owned by NPS.

Water pollution is closely tied to nutrient inputs from associated land uses. Elevated nitrogen concentrations in streams and groundwater are common in areas of intensive row cropping and areas underlain by carbonate bedrock (limestone). Tributaries draining agricultural areas yield the greatest quantity of nitrogen to the Potomac River; streams draining agricultural and urban areas yield the greatest quantities of phosphorus in most waters of the Potomac River Basin. Commonly used pesticides are found in the streams and groundwater, but only rarely at concentrations threatening to aquatic life. Chlorinated organic compounds, mercury, and lead are present in streambed sediment in concentrations that have come potential to adversely affect aquatic life. Banned chemicals are still being detected in sediments (chlordane and DDT, among others).

Carbonate rock (i.e., dolomite, limestone) appears to be the most favorable terrain in the Potomac River Basin for the development of large groundwater supplies. Groundwater in the Potomac River Basin, is of generally good quality, but local problems do exist, including the presence of elevated iron, acidity, radon, pesticides, and nutrients (Baloch et al. 1973; Brakebill 1993; Altor et al. 1998; Donnelly and Ferrari 1997). The quality of groundwater in karst (carbonate) landscapes such as those found at ANTI is particularly sensitive to land use practices such as agriculture (Poulson and Kane 1977; Stitt 1977).

1.4.4.4 Anthropogenic Context. The first archaeological evidence of human inhabitants in the region dates between 10,000 and 14,000 years ago when the first nomadic Paleo-Indians were believed to have reached the area. Evidence from riverine sites near the present District of Columbia indicates archaic people inhabited the region 4,000 years ago. The first cultivated crops appeared 1,000 to 1,500 years ago (Grumet 2000). Change from hunter-gatherer to more of an agrarian lifestyle allowed for larger, more centralized, permanent communities. By the time Captain John Smith charted the Chesapeake Bay in 1608, the major tribes east of the fall line were largely Algonquian (Swanton 1953; McCary 1957; Johnson 2000, NPS and TNC 2001). Siouan tribes including the Monacan inhabited parts of areas west of the Fall Line (McCary 1957).

The Native Americans were widely known to have used fire extensively in order to open understory for hunting and clear land for agriculture (Williams 2003). These practices along with climatic changes created new forest growth and canopy, openings significantly different from the region's dense closed canopies of previous centuries (Williams 2003; Grumet 2000). European settlers quickly adopted Native American practices of slash and burn agriculture and settled along the Potomac River. By 1699, most Native Americans had been killed or pushed west by the Europeans (NPS and TNC 2001), and by 1775 colonists had cleared as much as 30% of the Coastal Plain forest (Grumet 2000).

Agriculture within the region allowed continued population growth. The rise of industry created additional stresses to the landscape. Iron, charcoal, and timber for construction dominated early industry. Large tracts of forest were systematically cut down to supply charcoal for iron furnaces (Hickey 1975). The newly formed government devoted funds for canals, roads, and turnpike construction that improved access to new lands (Grumet 2000). Although approximately 90% of the region was forested in the 1700s, only about 30% of the region remained forested by the early 1900s (Porter and Hill 1998). The large-scale deforestation within Maryland and Virginia continued to create environmental problems for the region. The removal of forest cover led to increased sunlight that warmed waters, increased evaporation, created drier conditions on land, and increased sedimentation of many rivers and streams. At the same time, water-powered sawmills blocked the spawning runs of fish (Grumet 2000).

Coal began to replace charcoal as the primary fuel for the region's industry during the nineteenth century and added new environmental problems. Coal smoke from factory towers clouded the skies and acidic mining wastes entered local waterways. Additionally, wetlands were drained for agriculture and development as new roads and rails linked urban centers to outlying areas. Much of the Anacostia's thriving rice marshes, for example, were filled in the 1900s. In efforts to secure freshwater, Baltimore and the District of Columbia began creating reservoirs by damming rivers and streams. Fish hatcheries opened in the later half of the century due to concerns over dam construction blocking spawning grounds and increased fishing pressure (Grumet 2000).

The rate of development increased after World War II with the expansion of the federal government and an increased demand for new housing. Suburban sprawl continued and was fueled by subsequent boosts in the economy including the recent increase in the technology sector dominating the northern Virginia area during the 1990s. Between 1973 and 1996, Landsat observations show that the built up area around the District of Columbia expanded by approximately 22 km^2 per year (Masek et al. 2000). Population estimates just within the Potomac River subwatershed are expected to increase by 1.5 million between 1990 and 2020 (Chesapeake Bay Program 2002d). Although the District of Columbia metropolitan area is already developed, the majority of the subwatershed is still agricultural and forested. It is expected that many of these areas will become developed with the increase in population.

The majority of the NCRN is classified as forested or agricultural. However, within the Chesapeake Basin, between 1950–1980, the percentage of land used for residential and commercial purposes increased nearly 180% (EPA 2002b). If current trend continues, Maryland could use as much land for development in the next 25 years as it has used in the entire history of the state (EPA 2002b).

In addition to changes in land use, changes have also been noted among vegetation communities and wildlife populations over the centuries. Exotic plant species, for example, are now expected to account for 15% of the plant species in NCRN parks, and 30 species are considered invasive (NPS 1999b). House sparrows (*Passer domesticus*), European starlings (*Sturnus vulgaris*), and gypsy moths (*Lymantria dispar*) are well established. In addition to exotic species, the region has witnessed a number of extinctions including the passenger pigeon (*Ectopistes migratorius*), Carolina parakeet (*Conuropsis carolinensis*), and the eastern race of the peregrine falcon (*Falco peregrinus*). The American chestnut (*Castanea dentata*) is nearly extinct (Porter and Hill 1998) and the Bewick's wren (*Thryomanes bewickii*) and Bachman's sparrow (*Aimophila aestivalis*) have been extirpated. A number of neotropical migratory birds and grassland species have been declining and have been identified as priority conservation targets by Partners in Flight (Pashley et al. 2000). Furthermore, there has been recent documentation of amphibian and reptile declines in the northeast (Porter and Hill 1998; Reaser 2000) but there is a paucity of information documenting their status in the NCRN parks. Alternatively, a number of species have increased dramatically within the urban and suburban environments including white-tailed deer (*Odocoileus virginianus*), Canada goose (*Branta Canadensis*), and the gray squirrel (*Sciurus carolinensis*) (Manski et al. 1981; Porter and Hill 1998).

1.4.5 Park Resources

Within the ecological context of the region, each park has unique and valuable resources, such as vegetation communities and species of concern (table 1-5). For example, rare magnolia bogs and a shell-marl ravine community are found at NACE. PRWI has the largest example of Piedmont forest managed by the NPS. Several parks manage grasslands, including ANTI, MANA, MONO, and NACE. Karst landscapes are found at ANTI and caves are found at CHOH and HAFE. GWMP, NACE and PRWI contain several stands of extremely rare old growth forest.

TABLE 1-5: SUMMARY OF SIGNIFICANT NATURAL RESOURCES IDENTIFIED BY PARK PERSONNEL IN THE NATIONAL CAPITAL REGION NETWORK

Significant Natural Resources	ANTI	CATO	CHOH	GWMP	HAFE	MANA	MONO	NACE	PRWI	ROCR	WOTR	Total
Geologic Resources												
– Caves			X		X							2
– Karst landscape	X		X									2
– Rock formations					X							1
Landscape	X	X	X	X	X	X	X	X	X	X		11
Viewsheds		X	X	X				X				4
Unique Habitats												
– Riparian habitat	X	X	X	X	X	X	X	X	X	X	X	11
– Meadows or open fields	X					X	X	X		X		5
– Upland forest	X	X	X	X	X	X	X	X	X	X	X	8
Unique Species												
– Rare, threatened, endangered species	X	X	X	X	X	X	X	X	X	X		11
– Park significant species (e.g., brook trout, peregrine falcon, timber rattlesnake)		X			X							2

Some of the last freshwater tidal mashes in the region are found at GWMP and NACE. The Potomac Gorge, which spans GWMP and CHOH, is known to be one of the most biologically diverse areas of the region (Cohn 2004; NPS and TNC 2001).

Among the hundreds of species of concern identified by the parks, only four are federally listed as threatened or endangered, including the bald eagle (*Haliaeetus leucocephalus*) which nests in CHOH, Harparella (*Ptilimnium nodosum*) at CHOH, Small-whorled Pogonia (*Isotria medeoloides*) at PRWI, and Hay's Spring Amphipod at ROCR. (*Stygobromus hayi*). See appendix E for a complete list of species of concern.

Landscape features are considered important by the parks, especially given the link between cultural and natural resources. The battlefield parks including ANTI, MANA, and MONO, for example, manage natural resources within the a landscape preserved as it was during the time of the civil war.

1.4.6 Park Management Issues

Given the rapidly urbanizing landscape in the NCRN, parks are faced by a myriad of threats (table 1-6). Resource managers are well aware that rapid development inside and outside of the parks are a significant management concern. Boundary invasions occur regularly, and require constant vigilance. Similarly, the construction of cell towers, expansion of rights-of-way for utility lines, sewer lines, water lines, and culvert construction affect all NCRN parks.

In addition to development, the spread of exotic and invasive species is recognized as a significant threat to native vegetation and species of concern. The sources for invasive species include park neighbors whose plantings escape into the park and the introduction of invasive plant seeds along trails and other disturbed areas (L. Jameson, Exotic Plant Management Team Liaison, 2001 pers. comm.). Deer overabundance led to a region-wide deer monitoring effort in 2000 and the initiation of environmental impact statements at CATO and ROCR. The region started a multi-park monitoring

TABLE 1-6: SUMMARY OF SIGNIFICANT NATURAL RESOURCES THREATS FOR THE NATIONAL CAPITAL REGION NETWORK

Major Threats Identified by National Capital Region Park Personnel	ANTI	CATO	CHOH	GWMP	HAFE	MANA	MONO	NACE	PRWI	ROCR	WOTR
Air pollution (including visibility, acid deposition, ozone)	X	X	X	X	X	X	X	X	X	X	X
Climate change	X	X	X	X	X	X	X	X	X	X	X
Land-use change (inside parks e.g., cell towers, roads, utility right of ways, boundary encroachment, pipeline operations)	X	X	X	X	X	X	X	X	X	X	X
Land-use change (outside of parks e.g., urbanization)	X	X	X	X	X	X	X	X	X	X	X
Invasive species (e.g., tree of heaven, garlic mustard, multiflora rose, Japanese barberry, tartarian and Japanese honeysuckle, bamboo, Japanese stiltgrass)	X	X	X	X	X	X	X	X	X	X	X
Pest infestations/disease (e.g., gypsy moths, hemlock wooly adelgid, dogwood anthracnose, dutch elm)	X	X	X	X	X	X	X	X	X	X	X
Visitor impacts (including social trails, horseback riding, soil compaction)			X	X	X		X	X	X	X	
Water pollution (including agricultural runoff, sedimentation, eutrophication, streambank erosion)	X	X	X	X	X	X	X	X	X	X	X
White-tailed deer (over-browsing)	X	X	X	X	X	X	X	X		X	X

effort in 2000 to begin to collect data that would be needed for an environmental impact statement. Similarly, Canada geese have caused extensive overgrazing of aquatic vegetation at NACE.

Because of the urban landscape, air and water pollution easily cross over into park boundaries. The major stressors to water quality include impermeable surfaces and agricultural runoff. Air quality is affected not just by distant factors but also nearby industrial sources. An industrial site southwest of MONO and I-270 (which bisects the park) are believed to contribute air pollution to the park (T. Kopczyk, Park Ranger, Monocacy National Battlefield Park, 2001 pers. comm.).

Restoration efforts to mitigate threats are underway in all parks. The region, for example, hosts an Exotic Plant Management Team to deal with severe invasive species infestations. Wetland habitat restoration efforts are underway at MANA and NACE. HAFE has been reintroducing the Peregrine Falcons in the hopes of returning a breeding pair back to the park. CHOH is also developing a plan to reintroduce harparella, an endangered plant species.

1.4.7 Park Monitoring

There are numerous historic or ongoing monitoring projects within the NCRN (table 1-7). Most have been set up by park personnel, previous staff at the Center for Urban Ecology, universities, partner agencies and even volunteer organizations. The I&M program was not designed to replace park based monitoring efforts but is in a position to enhance programs that are part of the network's priority vital signs. The monitoring program will attempt to integrate new monitoring protocols with ongoing efforts whenever possible. One of the challenges is that for many park based monitoring projects, objectives are not clearly defined and monitoring protocols are not well developed. Analyses and reports from historic monitoring efforts are also difficult to find and data are no longer available. This section highlights some of the region's monitoring efforts. Details about park monitoring programs are presented in appendix D.

Air quality—Air quality is being monitored through national programs. At CATO, for example, a dry deposition monitoring station is part of the National Atmospheric Deposition Program (NADP). Particulates are being measured through an IMPROV station at National Capital Region headquarters. Visibility is monitored by a camera at GWMP. Also, ozone is being monitored effectively through CASTnet. Protocols will focus on synthesizing existing information.

TABLE 1-7: CURRENT AND HISTORIC MONITORING EFFORTS IN THE NATIONAL CAPITAL REGION PARKS

Current and Historic Monitoring	ANTI	CATO	CHOH	GWMP	HAFE	MANA	MONO	NACE	PRWI	ROCR	WOTR
Abiotic Resources											
Air Quality (including ozone, visibility, deposition)		H, C		C							
Fire occurrences									C	C	
Geologic resources					C						
Meteorology (available nearby)	C	C	C	C	C	C	C	C	C	C	C
Pesticide Use	C	C	C	C	C	C	C	C	C	C	C
Sound										C	
Water Quality											
– Gauging station	C	C			C					C	
– Macroinvertebrates		C		C		C			C	C	C
– Surface waters		C		C	C			C	C	C	
Biotic Resources											
Amphibians		C	C	C				C	C	C	
Birds											
– Eastern bluebird		C									C
– Christmas Bird Count		C		C		C				C	
– Breeding birds			H	C	H	C			C	H	
– Migration counts									H		
– Raptors					H					H	
– Kestrel						C					
– Mid-winter Counts			C								
– Bald eagle								C			
– Year-round								C			
– Waterfowl				C						C	
Fish											
– Trout		C									
Invasive plant species											
– Mapping (Exotic Plant Management Team)	C	C	C	C	C	C	C	C	C	C	C
Mammals											
– White-tailed deer (distance sampling)	C	C	C	C		C	C	C	C	C	C
– White-tailed deer (spotlight counts)										C	
– White-tailed deer (pellet counts)					C						
– White-tailed deer (roadkill surveys)	C									C	

TABLE 1-7: CURRENT AND HISTORIC MONITORING EFFORTS IN THE NATIONAL CAPITAL REGION PARKS (CONTINUED)

Current and Historic Monitoring	ANTI	CATO	CHOH	GWMP	HAFE	MANA	MONO	NACE	PRWI	ROCR	WOTR
Pest Species											
– West Nile virus (2001)	H	H	H	H	H	H	H	H	H	H	H
– Gypsy moth		C	C	C	C	C	C	C	C	C	C
– Hemlock wooly adelgid	C	C			C						
– Dogwood anthracnose		C			C					C	
Reptiles											
– Timber rattlesnake		C									
– Box turtle										C	
Vegetation											
– Goldenseal	C										
– Wildflower	C				C						
– Rare plants		C			C						
– Vegetation plots		C				C			C	C	
– Deer exclosures		C	C	C	C	C			C	C	
– Submerged aquatic vegetation								C			
– Wetland restoration								C			

Notes:
C = current
H = historic

Birds—Birds are monitored through a variety of standard and regional survey techniques. Christmas Bird Count circles, for example, cover parts of CATO, GWMP, MANA, and ROCR. Breeding bird data are being collected by the Fairfax Audubon Society for MANA. Other breeding bird projects have been implemented at ROCR, GWMP, and HAFE. A Breeding Bird Survey (BBS) was initiated at PRWI but does not follow the standard route specifications. Methods are not consistent among parks, and data are not maintained or analyzed by park staff. Most of the projects are volunteer-based.

Pesticides—Use and applications are tracked at each park according to NPS requirements.

Pest species—Pest species are monitored through the regional Integrated Pest Management Coordinator. Pest monitoring has focused on gypsy moths at all parks; hemlock wooly adelgid (*Adelges tsugae*) at ANTI, CATO and HAFE; dogwood anthracnose (*Discula sp*) at CATO, HAFE, and ROCR. Dutch Elm disease (*Ophiostoma ulmi*) is also monitored extensively at NACC. West Nile virus (genus *Flavivirus*) was monitored at all parks only in 2001.

Vegetation—Parks have initiated a variety of long-term monitoring efforts that focus on both vegetation and wildlife. CATO, PRWI, and ROCR, for example, initiated long-term vegetation plots in the 1990s to measure the impacts of deer on native flora. Protocols were developed by staff at the Center for Urban Ecology, but methods, justification, and the sampling strategy were not well documented, and implementation has been haphazard. In addition, data have not been managed or analyzed adequately.

Several parks including CHOH, HAFE, MANA, ROCR, and PRWI have built deer exclosures as a way to estimate deer impacts. The protocol for establishment of exclosures and monitoring, however, are different at each park. A review of the sample sites also suggests that more samples are needed to reduce variation (S. Bates, Wildlife Biologist, National Capital Region, 2003 pers. comm.).

Exotic species occurrences are being mapped by the region's Exotic Plant Management Team (EPMT). Their goal is to identify and prioritize treatment areas. Treatment effectiveness, however, is not being monitored.

Visitor numbers—Visitor numbers are monitored by most parks at nature centers, special events, or along roads. The impacts of visitors such as trail widening or the creation of social trails are not monitored anywhere.

Water quality—Extensive water quality monitoring has been conducted in the parks by various organizations, including the Audubon Naturalist Society, USGS, Fairfax County, Arlington County, and the Isaac Walton League. Each organization has its own protocols, and there are no consistent objectives. This makes data synthesis and interpretation very difficult.

Weather—Weather is monitored by several parks using fixed weather stations, including CHOH, HAFE, PRWI, and ROCR. Some of the data are managed using Weather Information Management Systems Standard weather stations are operated by the National Oceanic Atmospheric Administration and data from nearby locations are available to all parks. Protocols will focus on synthesizing existing information.

White-tailed deer—Deer density has been monitored by the parks using various techniques including spotlighting, infrared technology, and pellet counts. After a deer workshop in 2000, distance sampling was identified as the preferred monitoring method for most of NCRN parks. Dr. Brian Underwood was contracted to develop and initiate a pilot distance sampling monitoring program, and the region's wildlife biologist is currently refining the protocols and conducting yearly counts.

In addition to park based monitoring programs, various agencies monitor natural resources ranging from local county agencies or volunteer based efforts such as the Maryland Native Plant Society to national monitoring programs initiated by the EPA or USDA Forest Service (table 1-8). Working and collaborating with these agencies may provide opportunities to share lessons learned and protocols

1.5 MONITORING OBJECTIVES

Based on the parks' enabling legislation, GPRA goals, significant natural resources along with the ecological context, and major threats, the I&M staff identified broadly defined monitoring objectives during the planning process. The objectives were refined as conceptual models were developed (see chapter 2) and vital signs were selected and prioritized (see chapter 3) by the Science Advisory Committee and subject matter experts. Table 1-9 presents the network's most important monitoring objectives within a framework adopted by all I&M Networks as a way to organize and standardize the vital signs. Monitoring protocols will present more detailed objectives that include specific study designs and methods of data collection (see chapter 5).

TABLE 1-8: SUMMARY OF MONITORING EFFORTS CONDUCTED BY OTHER AGENCIES IN THE VICINITY OF THE NATIONAL CAPITAL REGION

Biotic Resources	Agency Conducting Monitoring
Amphibians	USGS, USFWS
Birds	Audubon Society Chapters (Fairfax Audubon, DC Audubon), Department of Defense (DOD), Institute for Bird Population Studies, Maryland Department of Natural Resources (MD DNR), Smithsonian, US Geological Survey (USGS), US Fish and Wildlife Service (USFWS), Monitoring Avian Productivity and Survivorship (MAPS), Dirginia Department of Game and Inland Fisheries (VDGIF).
Fish	Washington DC - Dept. of Environmental Quality, Interstate Commission for the Potomac River Basin, MD DNR, USFWS,
Invertebrates	DOD, North American Butterfly Association (NABA), US Department of Agriculture (USDA)
Mammals	DOD, USFWS, MD DNR, Various County Agencies, VDGIF
Reptiles	DOD
Threatened and endangered species	DOD, MD DNR, MD The Nature Conservancy (MD TNC), Virginia Heritage
Vegetation	Maryland Native Plant Society, USDA Forest Service (USDAFS), USFWS
Abiotic Resource	
Air quality	Clean Air Status and Trends Network (CASTNet), EPA, , Metropolitan Washington Council of Governments (MWCOG), Interagency Monitoring of Protected Visual Environments (IMPROVE), National Atmospheric Deposition Program (NADP), Virginia Department of Environmental Quality (VA DEQ)
Environmental contaminants	USFWS
Fire effects	NPS
Geology	Maryland Geological Survey, USGS
Landscape	EPA
Meteorology	National Atmospheric and Oceanic Administration (NOAA)
Water quality	Audubon Naturalist Society, DOD, EPA, Izaak Walton (Save our Streams), MD DNR, USGS, Various County Agencies, VA DEQ, Washington DC - Health Department

TABLE 1-9: SUMMARY OF MONITORING OBJECTIVES IDENTIFIED DURING THE NCRN PLANNING PROCESS

Level 1 Vital Sign Category	Level 2 Vital Sign Category	Monitoring Objectives
Air and climate	Air quality	Determine the spatial and temporal patterns and trends in atmospheric particulates, gases, and depositions.
		Track trends in sight distance and light extinction affecting visibility.
	Weather and climate	Track the change in weather patterns across NCRN parks.
Geology and soils	Geomorphology	Determine erosion and shoreline change along tidal streams.
Water	Hydrology	Track spatial and temporal patterns and variation in hydrology of freshwater streams.
	Water quality	Track spatial and temporal patterns and variation in water quality in freshwater streams.
Biological integrity	Invasive species	Use monitoring data for early detection and predictive modeling of incipient invasive species.
	Infestations and disease	Determine trends in incidence of disease and infestations in selected communities and populations. Early detection of new infestations.
	Focal species or communities	Determine trends in composition, structure, and function of populations of selected focal species or communities within the parks.
	At-risk biota	Determine trends in populations of threatened, endangered, and at-risk species within the parks.
Ecosystem pattern and processes	Land cover / land use	Determine spatial and temporal patterns in land use and effects on park resources.
		Determine spatial and temporal patterns and changes in land cover and community distribution.
	Productivity	Determine the landuse intensity in and around parks.

Chapter 2

Conceptual Models

2.1 OVERVIEW

A primary goal of the National Park Service (NPS) Inventory and Monitoring (I&M) program is to compress an enormous amount of information from multifaceted resource monitoring protocols into scientifically sound but understandable packages. Conceptual models play a key role in this effort. They are used to integrate current understanding of system dynamics, identify important ecosystem components and processes, facilitate communication of complex interactions, and illustrate connections between indicators and ecological states or processes.

This chapter provides a description of the conceptual models developed for the National Capital Region Network (NCRN). It outlines a hierarchical approach to model development, beginning with a general overview model that identifies key environmental systems and the anthropogenic stressors that influence those systems. Following the example of Harwell et al. (1999), resource and stressor endpoints are then accounted in detail along with associated field measures (i.e., vital signs). Natural resource sub-models identify potential interactions between stressors and resources within each of five natural resource domains. Finally, a conceptual framework is presented for representing the potential influence of urbanization on NCRN resources.

The conceptual models presented in this chapter are the result of multiple iterations based on input from the network's Scientific Advisory Committee (SAC), subject matter experts, and an exhaustive literature review. The models were used to help identify and prioritize the most appropriate ecological indicators for monitoring ecosystem health in the parks of the NCRN. As such, this chapter serves as a bridge between the network overview and general monitoring objectives described in chapter 1 and the detailed description of the process used to select vital signs provided in chapter 3.

2.2 CONCEPTUAL ECOLOGICAL MODELS

Conceptual ecological models provide a simplified overview of ecosystem structure and function (Haefner 1996; Noon 2003). Effective models can take the form of any combination of narratives, tables, or graphical depictions, but should be (a) easy to communicate and transparent to multiple audiences; (b) inclusive of key ecosystem endpoints and critical agents of change; and (c) adaptive and flexible in design to allow for response to novel events and findings. They can be used in monitoring programs 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;
- Facilitate communication on system dynamics and the Vital Signs Monitoring Program among network staff, managers, technical and non-technical audiences; and
- Identify areas where knowledge is inadequate and further research is needed.

Of special significance to the Vital Signs Monitoring Program, conceptual models may be useful in the initial development of performance criteria for those stressors that are suspected to be most important to influence environmental conditions. Once monitoring data have been collected, the models can be used as a framework for numerical models to quantify relationships and trends (Gentile et al. 2001).

Conceptual models are, of necessity, abstractions of reality based on incomplete information (Harris et al. 2003). They do not represent finished products, but are based on concepts that can and will change as monitoring provides new knowledge about ecosystem interactions. The purpose of this chapter is to explain current understanding of the ecological interactions between environmental stressors and selected natural resource components and processes in NCRN parks. The models presented should be regarded as provisional in an adaptive framework, and should be continually challenged in terms of their ability to capture reality and their utility for management.

BOX 1: KEY MODEL DEFINITIONS

Stressor **– Agent of change that potentially reduces the viability of a resource by impacting size, condition, and/or landscape context. A physical, chemical, or biological perturbation to a system that is either (a) foreign to that system or (b) natural to the system but applied at an excessive [or deficient] level.**

Source **– Cause of stress and/or degradation of a resource. A stress may have multiple sources (e.g., nutrient loading resulting from residential/commercial/office development, wastewater treatment and agricultural practices), and a source often causes multiple stresses (e.g., park visitations leading to habitat fragmentation, sedimentation, and toxins/contaminants).**

Ecological effect **– The measured or observed response caused by stressors. A change in an essential ecosystem characteristic.**

Threat **– Combination of stressor and effect that may alter ecosystem properties or performance.**

Vital sign **–A physical, chemical, or biological element or process selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.**

Development of the conceptual models followed the general approach outlined by Harwell et al. (1999) (figure 2-1). After defining specific goals and objectives, the process of model development involves first listing all stressors of interest for monitoring and then associating the stressors with tangible, measurable vital signs. Next, ecological effects and associated vital signs are listed. Using these fundamental building blocks, conceptual models are constructed that combine stressors and effects into specific threats to ecosystem properties or performance. A step-by-step description of model development follows.

2.3 GOALS AND OBJECTIVES

The first step in model development is the clear delineation of an overarching goal for model use and application. Chapter 1 summarizes the legislation, policies, and programmatic goals that direct the monitoring program to identify situations in which anthropogenic stressors negatively influence "ecological integrity," defined as the capacity to support and maintain a balanced, integrated, and adaptive community of organisms having the full range of biotic components and processes expected from natural ecosystems of the region (Karr 1991, 1996). The conceptual models are designed:

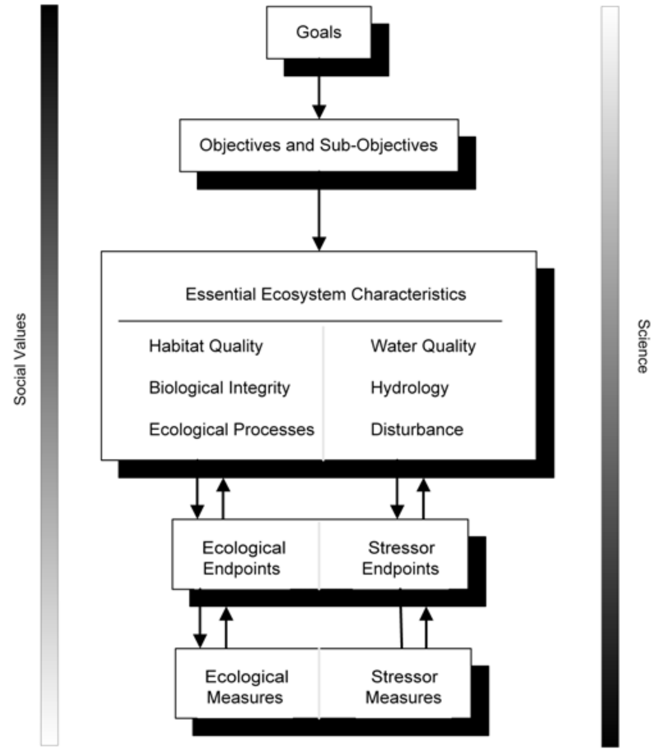


FIGURE 2-1: ECOSYSTEM INTEGRITY REPORT CARD FRAMEWORK (HARWELL ET AL. 1999)

> "In nearly all cases, the detail in a model should be limited to that which will fit comfortably on a single page" *(Gross 2003)*

(1) to highlight specific resource components that should be monitored to track potential changes in ecological integrity, and (2) to clarify relationships between resource and stressor endpoints that may contribute to any observed reductions in ecological integrity.

While an overarching goal provides the context for model development, specific objectives determine the elements of the model and the manner in which they are related. Together, the goals and objectives provide a comprehensive vision of what society deems meaningful about the environment (Harwell et al. 1999). Objectives were derived through a series of SAC meetings and a monitoring workshop. The objectives articulated in these meetings (table 1-9) reflect the consensus view of the primary stressors to natural resources in the region (table 1-6). The models are organized according to the Level 1 categories listed in table 1-9 and are designed to respond to the specific objectives detailed in the table. Special emphasis is given to the priority stressors provided in table 1-6. Given the close proximity of the NCRN parks to major metropolitan areas, it is not surprising that the majority of concerns raised by the planning groups relate to the urbanization of the landscape. The potential ecological effects of urbanization are considered in greater depth in the urbanization sub-model at the end of this chapter.

2.4 ORGANIZATIONAL FRAMEWORK

The next step in model development entails deciding upon the specific ecological systems to be modeled and the structure of the models used to represent these systems. Models are becoming easier to build, with a trend towards increasing model complexity (Gardner and Urban 2002);

however, a complicated, detailed model is not necessarily preferable to a carefully formulated simple model. Trade-offs exist between model complexity and other desirable attributes, including precision, generality, realism, and simplicity (Beven 2001; Gardner and Urban 2002). For example, the inclusion of additional interaction and feedback requires additional parameters and calibration (O'Neill and Gardner 1979). As more information is added, model errors associated with "sins of omission" can be replaced by errors associated with "sins of commission" (Peters et al. 2004) (figure 2-2). In particular, there is potential error associated with adding each new arrow (i.e., interaction among components) to a conceptual model. These errors relate to the selection of model formulation and eventually to the measurement of the input data and the estimation of parameters needed to quantify relationships once monitoring has begun. Thus, adding variables that are unmeasured or unmeasurable can easily result in a decrease in model utility. Because errors compound, overly complex models may have no predictive utility.

Overly simple models, in contrast, may fail to capture critical ecosystem properties and/or processes. Though easier to interpret, they can lack realism. Ultimately, the utility of a particular model is context sensitive and dependent upon model goals and objectives (Cale et al. 1983). Oftentimes, multiple models covering different organizational levels are useful. The framework invoked below employs a tiered approach, progressing from simple general models to detailed conceptualizations of specific ecosystem threats, including: (a) an overview model depicting the major stressors and ecosystem components listed in chapter 1; (b) simple stressor-effect sub-models representing individual stressors, effects, and associated vital signs for the major ecological systems depicted in the overview model; and (c) a more detailed conceptual diagram representing the potential feedbacks and interactions associated with increasing urbanization within the network. Taken together, they provide an integrative representation of how the measurement of individual vital signs will be used to assess ecological integrity of the NCRN.

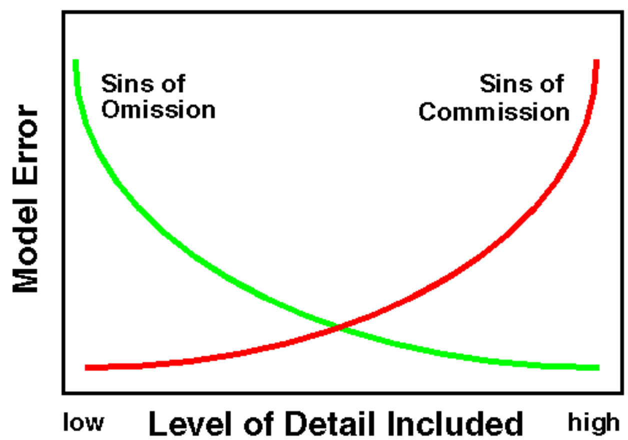


FIGURE 2-2: TRADE-OFFS ASSOCIATED WITH LEVEL OF DETAIL INCLUDED IN A MODEL (PETERS ET AL. 2004)

> "All models are wrong, but some are useful" *(Box 1979)*

2.5 OVERVIEW MODEL

The NCRN overview model follows the approach originally proposed by Jenny (1941), which emphasized the soil resource. The guiding principle of this formulization is that ecosystem properties are governed by both internal and external forces. Jenny (1941) described five state factors that influenced soil formation: parent material, climate, topography, potential biota, and time. These factors are external to the ecosystem boundary and have one-way controlling relationships with internal ecosystem processes. Chapin et al. (1996) extended this modeling concept to include four internal controls: local climate, soil resource supply, major functional groups of organisms, and disturbance regime. The relationships among these controls were considered dynamic and interactive, governing ecosystem processes but also being responsive to those processes.

The Jenny-Chapin model has been modified in three important ways to represent the NCRN (figure 2-3). First, the internal components have been expanded to consider resources beyond the soil domain. These changes facilitate a more complete and accurate representation of the interaction of ecosystem processes and all ecosystem resources, including soil, air, water, and biota (both terrestrial and aquatic). Second, it was important to consider spatial pattern and process as the central agent through which the internal components interact, as landscape patterns often directly shape ecological processes (O'Neill et al. 1988; Gardner et al. 1992; Turner et al. 2001). Finally, external constraints, which managers have little control over, were replaced with arrays of anthropogenic stressors that most concern resource managers (table 1-6). Primary stressors are those that directly influence relevant resources. Secondary stressors can affect a resource through the interaction with relevant ecosystem processes and patterns. For example, the influence of climate change on biodiversity is represented in the model as an indirect effect: climate change affects the air and climate domain, which interacts with biota through changes in ecosystem pattern and processes. The remainder of this chapter describes in detail the specific stressors, sources, ecological effects, and linkages among these components that will be addressed by the NCRN Vital Signs Monitoring Program.

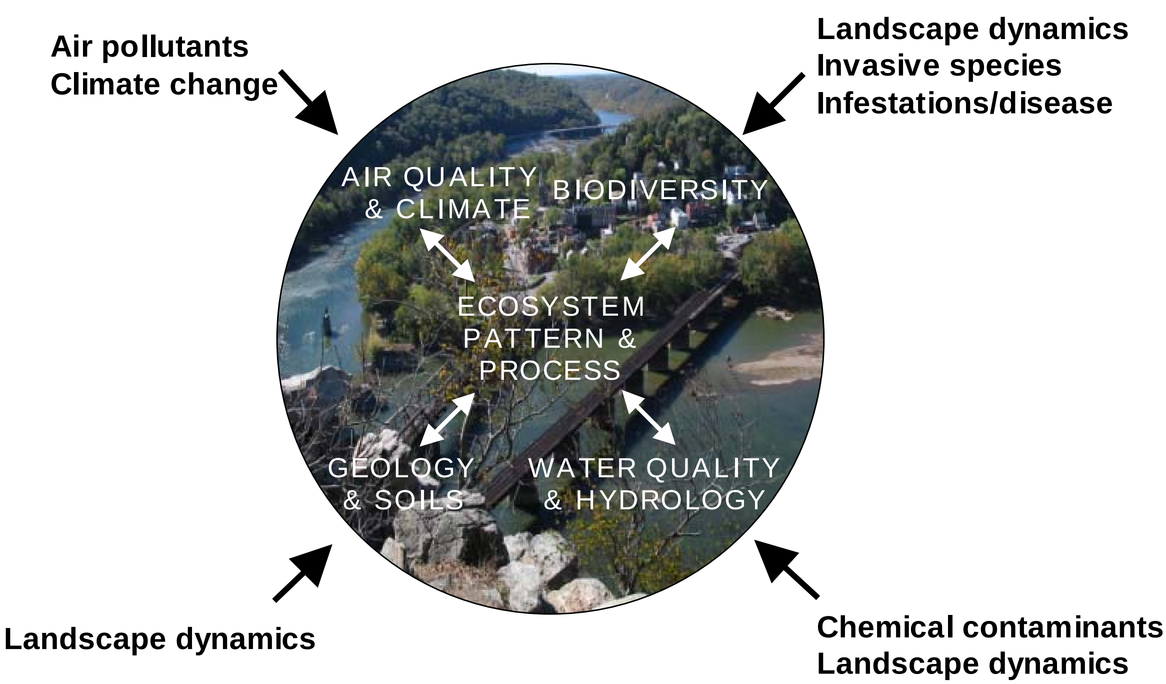


FIGURE 2-3: NCRN OVERVIEW MODEL

An attractive feature of the Harwell (1999) approach to model development is that it explicitly separates model components into environmental stressors and the effects of those stressors. They argue that stressors and ecological effects should be monitored and evaluated in parallel, following the framework developed for ecological risk assessment. Specific stressors and effects to be monitored in the NCRN are listed below. When possible, these attributes are selected from the Level 2 nationally standardized list of vital signs. Specific field measures (i.e., network vital signs) are derived from the national Level 3 list and are also included in the figures below.

2.5.1 Stressors

The following environmental stressors to NCRN resources were recommended for monitoring by the SAC and monitoring workshop participants: air pollutants, climate change, water pollutants, land use change and intensity (both within and outside park boundaries), invasive species, and infestations and disease. These stressors are presented in figure 2-4 along with associated vital signs to be monitored within the NCRN. Detailed descriptions of the individual vital signs are included in the discussion of the resource models. Additional information on the selection of vital signs can be found in chapter 3, and specific monitoring protocols associated with each vital sign can be found in chapter 5.

At present, the NCRN monitoring plan focuses on anthropogenic stresses and not natural disturbances such as fires and floods. This is not to imply that these natural processes are not important to these systems; rather, the models are meant to emphasize the unique urban nature of the NCRN parks. For example, while fire management may be an issue for several of the parks, a rapidly urbanizing landscape is a far more universal concern for all parks. Resource managers consider anthropogenic pressures to be a major regional concern about which the Vital Signs Monitoring Program can contribute valuable information. Processes of particular interest are those that both strongly impact park resources and also have the potential for management relief.

2.5.2 Effects

The following essential ecosystem characteristics were recommended for monitoring: air quality, weather and climate, geomorphology, hydrology, water quality, focal species and communities, at-risk biota, and productivity. These response variables are presented in figure 2-5 along with associated vital signs to be monitored within the NCRN. An effect is defined as a change in any of these characteristics. As defined in Harwell's (1999) assessment framework (figure 2-1), these ecological attributes are sufficiently important to humans that they can be used to inform management decisions. Because stressors oftentimes can be characterized more easily than their effects, special consideration has been paid to designing monitoring protocols for explicitly tracking ecological responses to stress (chapter 5).

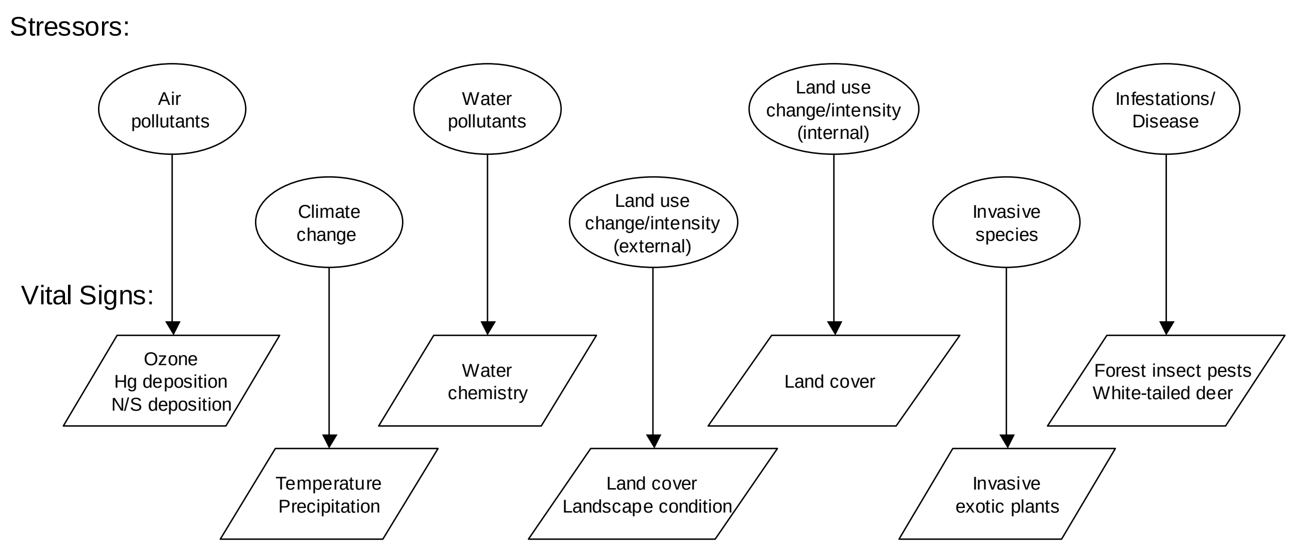


FIGURE 2-4: STRESSORS AND ASSOCIATED VITAL SIGNS CONSIDERED FOR NCRN MONITORING

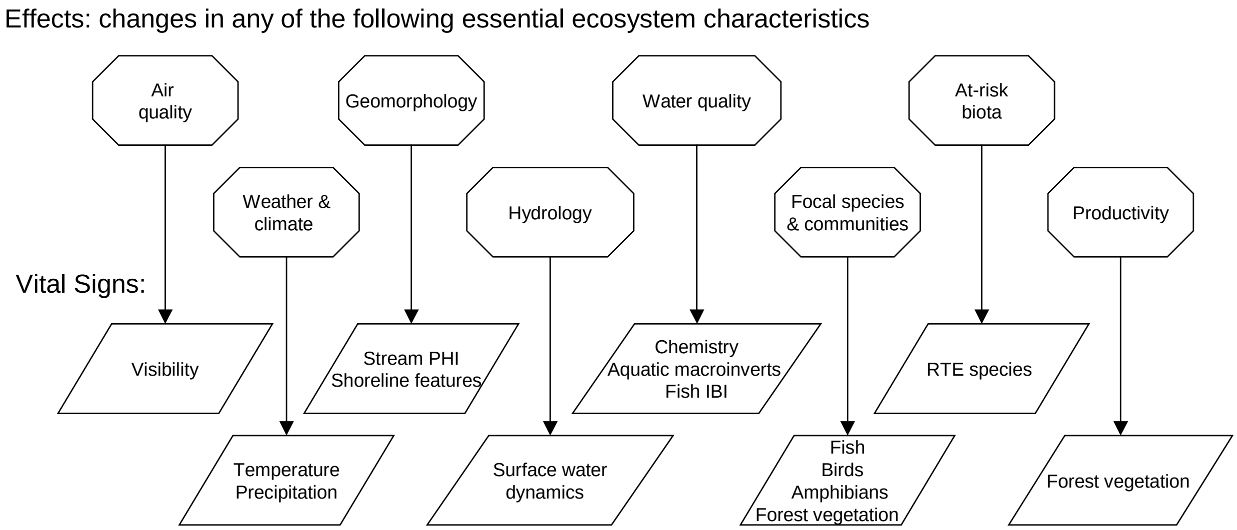


FIGURE 2-5: ECOLOGICAL EFFECTS AND ASSOCIATED VITAL SIGNS CONSIDERED FOR NCRN MONITORING

2.6 RESOURCE MODELS

This section presents and describes the five resource-based models: air and climate, geology and soils, water, aquatic biota, and terrestrial biota. These resources were selected to correspond to the Level 1 nationally standardized list of vital signs. An outline of the stressors and effects associated with each of these models is provided in figure 2-6. The models are consolidated from information attained from the literature, the SAC, and the monitoring workshop (appendix F). They combine the separate lists of stressors (figure 2-4) and effects (figure 2-5) into specific scenarios of threat on ecosystem properties or performance. The simple box and arrow diagrams trace the pathways from specific stressors to putative ecological effects. The success of the models depends on their ability to depict the relationships among resources of interest, potential agents of change, and their respective performance measures. The models are also effective communication tools, informing diverse audiences of the approach being employed to understand and manage the adverse consequences of environmental change.

2.6.1 Air

From a human perspective, the atmosphere is perhaps the most dynamic and multi-scaled portion of the environment, where changes can occur over timescales of microseconds to months and years. As humans continue to modify their physical and chemical environment, their influence often will be manifested first in the atmosphere, which may propagate change through the hydrosphere, geosphere, and biosphere (Schlesinger 1991). This means that changes to the atmospheric environment can have immediate and substantial effects for all parts of the environment, simply because air moves quickly over great distances, and it interacts with all other resource domains. Airsheds, like watersheds, are discrete areas of the atmosphere that most influence the environment of a given location (i.e., a NCRN park). Because the atmosphere is so dynamic, the boundaries of airsheds are not geographically stable (horizontally or vertically), but fluctuate with changing patterns in weather, climate, and season. To address this variability, the U.S. Environmental Protection Agency (EPA) defines airsheds as "the geographic area responsible for emitting 75% of the air pollution reaching a body of water [or park]." According to this definition, the NCRN airshed incorporates a large area extending north, south, and west of the Mid-Atlantic Region (figure 2-7).

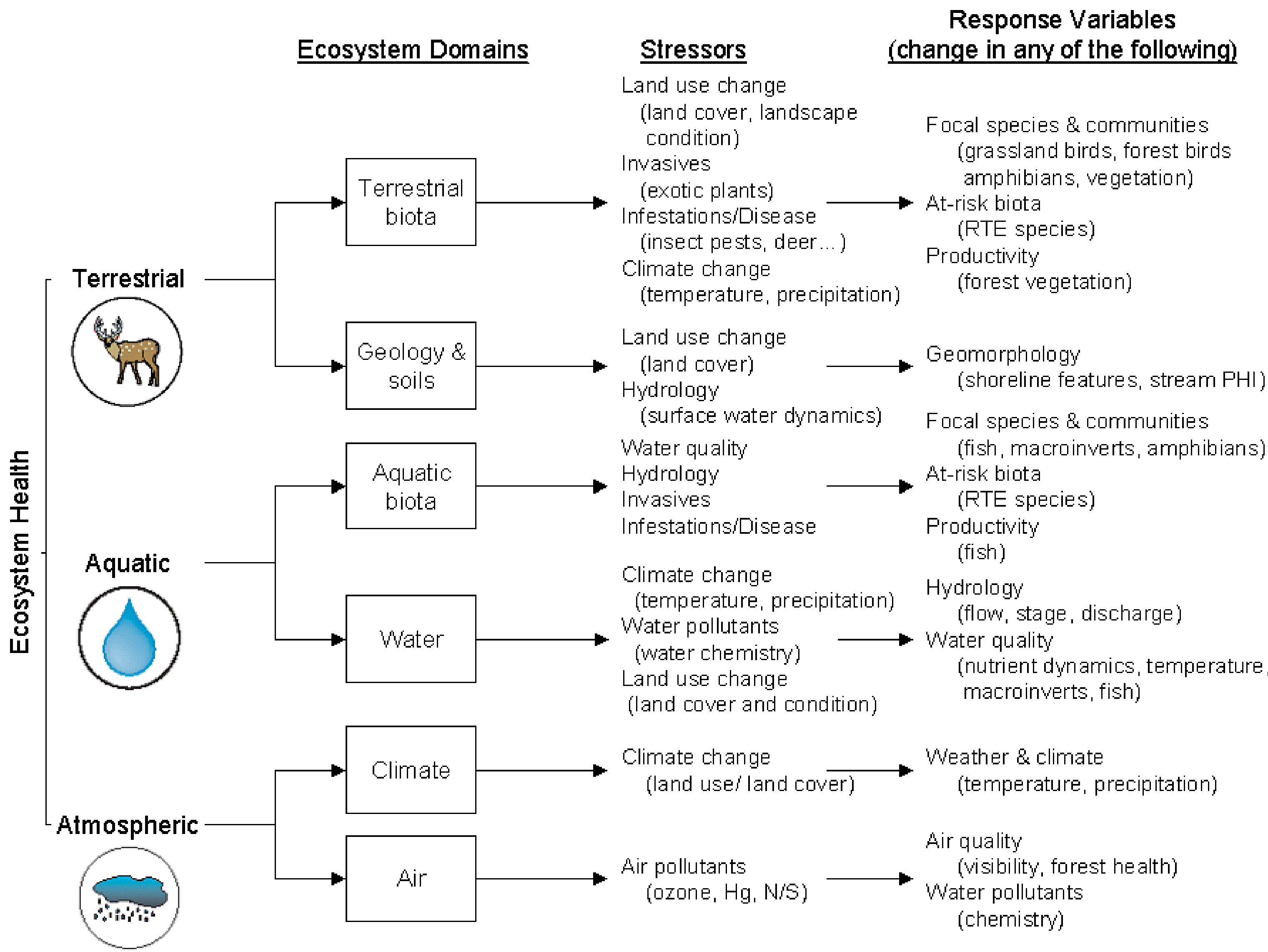


Figure 2-6: Summary of Ecosystem Domain Models for NCRN

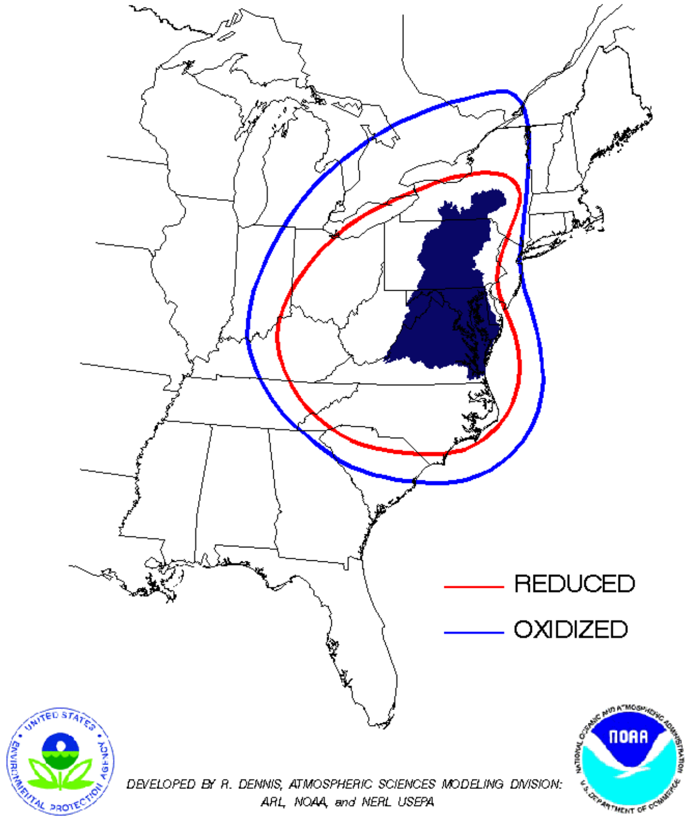


FIGURE 2-7: EPA ESTIMATED NITROGEN AIRSHEDS FOR THE CHESAPEAKE BAY

As managers in the NCRN look for ways to monitor the effects of anthropogenic activity on the parks, they will find that the health of many resources will be strongly linked to the air domain. For example, increases in airborne particulate matter can decrease visibility and degrade air quality for human health. Urbanization can result in increased levels of other air pollutants (e.g., mercury, ozone, and nitrogen) that can be transported to river and stream resources through processes such as acid rain. Changes in land cover and land use also can lead to localized changes in temperature and precipitation. These processes are captured in the stressor-effect model in figure 2-8. The vital signs linked to specific stressors and effects are associated with detailed monitoring protocols as described in chapter 5. The remainder of this section elaborates on the stressors listed in the model and the potential consequences of these pressures on air and climate resources.

2.6.1.1 Stressors

Climate Change. Among the most widely publicized human induced stressors is the projected change in climate due to anthropogenic release of CO_2 and other greenhouse gases. During periods of natural climatic transition, the average rate of climate change has been approximately 1°C per 1,000 years (Hidinger and Glick 2000). In contrast, temperature is projected to increase globally by 1.4°C–5.8°C over the next 100 years in response to rising atmospheric CO_2 levels (IPCC 2001b). Fossil fuels burned to run cars and trucks, heat homes and businesses, and power factories are responsible for approximately 98% of U.S. CO_2 emissions. Increased agriculture, deforestation, landfills, industrial production, and mining also are significant global sources of emissions. Thus, changes in land use and intensity are critically important to regional and global CO_2 concentrations.

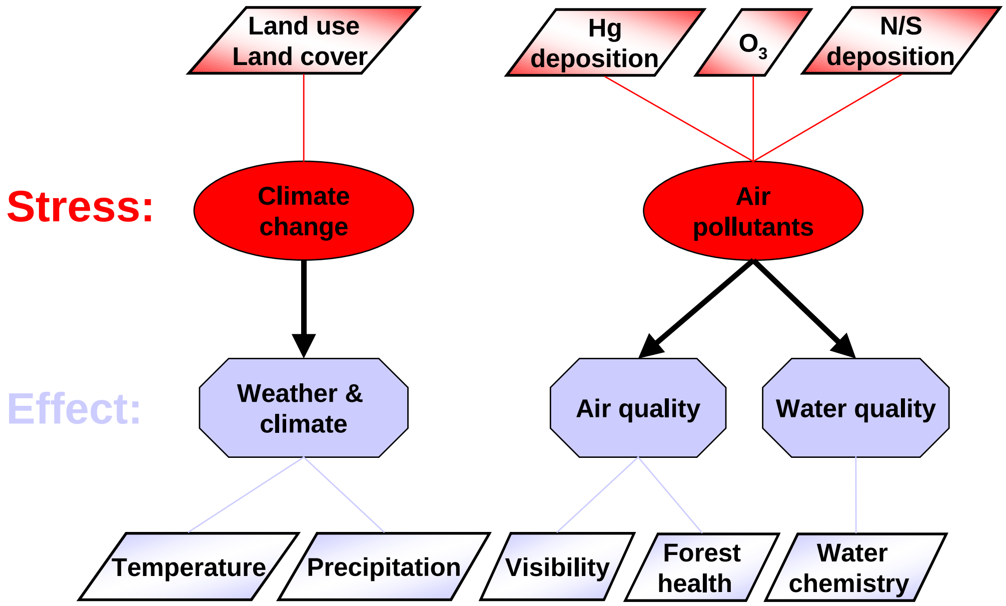


FIGURE 2-8: AIR AND CLIMATE ECOSYSTEM DOMAIN MODEL

Air Pollutants. Aerosols are suspensions of solid or liquid particles in a gas (e.g., air). The discrete, solid portions of an aerosol are referred to as particulate matter (PM) and can range in size from 0.001 to greater than 100 microns (10^{-6}) in diameter. Aerosols are produced naturally (e.g., in volcanic eruptions, dust storms) and as a result of a variety of human activities, including burning of fossil fuels (including diesel), mixing and application of fertilizers and pesticides, road construction, industrial processes such as steel making and mining, agricultural burning, and operation of fireplaces and woodstoves (Schlesinger 1991). In the NCRN, the sources for particles are both local (e.g., cars and power plants) and regional to continental. Modeling work has shown that aerosol levels in the Mid-Atlantic are heavily influenced by emissions within the region itself, with a substantially smaller contribution from Midwest sources (Mueller et al. 2004).

Toxic air pollutants, also known as hazardous air pollutants, are those that are known or suspected to cause cancer or other serious health or environmental effects. Most of these originate from anthropogenic sources, including mobile (e.g., cars, trucks, buses) and stationary sources (e.g., factories, refineries, power plants, and some building materials and cleaning solvents). Although localized, isolated emission events might cause harm to humans and animals in the NCRN, substantial ecological effects of air toxics at the regional scale are not anticipated for the NCRN. EPA and other regulatory agencies will be relied upon to inform park managers if and when this assumption is violated. As a result, the conceptual models do not include any air toxics other than mercury.

Mercury — Mercury is found in many of the types of fuel burned in today's combustion engines and power plants. Emissions from these combustion sources contribute tons of mercury to the atmosphere on top of that naturally present in the environment (Morel et al. 1998). Of all the inorganic air toxics, mercury is the only one that bioaccumulates in food webs, affecting both humans and their ecosystems. Recent EPA estimates based on fish tissue measurements have shown that in spite of the abundance of urban combustion sources, methylmercury body burdens in NCRN fish are only slightly above the criteria threshold. Consequently, only moderate air deposition reduction is likely required to meet safety standards (figure 2-9). Several studies suggest that this relatively mild pollution of NCRN might be attributed to the limitation of methylmercury formation by sulfide rather than the absence of mercury pollution (Benoit et al. 1998; Morel et al. 1998).

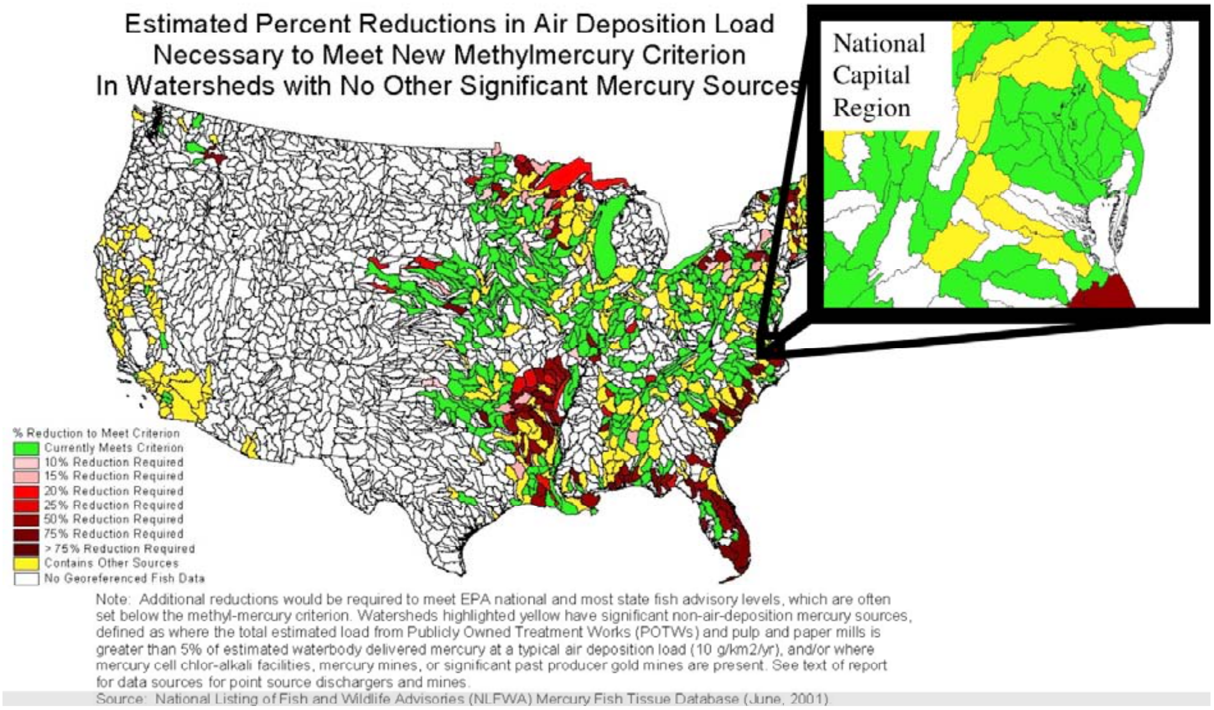


FIGURE 2-9: EPA ESTIMATED PERCENT REDUCTIONS IN AIR DEPOSITION LOAD NECESSARY TO MEET NEW METHYLMERCURY CRITERION IN WATERSHEDS WITH NO OTHER SIGNIFICANT MERCURY SOURCES

Ozone — Most ozone (O_3) is formed from the reaction of light with O_2 in the upper atmosphere, where O_3 acts to shield the earth from the sun's damaging ultraviolet rays. However, the absorption of light by NO_2 molecules also can produce O_3 in the lower atmosphere (troposphere), where it can be harmful to human health and act as a potent phytotoxin (plant poison). In non-urban settings, O_3 concentrations typically range from 20 ppb (parts per billion) to 40 ppb. In and downwind of urban areas, the photochemical reaction creating O_3 is fed by industrial and vehicular emissions of NO_2 (Schlesinger 1991). Consequently, tropospheric O_3 concentrations in the highly urbanized Mid-Atlantic Region were the highest recorded in the eastern United States from 1993-2002 (Lehman et al. 2004), frequently exceeding phytoxicity levels (Coulston et al. 2003) and National Ambient Air Quality Standards (NAAQS) for human health (Ryan et al. 1998). Tropospheric O_3 levels in the Mid-Atlantic Region also have been shown to be highly sensitive to variability in biogenic emissions of volatile organic compounds (VOCs) associated with changes in land use and climate (Bell and Ellis 2004).

Concentrations of this photochemical pollutant show a strong seasonal signal in the Mid-Atlantic, reaching maximum values during the long summer days of July (Eder 1993; Lehman et al. 2004). Peak summer O_3 levels in the region range from 30 ppb to 180 ppb (Ryan et al. 2000). These concentrations can be elevated for multi-day episodes triggered by specific atmospheric conditions (Ryan et al. 1998) or extreme weather events (Doddridge et al. 1991).

Nitrogen/Sulfur Deposition — Elevated photochemical activity associated with urban pollutants also increases the amount of nitrogen in the air. Airborne nitrogen can take two forms: reduced nitrogen composed primarily of ammonia (NH_3) and oxidized nitrogen composed primarily of HNO_3 and its derivative wet deposition component NO_3^-. The shape of atmospheric deposition airsheds may exceed watershed boundaries by 10 to 20 fold (Paerl et al. 2002), but differ greatly for the highly reactive reduced form, which gets scrubbed quickly from the atmosphere, and the less reactive oxidized form (figure 2-7). Although emission rates are very hard to quantify, high NH_3 concentrations generally occur around farms and other agricultural sources, whereas HNO_3 is emitted more around urban centers with high fossil fuel combustion. According to 30 years of data from the National Acid Deposition Program (NADP), intensification of animal farming operations has led to increasing NH_3 emissions and deposition in the Mid-Atlantic Region (Paerl et al. 2002). Meanwhile, changes in NO_3^- concentrations in precipitation have been small over the last couple of decades as decreased emissions from non-vehicle sources have been substantially offset by increased emissions from the vehicle sector (Butler et al. 2003). A study comparing the relative contributions of wet and dry deposition suggests that wet deposition contributes approximately 57% to total nitrogen deposited in the region (Russel et al. 2003).

Acid rain occurs when sulfur dioxide (SO_2) and nitrogen oxides (NO_X) react in the atmosphere with water, oxygen, and other chemicals to form mild solutions of sulfuric and nitric acids (Lindberg and Lovett 1986). Sunlight increases the rate of most of these reactions. Chemicals contributing to acid deposition are most notably from power plants. In addition, SO_2 is produced by some industrial processes, such as production of paper and smelting of metals, and NO_X are released by fossil fuel combustion in automobiles (Driscoll et al. 2001; Menz and Seip 2004). In total, anthropogenic sources are responsible for approximately 41% of total SO_2 emissions and from 26%–50% of total NO_X emissions nationwide (EPA 2004a).

2.6.1.2 Effects

Weather and Climate. Many observed changes in weather and climate may be associated with global change events over which park managers have little control. Nevertheless, it is important to track these trends, if for no other reason than to be able to distinguish the signal of events with localized drivers from background noise. Local weather and climate effects include phenomenon associated with urban heat island processes. Urban heat islands arise when natural vegetation is replaced by heat-absorbing, non-transpiring surfaces such as building roofs and walls, parking lots, and streets. In highly developed landscapes, such as those in the NCRN, the large number of these surfaces can create unique temperature and precipitation regimes (Oke 1992; Jauregui and Romales 1996; Bornstein and Lin 2000). Extreme heat events are responsible for greater loss of human life than hurricanes, lightning, tornadoes, floods, and earthquakes combined (Heinz Center 2002). In addition to the potential effects on human health, changes in temperature regime can cause physiological stress to other animals and plants, encourage the spread of pathogens and exotic species, and accelerate the formation of ozone and other air pollutants (Schlesinger 1991; NRC 2003). Precipitation regimes also can be altered by urban heat islands through their influence on summertime thunderstorm formation (Bornstein and Lin 2000; Lee et al. 2002).

Air Quality. Nearly all parks in the NCRN are tasked with the preservation of natural and/or historic vistas. Clean air provides high visibility, which can greatly determine the extent to which visitors appreciate these vistas. The concentration of light scattering particles in the air between an observer and a target controls the apparent clarity of the atmosphere. The most effective light scattering pollutants are those with a diameter equal to the wavelength of the light they are scattering (about 400–700 nanometers for visible light). Particles of this size are difficult to isolate and therefore are often lumped with particulate matter up to 2,500 nanometers (2.5 microns) in diameter (PM-2.5). Sources of PM-2.5 include, but are not limited to, gasoline and diesel exhaust, wood stoves and fireplaces, land clearing, and wildland fires (EPA 1999). In addition to reducing visibility, these microscopic particles can be breathed into lung tissue, become lodged, and cause respiratory disease and lung damage.

Mercury — Clean air also provides benefits to environmental and human health in the region. While atmospheric concentrations of mercury are low, the bioaccumulation of methylmercury can become extremely toxic to higher trophic level species. Mercury is transformed into methylmercury by bacteria in generally wet, oxygen-poor environments (Benoit et al. 1998). The contaminant enters the food chain via invertebrates and other low-level consumers. It slowly accumulates into high concentrations in tissue as it works its way up the food chain. Methylmercury is a potent neurotoxin in high-level consumers such as many piscivorous biota, causing dementia and brain damage when accumulated in fatty and brain tissue. As a result, the strongest link between mercury and NCRN resources is at the higher trophic levels (i.e., fish, herons, and other predators) represented in the biota conceptual models, several steps removed from atmospheric mercury deposition.

Ozone — Ozone is reactive with human lung tissue and plant tissue where it creates highly destructive free-radical molecules. Plants in urban environments that are exposed to high concentrations of ozone on a chronic basis often experience substantial reductions in growth. Ozone-sensitive species at these locations may be replaced by more ozone-tolerant species that otherwise would not be competitive. For example, in the forested mountains downwind of Los Angeles, where ozone reaches some of the highest values found in the United States, chronic ozone exposure has resulted in a shift from Ponderosa pine-dominated forests to more ozone-tolerant shrub and oak-dominated communities (Fenn et al. 2003b). In the NCRN, sweetgum, loblolly pine, and black cherry are highly sensitive to foliar injury from ozone exposure (Coulston et al. 2003). Susceptibility to ozone damage is especially high on wetter sites within the parks (Hildebrand et al. 1996). Tropospheric ozone pollution can have ecosystem-level effects as well, as described by Ollinger et al. (2002) for northeastern temperate forests. Decreases in productivity attributed to ozone in these forests were credited with offsetting gains that may have been realized due to carbon dioxide and nitrogen fertilization.

The relationships between ozone and forest composition demonstrate how the effects of atmospheric contamination cross into the biota resource domain. It is not uncommon for an effect in one resource domain (e.g., a change in air quality due to increased local development) to become a stressor in another domain (e.g., high mercury concentrations leading to declining fish populations). Additional examples are provided in the pertinent sections below and illustrate the need for an integrative approach to monitoring.

Nitrogen/Sulfur — One of the primary sources of PM-2.5 is chemical reactions that sulfur dioxide and nitrogen oxides undergo in the atmosphere. Nitrogen and sulfur derived compounds contribute nearly 60% to Mid-Atlantic regional aerosols (Lee et al. 2002). This pollution accounts for a significant portion of the visibility problems in the eastern United States. For example, nitrogen dioxide (NO_2) absorbs light in the visible range, creating an orange glow commonly observed in sunsets in the region. Aerosols originating in the Mid-Atlantic corridor also have been associated with the highest levels of haziness recorded in the White Mountains of New Hampshire (Slater et al. 2002).

In addition, the potential consequences of acid rain have been well documented across multiple resource domains including (a) soil depletion of various nutrients (Likens et al. 1996); (b) sugar maple dieback due to potassium (K) deficiency (Bernier and Brazeau 1988); (c) forest decline due to magnesium (Mg) deficiency (Oren et al. 1988); and (d) poor bird reproduction due to calcium (Ca) deficiency (Graveland et al. 1994).

Water Quality. Perhaps the most significant impact of pollutants carried in rainfall is on water quality (Likens and Bormann 1995). Nitrogen can act as a limiting resource when in short supply, and its addition has been shown to stimulate growth in a variety of ecosystems (Vitousek et al. 1998; Ollinger et al. 2002). Nitrogen deposition has been strongly linked to increases in productivity of aquatic resources through a process referred to as eutrophication (Smith 1998). For example, atmospheric sources have been determined to be substantial contributors to the eutrophication of the Chesapeake Bay (Chesapeake Bay Foundation 2003). Castro and Driscoll (2002) estimated atmospheric nitrogen deposition to be 10% to 42% of total nitrogen input for 10 estuaries in the eastern United States. Consequences of nitrogen-driven eutrophication include changes to water quality, phytoplankton community composition, and trophic and biogeochemical process (e.g., algal blooms, hypoxia, and food web disruptions) (Paerl et al. 2002). At high concentrations, sulfur also can change the chemistry of lake and river water, making it less habitable for aquatic plants and animals.

2.6.2 Geology and Soils

As with the air resource, the unique urban qualities of NCRN parks strongly influence the soil resource. Urban soils are often poorly drained; low in organic matter; disconnected from the water table; and contributors of excess water, sediment, and contaminants to nearby stream environments. Many of the soils in and around Washington, D.C., have their origins as fill dirt used to create land on top of pre-existing swamps. These soils may behave differently than soils derived naturally from underlying bedrock in terms of water holding capacity and drainage characteristics. Soil characteristics also are dependent upon on-site (e.g., around visitor centers, picnic areas, trails, tow paths, etc.) and off-site human activities. During the past 50 years, human land use has resulted in the degradation of 5 billion hectares (ha) of soil worldwide (Brady and Weil 1999). This soil degradation is linked to other resource domains (e.g., water and plant communities) through processes of erosion, nutrient depletion, and soil compaction.

In addition, the diverse geology of the region affects biological and other resources and should be considered in designing a monitoring program. For example, the range boundaries for many tree species in the southeastern U.S. closely correspond to boundaries of physiographic regions (e.g., the Fall Line that separates the Coastal Plain from the Appalachian Piedmont) and do not appear to be controlled by large-scale climatic patterns (Shankman 2005). NCRN parks cover four physiographic regions (table 2-1; figure 2-10), incorporating dramatic changes in topography, rock type, and geologic structure and history. Combined, the attributes associated with urban soils in diverse physiographic regions form a unique backdrop for ecosystem structure and function throughout the region. The model of geology and soils presented in this section addresses both on-site and off-site factors that create changes in the soil environment (particularly erosion) within the parks (figure 2-11). The consequences of these changes on plant and water resources are addressed in the sections pertaining to those specific resources.

2.6.2.1 Stressors

Land Use Change (internal). Land use change or changes in intensity of land use, particularly within the parks, results in deterioration of the soil resource through both mechanical and chemical perturbations. For example, construction of cell towers, utility rights-of-way, sewer lines, water lines, or other infrastructure are associated with soil disturbance. Visitation also can cause localized soil compaction and erosion. Infilling for development and dredging for sand and gravel has resulted in a massive loss of marshland in and around Washington, D.C., and remediation activities within the parks (e.g., Dyke Marsh) are another source of landscape change to be monitored (Hartwell 1970).

TABLE 2-1: PHYSIOGRAPHIC PROVINCES OF NCRN PARKS

Park	Physiographic Province
Antietam NB	Ridge and Valley
Catoctin Mountain Park	Ridge and Valley
Chesapeake and Ohio Canal NHP	Coastal Plain, Piedmont, Blue Ridge, Ridge and Valley
George Washington Memorial Parkway	Coastal Plain, Piedmont
Harpers Ferry NHP	Ridge and Valley
Manassas NBP	Piedmont
Monocacy NB	Piedmont
National Capital Parks-East	Coastal Plain, Piedmont
Prince William Forest Park	Coastal Plain, Piedmont
Rock Creek Park	Coastal Plain, Piedmont
Wolf Trap Farm Park	Piedmont

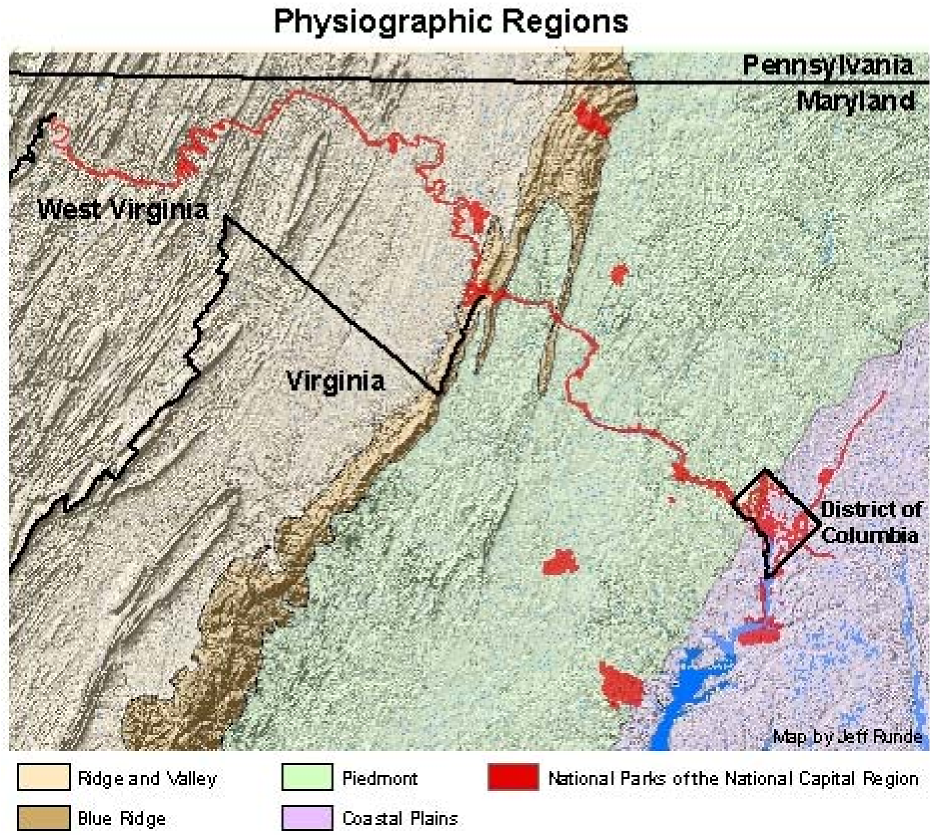


FIGURE 2-10: PHYSIOGRAPHIC REGIONS OF THE NCRN

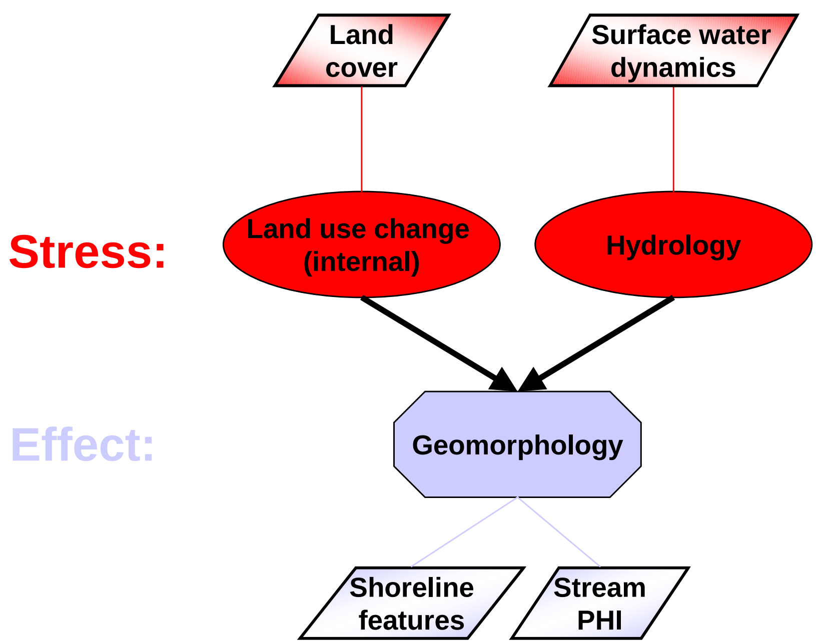


FIGURE 2-11: GEOLOGY AND SOILS ECOSYSTEM DOMAIN MODEL

Running Water. Running water is the single most important agent sculpting the planet's surface (Tarbuck and Lutgens 1984). Timing, amounts, and intensity of precipitation (i.e., weather and climate) determine stream flow rates. These rates are modified by land cover and soil attributes of the surrounding landscape matrix. Increased flow rates (e.g., as a result of changes in climate or land cover) can substantially increase erosional processes (Bronstert 2004). The potential sources of changes in stream flow are discussed in detail as part of the water resource model.

Changes in stream sediment load also accelerate rates of erosion. In urban environments sediment loads can be influenced by a combination of factors, including land use, soil type, slope, intensity of precipitation, runoff amount and velocity, stormwater sewer overflow, commercial/industrial dumping, and amount of vegetative cover. For example, extensive areas of poorly- or un-vegetated soil have been shown to dramatically increase sedimentation rates (Hoffman et al. 1985). Studies of sediment transport to the Chesapeake Bay have indicated that the Potomac River Basin contributes an average of 4.1 billion pounds of suspended sediments per year to the bay (Darrell et al. 1998). These data suggest that suspended sediment loads in the Potomac have been declining as a result of best management practices such as the restoration and maintenance of riparian buffers.

2.6.2.2 Effects

Geomorphology. The primary effect of these stressors on the soil environment is an accelerated rate of erosion. Erosion is the process of turning soil particles into sediments. Although this process occurs naturally, human activities may accelerate the rate of erosion to ecologically damaging levels. Two vital sign endpoints are considered relative to rates of erosion: shoreline change and change in stream physical habitat. Secondary effects of erosion, including impairment of water quality, water supply, and health of aquatic organisms, are discussed in the sections pertaining to the modeling of water and aquatic biota resources.

The U.S. has approximately 150,000 km of shoreline that is continuously affected by coastal development activities, sediment deposition from upland sources, and offshore mineral and oil exploration (National Safety Council 1998). While the NCRN does not have any coastal parks, several park subunits (e.g., Dyke Marsh, Piscataway, Fort Washington, Kenilworth Aquatic Gardens, and Anacostia) are located in tidal areas along the Potomac and Anacostia Rivers. Given the environmental, economic, and aesthetic values of these resources, combined with the high level of urbanization in the region, it is important to understand the progression of shoreline change, especially as it relates to flooding frequency and extent, and sedimentation and deposition cycles. Changes in surface water flow (and corresponding changes in sediment cycling) due to increasing impervious surfaces in the watershed could exacerbate the processes leading to shoreline change.

Sediment loading and increased scouring associated with altered hydrology also could result in the deterioration of physical habitat in streams. Processes by which habitat may be altered include (a) increased siltation; (b) change in “normal” sedimentation sequence and composition; (c) filling of channels; and (d) change in number, timing, and presence of vernal and ephemeral pools. Measures of stream physical habitat will include information regarding channel structure, watershed/riparian/stream morphology, and sediment accumulation.

2.6.3 Water

Hundreds of rivers, streams, ponds, and seeps run through the NCRN parks and contribute substantially to the overall water quality of the region. Water resources also act as habitat for aquatic life. This section discusses the physical components of the water resource domain. Biological components are discussed in the next section.

The earth contains approximately 1.36 billion km^3 of water, of which freshwater comprises only a small fraction (less than 3%) (Christopherson 2003). Roughly 22% of all freshwater is found in groundwater reservoirs (Hornberger et al. 1998), including pore spaces between rock and soil particles and cracks, crevices, and spaces in unconsolidated parent material. An important concept with regards to groundwater availability to plants and humans is the water table (i.e., the depth of the soil unsaturated zone), which is determined by factors including the amount of precipitation, vegetation type, soil type, and the quantity of groundwater that is withdrawn from the system for human use or which exits naturally into lakes, rivers, and streams. The consequences of groundwater depletion through excessive withdraw is an increasingly important environmental concern (Brown et al. 2000) and was highlighted by the SAC as a priority management issue in at least one of the NCRN parks (CATO). Over-consumption of groundwater may lead to a lower water table, changes in plant productivity or vegetation community composition, lower stream flow, increased levels of contaminants, and increased encroachment of salt water in coastal areas.

Surface water is far less abundant than groundwater (approximately 0.26% of all freshwater; the vast majority of freshwater is in glaciers and ice), but accounts for nearly 80% of U.S. water consumption and nearly 100% of consumption in Virginia, Maryland and the District of Columbia (EPA 2004b). Extractive benefits of this resource include drinking, industrial production, and irrigation. Nonextractive or instream benefits include flood control, transportation, recreation, hydroelectric power, and habitat for aquatic life (Jackson et al. 2001). Issues of both water quantity and water quality are of concern to NCRN management (figure 2-12). In addition to the stressors discussed in this section, stressors to water resources may arise from changes in the air and soil domains as described in the previous two sections. The changes themselves may adversely impact aquatic biota, as will be discussed in the following section.

2.6.3.1 Stressors

Water Pollutants. Biogeochemical cycling of surface and groundwater contaminants (e.g., nutrients, pesticides, and toxics) is controlled by chemical and biological processes that are ultimately influenced by soil type, surficial geology, land use, climate, and vegetation. Acid rain is a well-documented example of a stressor crossing from the air to the water resource domain, and acid deposition was responsible for an estimated 32% of the total nitrogen load to the Chesapeake Bay in 2000 (Chesapeake Bay Program 2002a). The chemical cycling of these acids is strongly related to seasonal changes in hydrology. For example, concentrations of atmospherically derived contaminants, particularly sulfate, in stream water of CATO increase significantly in winter when stream discharge consists primarily of shallow groundwater (Rice and Bricker 1995). Although the amount of sulfuric and nitric acids that NCRN streams are believed to be receiving from the atmosphere under current conditions are believed to be much lower than the amount required to cause ecologically damaging levels of acidification, monitoring will be used to verify this belief and to track future trends.

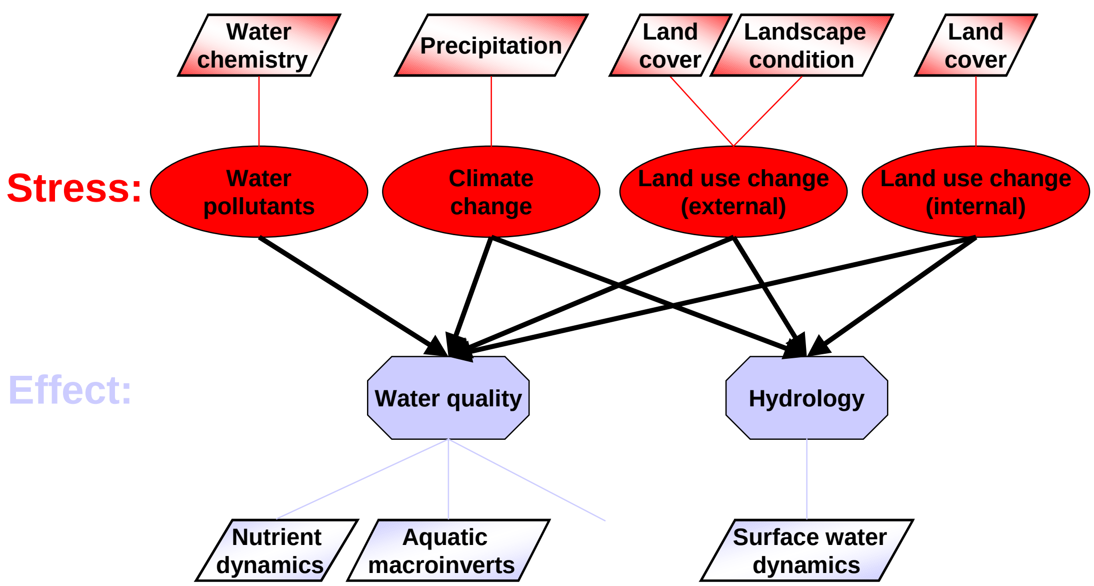


FIGURE 2-12: WATER ECOSYSTEM DOMAIN MODEL

Previous studies in the Potomac River Watershed have identified the following additional water pollutant issues: (a) nutrient, heavy metal, and organic chemical contamination in runoff and surface waters from urbanized watersheds; (b) nutrient and pesticide contamination in streams found in the Ridge and Valley and Piedmont physiographic provinces; and (c) non-point source contaminants (i.e., fertilizers, pesticides, and septic effluent) in groundwater aquifers found in limestone formations (USGS 1991).

Climate Change. Any future change in climate may have direct impacts upon stream hydrology and biochemistry. For example, a warming planet is generally predicted to intensify most parts of the water cycle, resulting in global increases in precipitation, evapotranspiration, storm occurrence, sea level, and biogeochemical processes (Jackson et al. 2001). Predictions of regional impacts are more variable. Some climate models forecast future decreases in precipitation in the eastern U.S. but increases in runoff due to changes in vegetation parameters (e.g., VEMAP II - Aber et al. 2001). By changing the rate of nutrient and chemical transformations, climate change also could have profound effects on biogeochemical cycling within aquatic environments.

Land Use Change (external). The rapid population growth and accompanying changes in development and agriculture have had profound effects on water resources. For example, predominantly agricultural or urban watersheds are more likely to have measurable levels of nitrogen- and pesticide-based contaminants in streams than predominantly forested watersheds (Ator and Ferrari 1997). Leakage from septic systems contribute substantially to nutrient loading throughout the region, while combined sewer overflows (CSOs) are a problem along the Anacostia River and sections of the Potomac River near Rock Creek. Another consequence of development is an increase in impervious surfaces that lead to increased runoff and nutrient and sediment loading of streams (Goetz et al. 2004). During winter, road salt is washed from the region's many streets into nearby streams. Other hydrologic changes associated with urbanization include (a) reengineered stream channels, including concrete channels and streambank stabilization; (b) reduction of wetland tree species; (c) increase in upland tree, shrub, and herbaceous species; (d) poor riparian and instream habitat; and (e) inferior water quality (Groffman et al. 2003).

Land Use Change (internal). The main sources of park internal development are new facilities, concessions, utilities, and maintenance of park infrastructure. Land use change or changes in intensity of land use within the parks can result in the deterioration of water resources. Visitation can cause soil compaction and denudation of vegetation, both of which influence hydrologic regime. Increased visitor use around sensitive hydrologic elements such as streams, ponds, and ephemeral pools is especially damaging. Abandoned mines in the NCRN, including those at CHOH and PRWI, can contribute to contamination of surface and groundwater systems, as pollutants (typically acids and metals) leach through the soil into the water. Although acid mine drainage as a source of stream acidity is thought to affect only 3% of the total stream miles in Maryland, localized effects upon the soil and surface water systems can be devastating (Boward et al. 1999).

2.6.3.2 Effects

Water Quality. Water quality refers to the water's physical and chemical state. Surface water in the NCRN must satisfy varied ecological needs, such as providing habitat for fish and other aquatic organisms, recharging groundwater, and supporting native riparian and submerged aquatic vegetation. These services may be diminished under polluted conditions. The effects of nutrient loading upon ecosystem health include eutrophication, algal growth, diminished dissolved oxygen concentrations, and an accumulation of toxic waste byproducts (Smith 1998; Boward et al. 1999). Chemical contamination including pesticides may have immediate, toxic effects upon both aquatic and terrestrial organisms (including humans) using water resources. Increased acidity associated with atmospheric deposition is of special concern. In addition, bioaccumulation of contaminants within upper trophic level species can cause long-term reproductive and physiological problems, which can have lasting effects on species populations (Yeardley et al. 1998). The potential synergistic effects of exposure to multiple pesticides, as well as continuous exposure to low or trace levels of pesticides, are less well understood and require additional study.

Hydrology. Changes in climate or land use can lead to changes in hydrology, which affects the functioning of surface water systems, wetlands, and riparian areas. Height of stream flow varies seasonally under natural conditions and stream gage data can be used to track these changes. Anthropogenic influences can intensify the variation. For example, high (peak) and low (base) flows are exacerbated in urban areas that have a large number of parking lots, streets, sidewalks, buildings, and other impervious surfaces (Dougherty et al. 2004). As impervious surfaces increase across the landscape, less water infiltrates into the soil and flow is rerouted directly into streams. As a consequence, groundwater recharge and base flow are reduced, while peak flow height and velocity are increased. In addition, the likelihood of contaminants and sediment being carried directly into rivers and streams increases with increases in impervious surfaces (Schlosser 1991; Tague and Band 2001). The Maryland Biological Stream Survey has shown a direct link between percent imperviousness and declines in various indicators of stream health throughout the state (Boward et al. 1999). Water withdrawal and dams, including roads that act as dams, also may alter seasonal water patterns (Heinz Center 2003). Any change in flow regime can result in impairment of water quality, water supply, and physical habitat, including (a) alteration of intensity and frequency of disturbance; (b) change in vegetation productivity, reproduction, and composition; (c) alteration of wildlife behavior; (d) increase in tolerant, non-native and less desirable species; and (e) change in migration patterns and spawning time and location (Baxter 1977; Jeglum 1975; Schneider 1988; Hackney et al. 1995; Perry and Hershner 1999).

2.6.4 Aquatic Biota

The influences of changes in the physical and chemical properties of water resources are felt most immediately and directly by biota living in the water domain. The biological component also is the part of the ecosystem that tends to be most noticeable to park visitors and, thus, attracts the most management attention. Aquatic biota to be monitored include common and representative fish, herpetofauna, and macroinvertebrates, and rare, threatened and endangered (RTE) species of all taxonomic groups (figure 2-13).

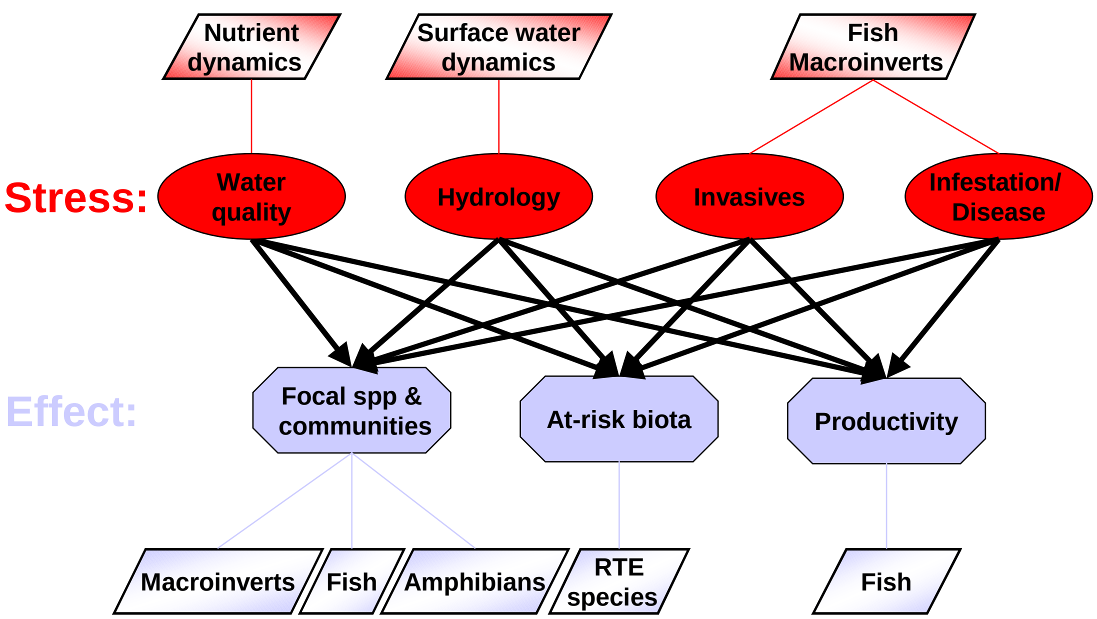


FIGURE 2-13: AQUATIC BIOTA ECOSYSTEM DOMAIN MODEL

Fish — To date, over 100 fish species have been documented in ongoing inventories of the NCRN. Among these, brook trout at CATO have received special management consideration. NACE, ROCR, and PRWI parks are especially diverse in fish, each having recorded more than 40 species. Water clarity, water flow, aquatic and riparian vegetation, and spawning beds and pools are all important elements of fish habitat. Clear, fast-moving water provides good air-water mixing, which increases the amount of dissolved oxygen in the water. Streamside trees are important contributors of detritus (leaf litter) and large woody debris, which provide habitat complexity and nutrients. Pools provide shelter and spawning habitat in deep water beneath undercut banks, overhanging vegetation, rocks, and logs (Vannote et al. 1980).

Herpetofauna — Approximately 40 species of aquatic herpetofauna are expected to occur within the NCRN (Gray and Koenen 2001). These include amphibians that are bound to freshwater for their reproduction and reptiles that lay terrestrial eggs but feed in aquatic environments. Small salamanders are a principle vertebrate predator in headwater streams, while tadpoles are important grazers in shallow water bodies. Reptiles that feed in surface waters include water snakes (predators of fish and invertebrates) and turtles (omnivores in sluggish streams that consume substantial amounts of invertebrate and fish prey) (Allan 1995).

Macroinvertebrates — Macroinvertebrates are an especially significant food source of many fish in shallow, well-aerated stream riffles. Aquatic macroinvertebrates found in NCRN marsh communities include amphipods, oligochaete worms, freshwater snails, and insect larvae. Several rare amphipods are found in the parks' seeps and springs, and copepods and cladocerans are abundant in tidal creeks (Mitsch and Gosselink 1993).

Vegetation — Aquatic vegetation includes wetland vegetation and submersed or emergent vegetation found in rivers, streams, and ponds. In-stream vegetation provides food, habitat for aquatic animals, detritus, and oxygen to the water column. Bank trees and shrubs in the riparian/floodplain zone also are important to aquatic systems. Riparian vegetation influences stream temperature, woody debris, and sediment loads. In-stream monitoring of vegetation is not currently a focus of NCRN efforts, while riparian and wetland vegetation are discussed in the terrestrial biota section.

2.6.4.1 Stressors

Water Quality. Pollutant and nutrient loads in the water column will be monitored as part of the water chemistry monitoring. The sources and pathways of these contaminants are detailed in the water resource model. In this section, poor water quality is considered as a stressor to aquatic biota. Contamination by toxins from industry, farms and sewage are major causes of declines in fish and aquatic macroinvertebrates. High concentrations of nutrients can encourage algal growth (eutrophication), leading to declines in oxygen availability for other aquatic biota. The effects of sediment loading upon the health of aquatic organisms also are significant and include (a) destruction of quality habitat, (b) reductions in ecosystem productivity, (c) altered wildlife behavior, and (d) disruptions in species population cycles and size.

Hydrology. The sources and pathways of changes in stream hydrology also are considered in the water resource model, but alteration of surface water dynamics can have substantial impacts on aquatic life. For example, reduced flow can result in: (a) changes in the number, timing, and presence of pools; (b) increases in disease and other pestilence; (c) fish kills; (d) changes in the ratio of stenothermal to eurythermal fish and herpetofauna; (e) loss of populations or species; (f) increases in surface water temperature; and (g) decreases in water quantity. Low flow in the Potomac additionally can lead to saltwater incursion in the tidal areas. Inflated flow regimes also can stress aquatic life, particularly if high levels of pollutants accompany the high flow. For example, the routing to streams of stormwater associated with impervious surfaces in urban watersheds has been shown to result in the replacement of sensitive macroinvertebrates with those more tolerant of hydrologic stress, and the drop in plant and amphibian community richness (Watershed Protection Techniques 1994).

Non-native Invasive Species. Non-native (or exotic) species are those species whose historic ranges do not fall within the NCRN. Those species that spread aggressively once introduced are additionally referred to as invasives. There are numerous pathways for the introduction of nonnative aquatic species including the release of ballast water by foreign vessels entering ports (Carlton and Geller 1993; Ludsin and Wolfe 2001). Occasionally, non-native species are intentionally introduced to an ecosystem (e.g., brown trout, a native of Europe, was introduced for fishing purposes). Regardless of their source, the introduction of non-native species can have significant effects on native wildlife populations. They may act as additional predators, parasites, disease vectors, or competitors for native species. As a consequence, watersheds that experience an increase in non-native species are likely to experience corresponding decreases in native species diversity. In addition, non-native species may become more easily established in waters that have high levels of other stressors (e.g., degraded water quality, altered hydrologic regime) and they increase the likelihood of future ecological disruptions (Heinz Center 2002). A species of special concern is the northern snakehead (*Channa argus*), which has been observed intermittently in the Potomac River over the past few years.

Infestation and Disease. The study of infectious disease is one of the top challenges confronting scientific understanding of the environment and humanity's place in it (NRC 2003). Major areas of focus within the scientific research community include (a) understanding the evolution of disease systems; (b) determining the biodiversity and modes of action of pathogenic organisms; (c) characterizing the role of disease systems in community structure, ecosystem functioning, and biodiversity; and (d) predicting the timing and locations of disease outbreaks (Glass et al. 2004). Waterborne diseases are of particular concern to human populations. Potable water is a basic societal objective and the number of disease outbreaks linked to contaminated water is a direct measure of the health of the nation's water (Heinz Center 2002). State and local public health departments are primarily responsible for tracking waterborne disease outbreaks; therefore, these data will not be collected by park personnel, but information from these sources will be used to identify any contamination linked to aquatic resources within the parks.

2.6.4.2 Effects

Focal Species and Communities. Nearly all NCRN parks occur within the Potomac River drainage, a transitional region that serves as a range boundary for several freshwater fishes (Lee et al. 1980; Hocutt et al. 1986). Monitoring will track the status and trends of common species and communities of fish, amphibians, and macroinvertebrates in the parks' streams, riparian areas, springs, and vernal pools. The distribution of these biota is strongly related to modifications of the environment. For example, changes in stream hydrology can result in a shift from native rheophilus fish species (such as sculpins and darters) to fish that prefer warmer temperatures, lower stream velocities, and stream bottoms coated with silt (such as sunfish and trout). Upland and riparian vegetation also play important roles in structuring aquatic habitat and thereby influencing the composition of aquatic communities (Roth et al. 1996).

Amphibians are particularly good indicators of environmental change because of their low vigility, narrow physiological tolerances, and complex life cycles. Macroinvertebrate species also are highly sensitive to anthropogenic stressors. For example, Ephemeroptera, Plecoptera, and Trichoptera species generally decrease in streams with substantial human impact whereas the proportion of oligochaetes and chironomids typically increase with human disturbance (Karr et al. 1985; Petersen et al. 1991). Sediment-dwelling (benthic) macroinvertebrates are especially desirable indicators because of the wide range of physiological tolerances covered by this diverse group of relatively immobile species (Boward et al. 1999).

At-risk Biota. People value species for a variety of reasons: they provide goods and services (e.g., food, recreation); they serve as key elements of ecosystems, which in turn provide additional goods and services (e.g., clean water); and many argue they have their own intrinsic value (NRC 2000; Ghilarov 2000). Although the maintenance of biodiversity is a NPS priority, a number of the fish, herpetofauna, and macroinvertebrates in the NCRN have been designated as at-risk species (i.e., species with a relatively high probability of extinction) (Gray and Koenen 2001).

Small populations of a species may reflect either natural rarity or actual population declines. Monitoring is needed to distinguish between these two options. However, even naturally rare species may be especially susceptible to new or increased environmental stressors (Heinz Center 2002). The sensitivity of rare and endangered species to stressors along with the high level of attention bestowed upon these species by the public make them excellent vital sign candidates (Angermeier 1997). Adams (2002) further proposed that organism- to species-level indicators of aquatic ecosystem stress provide the best coupling of mechanistic understanding and ecological relevance.

Productivity. Without clear water, sunlight cannot penetrate deeply enough to give underwater grasses the energy they need to grow (Chesapeake Bay Program 2000a). The resulting loss in net primary productivity can alter water chemistry in at least two important ways: (1) less dissolved oxygen is generated; and (2) minerals not taken up by plants remain dissolved in the water column. Both of these conditions can affect productivity of fish and other aquatic animals. Fish productivity also may be reduced directly as a result of anthropogenic stressors such as recreational fishing. The Maryland Biological Stream Survey provides a regional context for productivity estimates within the parks. This ongoing monitoring, conducted by the Maryland Department of Natural Resources, has sampled fish, benthic macroinvertebrates, and herpetofauna in over 1,000 randomly selected sites on first- through third-order freshwater streams throughout Maryland (Boward et al. 1999). Stream conditions in Virginia and Washington, D.C., are similar enough to Maryland that comparisons with the Maryland Biological Stream Survey are also appropriate.

2.6.5 Terrestrial Biota

The NCRN parks contain a diverse range of ecological communities and act as green island refugia for at-risk flora and fauna in the urbanizing landscape. As in the aquatic environment, species extirpations and population declines in the terrestrial environment have been noted widely. For example, the number of breeding bird species has been declining in many areas throughout the region, including a 61% loss of species on Plummer's Island over the past 50 years as a result of changes in vegetation on the island. The selection of specific vital signs for monitoring terrestrial biota emphasizes species and communities that are both sensitive to stress and practical to monitor (figure 2-14).

Herpetofauna — Reptilian species found within the NCRN include 11 turtles, 22 snakes, and six lizards (Gray and Koenen 2001). Amphibians provide a strong link between the terrestrial and aquatic environments.

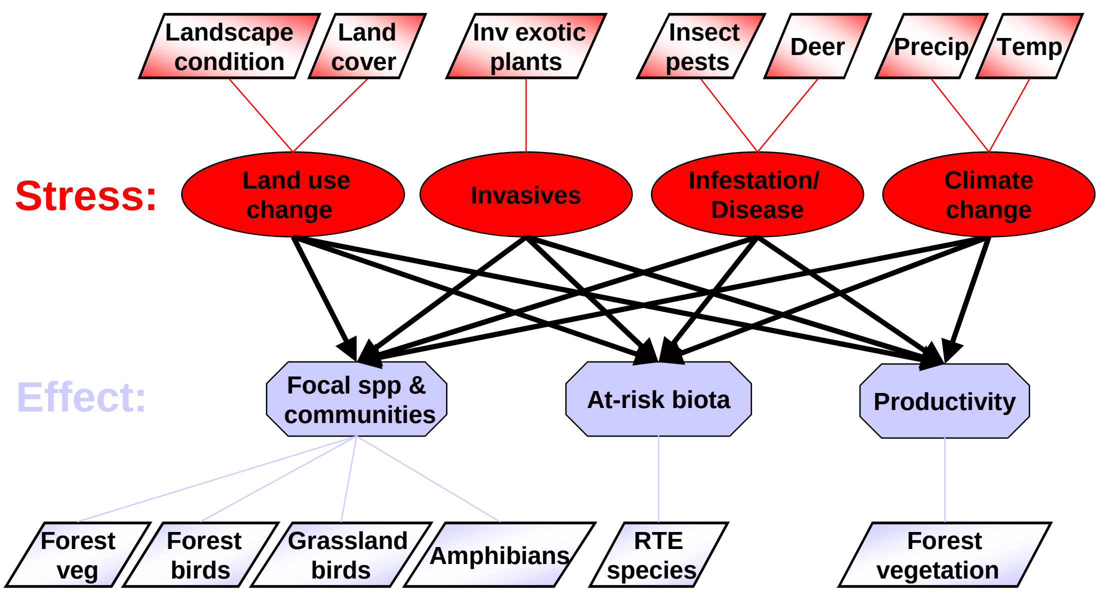


FIGURE 2-14: TERRESTRIAL BIOTA ECOSYSTEM DOMAIN MODEL

Mammals — At least 33 species of mice, rats, voles, shrews, weasels, moles, and flying squirrels occur within the NCRN (Gray and Koenen 2001), including the rare Allegheny woodrat (McShea 2002). Larger herbivores include deer, beaver, eastern cottontails, and woodchucks. Carnivorous mammals include fox, weasels, coyote, raccoon, bobcats, otter, skunk, opossum, mink, and bear. As many as 10 species of bats are thought to occur within the NCRN, including the endangered Indiana bat (Gray and Koenen 2001).

Birds — A diverse collection of birds can be observed in the NCRN, including forest interior dwelling birds, grassland birds, waterfowl, colonial waterbirds, and raptors. In sum, 228 avian species have been recorded, of which 137 are thought to breed in the region (Gray and Koenen 2001). Data from Fort Belvoir in Fairfax County suggests that adult populations of several priority species including Acadian flycatcher, wood thrush, and Kentucky warbler are declining in the region (Nott et al. 2002).

Vegetation — The Appalachian/Blue Ridge forests are among the most diverse temperate broadleaf and mixed forests in the world (Olson and Dinerstein 1998), and the number of fine-scaled vegetation associations in the NCRN are too numerous to account in detail. For example, Thomson et al. (1999) identified 14 vegetation community types in the Potomac River Watershed for floodplain forests alone. NatureServe has developed a system for classifying plants that tend to co-occur on landscapes at spatial scales of tens to thousands of hectares and temporal scales of at least 50 years (Comer et al. 2003). These mesoscale ecological systems are designed specifically for applications such as ecological monitoring. Of the 599 ecological systems described for the coterminous U.S., adjacent portions of British Columbia, and Alaska, 26 are found within the NCRN (NatureServe 2003).

2.6.5.1 Stressors

Land Use Change. Land use change and increased intensity of land use has been highlighted as one of the most pervasive environmental stressors facing terrestrial biota (NRC 2001, 2003). The rapid population growth and development underway in the Mid-Atlantic Region can have a direct, immediate, and significant impact on species diversity (Lindborg and Eriksson 2004), exotic species invasions (Vitousek et al. 1997; McCay 2001), and ecosystem productivity and biogeochemical cycles (Osher et al. 2003; Williams et al. 2004). The long-term consequences are difficult to assess, but it is becoming increasingly evident that landscape change also may interact with climate to create novel environmental settings for biota (Pyke 2004) and promote the spread of new diseases (Langlois et al. 2001).

Non-native Invasive Species. Globally, invasive species are second only to habitat destruction in the severity of threat they present to imperiled native species (Morse et al. 2004). Economic damages (including efforts at control) associated with invasive species are approximately $137 billion per year (Pimentel et al. 2000). Among plants alone, over 3,500 non-native species are now found growing wild in the U.S. (Morse et al. 2004). Non-native predators and competitors have been introduced through both human (e.g., pet trade and commercial ports) and natural sources (e.g., migration, storms, air, and water sources), and the problem is likely to worsen as global trade and travel continue to increase (Williamson 1996).

Of an estimated 2,000 plant species occurring in NCRN parks, nearly 300 are non-native and about 30 of these are recognized as being invasive (NPS 1999c). The ten highest priority species cover a combined 2,902 ha and include tree-of-heaven (*Ailanthus altissima*), the exotic bush honeysuckles (*Lonicera spp.*), Japanese honeysuckle (*L. japonica*), porcelainberry (*Ampelopsis brevipedunculata*), English ivy (*Hedera helix*), kudzu (*Pueraria montana* var. *lobata*), Asiatic bittersweet (*Celastrus orbiculatus*), garlic mustard (*Alliaria petiolata*), and lesser celandine (*Ranunculus ficaria*) (NPS 1999c). Non-native invasives are considered to be an especially critical threat to the resources of the Potomac Gorge (Cohn 2004; NPS and TNC 2001). Sources of invasive plants include accidental and deliberate introductions and horticultural propagation. Natural and anthropogenic habitat disturbances are mechanisms that likely facilitate exotic species establishment (Williamson 1996).

Infestation and Disease. Forest insects and pathogens are the most pervasive form of forest disturbance in North America, with an annual impacted area more than 40 times larger than that of fires (Dale et al. 2001). Empirical and modeling evidence suggests that insect outbreaks are likely to intensify in a warming environment (Logan et al. 2003). Prevention of pest invasion is particularly difficult in fragmented landscapes such as the Mid-Atlantic Region (Myers et al. 1998). Effects of insect outbreaks include decreased transpiration and tree growth, increased tree mortality, increased light penetration to the forest floor, increased production of defensive compounds in foliage, increased populations of insectivorous birds, and altered ecosystem biogeochemical cycling (Lovett et al. 2002).

The gypsy moth caterpillar, one of the most widespread and damaging pests in the Northeast (Porter and Hill 1998), is a common pest species in many areas of the NCRN. It was introduced from Europe around 1870, and spread rapidly by human transport throughout the region (Porter and Hill 1998). Within the NCRN, the caterpillar has affected many species of oaks in particular. The outbreak cycle and root causes of infestation, however, are poorly understood.

Broadly defined, an infestation is the state of being overrun in numbers large enough to be harmful, threatening, or obnoxious, which accurately describes the situation in many NCRN parks with regards to white-tailed deer. Forest protection on public lands since the last wave of logging has led to an increase in deer habitat throughout the Mid-Atlantic Region (Sweeney and Czapka 2004). Deer are particularly adept at expanding their populations in mixed-use landscapes such as those prevalent in the Mid-Atlantic. Interior forest habitat is used for reproduction and the raising of young, while forest edge habitat is used for foraging (Porter and Hill 1998). As a result, deer have become a major part of the landscape in the parks of the NCRN, often to the detriment of forest regeneration (Alverson et al. 1988). They have rebounded from near extinction to record densities of as high as 64 deer/km^2 (Rossell et al. 2005), well above the estimated regional carrying capacity of approximately 15 deer/km^2 (Whittington 1984). In addition, inflated deer populations can cause damage to crops and can be hazardous to traffic (Xie et al. 2001).

Climate Change. Monitoring of ecological response to global climate change is important to test models and forewarn policymakers of any unforeseen consequences (Neilson 1993; IPCC 2001b). Most current models interested in the potential consequences of global climatic change rely upon observed correlations between terrestrial biota and elevation or latitude to predict biotic response to a changing climate. For example, species range shifts of hundreds of meters in elevation or hundreds of kilometers latitude are predicted to accompany a 2°C increase in temperature (Peters and Darling 1985). While some of these shifts may be gradual due to demographic processes (e.g., growth, reproduction), others may be sudden, triggered by thresholds in ecosystem processes (e.g., water, nutrient cycling) (Fujiware and Box 1999). Fire or other forms of disturbance also may trigger abrupt responses to a changing climate (Dale et al. 2001). Several recent reviews have shown that species range shifts are already beginning to be observed (Parmesan and Yohe 2003; Walther et al. 2002), and fragmented landscapes, such as those that dominate the NCRN, are viewed as particularly vulnerable to species extinctions as a result of these shifts (Noss 2001). Along with species range shifts, observations have been made over the past 30 years of changes in phenology, increased susceptibility to invasion, and changes in community associations (Walther et al. 2002). Simulations predict additional changes in productivity, carbon storage, and the water balance as a consequence of changes in climate (Aber et al. 2001).

2.6.5.2 Effects

Focal Species and Communities. Monitoring of terrestrial species and communities will focus on assessing the condition of forest vegetation, birds and amphibians. Vegetation is generally recognized as the dominant form of terrestrial biota because of its central role in primary production, nutrient and hydrologic cycles, disturbance regimes, and the structuring of wildlife habitat at multiple scales. In addition, most of the parks in the NCRN have a specific mandate in their founding legislation related to management of forests, the prevalent natural vegetation cover of the region. Thus, monitoring of forest vegetation resources will be an area of special emphasis in vital signs monitoring.

NatureServe developed a classification of terrestrial ecological systems that relies on groupings of plant community types (associations) that tend to co-occur within landscapes (Comer et al. 2003). The 26 of these communities found in the NCRN (NatureServe 2003) represent a diverse range of natural variation including forests, riverine, wetland, and riparian environments (table 2-2). While monitoring will be conducted across community types, the majority of vegetation samples will be collected in upland forest communities. Upland forests in the region are dominated by oak (*Quercus spp.*) and hickory (*Carya spp.*), with smaller components of black cherry (*Prunus serotina*), white ash (*Fraxinus americana*), hackberry (*Celtis occidentalis*), sugar maple (*Acer saccharum*), black locust (*Robinia pseudoacacia*), and other winter-deciduous species (Everson and Boucher 1998).

Changes to other vegetation community types are also possible, but will be monitored with lower intensity. Riparian and floodplain areas occur at the interface between terrestrial and aquatic ecosystems, stretching outward from waterways to the limits of flooding. They are highly affected by changes in hydrology, riverbank location and stability, and erosion and deposition cycles. Riparian zone plant communities are major determinants of abundance and quality of nutritional resources for animals living in and around streams. These forests are dominated by cottonwood (*Populus deltoides*) and sycamore (*Platanus occidentalis*), with historic abundances of elm species (*Ulmus* sp.) (Manville 1968). Managed grassland fields are particularly important resources within four of the NCRN parks (ANTI, MANA, MONO, WOTR). Open grasslands may once have been common throughout the east coast (Askins 2000). Although currently they are much less ubiquitous in the region, a number of parks including MANA are restoring native grass species. Shrubs present in these open areas include dogwoods (*Cornus* sp.), viburnums (*Viburnum* sp.), and haws (*Crataegus* spp.) (Bailey 1978).

At-risk Biota. At present, approximately 19% of the native animal species and 15% of native plant species in the U.S. are considered imperiled (Heinz Center 2002). Inventory surveys are currently being conducted to determine the number of these species occurring within NCRN parks (Gray and Koenen 2001). The federally endangered vascular plant harperella (CHOH) and a number of state-rare birds, mammals, and vascular plants have already been identified. The distribution and abundance of these species will be monitored at levels beyond those required by the focal species and community monitoring plans, which focus more on common and representative biotic elements.

Productivity. Because trees can survive for decades to centuries and take decades to establish, forests may not immediately exhibit shifts in composition in response to environmental stress (Camill and Clark 2000). Changes in demographic mechanisms such as productivity may be the initial indicators of changes in climate (Magnani et al. 2004), land use (Ollinger et al. 2002), invasive species (Mooney and Cleland 2001), pollution (Bauch 1986), and/or insect infestations (Lovett et al. 2002). Over the past 70 years, the U.S. Forest Service Forest Inventory and Analysis has established national and regional estimates of forest productivity, which will serve as reference conditions for measurements taken in NCRN parks (Frayer and Furnival 1999).

2.7 URBANIZATION SUBMODEL

As vital signs monitoring proceeds, it will undoubtedly identify a number of priority issues of concern. Additional, more-detailed conceptual models can explore the small subset of ecological processes deemed most critical for protecting NCRN resources. For example, a common theme throughout the five resource models is the potential influence of human land use on park resources. Given the rapidly urbanizing landscape, it should not be surprising that many park management issues are related to anthropogenic stressors. The Mid-Atlantic Region is experiencing some of the most rapid population growth in the country (section 1.4.4), which has led directly to an increase in development in areas surrounding the NCRN parks. The high population density of the region also results in extremely heavy use of the parks. For example, the George Washington Memorial Parkway alone had over 7 million recreational visits in 2004, making it the sixth most visited unit in the National Park System (Barna and Gaumer 2005).

Pickett et al. (2001) have argued that massive human pressures on ecological resources can no longer be viewed as exogeneous, perturbing forces, but must be incorporated into environmental assessments to fully account for the exchange of material and energy within the earth’s ecosystems. Understanding the dynamics of urban ecosystems is particularly important to conservation, as the majority of the world’s conservation priority areas are located

TABLE 2-2: ECOLOGICAL SYSTEMS OF THE NCRN

NatureServe Ecological System	CHOH	GWMP	NACE	PRWI	CATO	ROCR	HAFE	ANTI	MANA	MONO	WOTR	Sum
Forests												
Appalachian Hemlock-Hardwood Forest					1							1
Atlantic Coastal Plain Northern Basin Swamp and Wet Hardwood Forest	1	1	1						1			4
Northeastern Interior Dry Oak Forest	1	1	1	1	1		1			1	1	8
Southern Piedmont Dry Oak-Heath Forest	1	1	1	1							1	5
Central Appalachian Oak and Pine Forest	1	1			1	1	1					5
Central Appalachian Pine-Oak Rocky Woodland	1											1
Atlantic Coastal Plain Northern Dry Hardwood Forest	1	1	1	1		1					1	6
Atlantic Coastal Plain Northern Mixed Oak-Heath Forest		1	1	1		1						4
Atlantic Coastal Plain Mesic Hardwood and Mixed Forest		1	1	1		1						4
Central Appalachian Alkaline Glade and Woodland	1							1				2
Southern and Central Appalachian Cove Forest	1	1			1		1	1	1	1		7
Grasslands												
Fields								1	1	1	1	4
Riverine												
Atlantic Coastal Plain Northern Subtidal Aquatic Bed		1	1									2
Wetlands/Floodplains												
Atlantic Coastal Plain Brownwater Stream Floodplain Forest	1	1	1	1								4
Atlantic Coastal Plain Small Brownwater River Floodplain Forest	1	1	1	1		1			1		1	7
Central Appalachian Floodplain	1	1	1	1	1	1	1	1	1	1	1	11
Atlantic Coastal Plain Northern Fresh and Oligohaline Tidal Marsh		1	1									2
Southern Piedmont Upland Depression Swamp	1	1		1								3
Atlantic Coastal Plain Northern Tidal Wooded Swamp		1	1									2
Riparian												
Central Appalachian Riparian	1	1	1	1	1	1	1	1	1	1		10

TABLE 2-2: ECOLOGICAL SYSTEMS OF THE NCRN (CONTINUED)

NatureServe Ecological System	CHOH	GWMP	NACE	PRWI	CATO	ROCR	HAFE	ANTI	MANA	MONO	WOTR	Sum
Riparian (continued)												
Southern Piedmont Small Floodplain and Riparian Forest	1	1	1	1			1	1	1	1		8
Shale Barrens / Talus Slopes												
North-Central Appalachian Circumneutral Cliff and Talus	1						1	1	1	1		5
North-Central Appalachian Acidic Cliff and Talus	1				1		1			1		4
Appalachian Shale Barrens	1				1							2
Continually Flooded Swamps and Bogs												
Southern Piedmont Seepage Wetland	1	1	1	1	1	1			1		1	8
North-Central Appalachian Acidic Swamp	1	1	1	1	1	1					1	7
North-Central Interior and Appalachian Rich Swamp					1							1
Sum	20	20	17	14	12	10	9	8	10	9	8	

in areas of high human population density (Cincotta et al. 2000); yet from 1995 to 1999, less than 1% of the papers in nine leading ecological journals described work conducted in urban environments (Collins et al. 2000). The National Science Foundation recognized this knowledge gap by establishing two Long-Term Ecological Research sites within urban landscapes (Parlange 1998), one of which is located within close proximity of the NCRN parks (Baltimore Long-Term Ecological Research).

McDonnell and Pickett (1990) proposed a model to describe the effects of urbanization on ecological phenomena along urban-to-rural gradients (figure 2-15). The model was developed to study ecologically important impacts of development along a gradient of land use radiating from New York City to increasingly distant suburban and rural areas of New York and Connecticut. The concepts are equally applicable to NCRN parks in and around Washington, D.C. The model serves as a framework to be filled in as vital signs monitoring improves understanding of urban ecosystem dynamics of the region. Examples of potential elements of the framework include (a) factors that constitute urbanization such as urban structures and human population densities; (b) biotic and environmental effects of urbanization such as physical, chemical, population, or community changes; and (c) resultant ecosystem effects such as changes in decomposition rates or nitrogen cycling (McDonnell et al. 1997). Information from the natural resource monitoring will be useful for filling in rows 1 and 2 of the model, whereas row 3 will be helpful in guiding management decision-making.

The preliminary model of the ecological effects of urbanization in the NCRN is depicted in the conceptual diagram and text in figure 2-16. More detailed descriptions of the specific influences of urbanization on air, soil, water and biota are provided in the resource models (section 2.6). Because of the variety of pathways through which urbanization can alter ecological structure and function, management of the biological, recreational, and scenic resources in urban parks requires a broad understanding of the complex interactions between multiple environmental stressors. Special attention will be given to the following three properties, which distinguish urban areas from more rural settings: connectivity, succession, and invasiveness (Trepl 1995; Niemela 1999). Urban landscapes are typically characterized by their (1) patchiness and low connectivity, (2) abundance of early successional communities maintained by mowing and other frequent disturbance, and (3) susceptibility to invasion by non-native species.

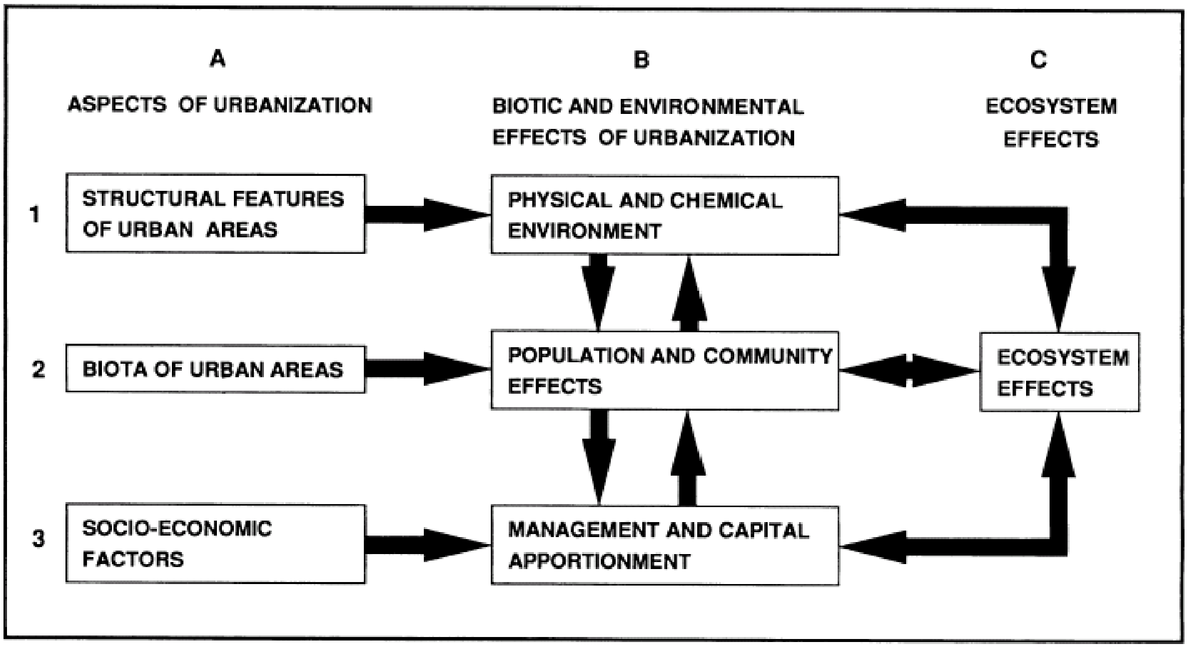


FIGURE 2-15: URBAN-RURAL GRADIENT MODEL OF ECOLOGICAL EFFECTS OF URBANIZATION (MCDONNELL AND PICKETT 1990)

In the NCRN, encroachment of urban development against park boundaries can have a direct, immediate and significant impact on scenic vistas, historic sites, exotic species invasions, recreational opportunities, species diversity and ecosystem productivity. Changes in land use intensity within the region can influence spatio-temporal patterns in temperature, precipitation and air pollution. Regional urbanization also can alter water quality and quantity through the modification of stream channels, the loss of forest and grassland areas, and the addition of new sources of pollutants. In addition, major transportation and utility corridors bisect many of the parks and can interrupt the natural flow of water, air and biota. Information on many of these threats will be collected as part of NPS Vital Signs monitoring.

FIGURE 2-16: URBANIZATION MODEL FOR THE NCRN

2.8 SUMMARY

Conceptual ecological models provide a simplified overview of ecosystem structure and function. They can take the form of any combination of narratives, tables, or graphical depictions, but should be:

- Easy to communicate and transparent to multiple audiences;
- Inclusive of key ecosystem endpoints and critical agents of change; and
- Adaptive and flexible in design to allow for response to novel events and findings.

Well-designed conceptual models can be valuable assets for adaptive management by creating a structure for translating monitoring data into management actions. Ultimately, quantitative and mechanistic models can be constructed to describe the significant components of the conceptual models, but a large up-front investment in conceptual models is extremely useful in clearly defining objectives, optimizing sampling designs, and determining how monitoring results will be used.

Most relevant to the Vital Signs Monitoring Program, the conceptual models contained in this chapter present a general framework for the identification of indicators for monitoring long-term ecosystem health. For the NCRN, perhaps more so than any of the other NPS networks, landscape context is critically important to ecological integrity. Factors and events external to the park boundaries have strong, controlling relationships with internal ecosystem processes. Significant stressors considered for these urban parks were: land use change and land use intensity (both within and outside of park boundaries), air pollutants, water pollutants, regional and local changes in climate, invasive species, and infestations and disease. The ecological effects of these stressors vary widely but generally are related to the degradation in quality of air, water, and geological resources and to population declines of biological resources. Specific vital signs for these stressors and effects are listed in the models and described further in chapter 3.

> "Designing a monitoring project is like getting a tattoo:
> you want to get it right the first time because making
> major changes later can be messy and painful." *(Oakley et al. 2003)*

Chapter 3

Vital Signs

3.1 OVERVIEW

The nature of identifying and selecting vital signs is an iterative process that changes as new information is learned and incorporated into the planning process (Kurtz et al. 2001). The vital sign selection process for the National Capital Region Network (NCRN) applied an iterative approach that drew upon a large pool of subject matter experts who whittled an initial list of over 200 potential monitoring issues down to a short list of 21 vital signs. Whereas chapter 1 describes the legislative, historical, and ecological setting of the parks; and chapter 2 provides the conceptual framework that links resources and related stressors to appropriate ecological indicators (vital signs); this chapter will summarize the vital signs and explain the process for their selection. Even this selection of vital signs is likely to change over time as protocols are developed, tested, and fine tuned (Kurtz et al. 2001).

3.2 COMPREHENSIVE LIST OF MONITORING ISSUES

To begin the vital sign selection process, background information on park management concerns, legislation, and ongoing monitoring efforts were synthesized by visiting the parks and reviewing relevant documents (appendices A, D, G, H, I). The information was given to the 27-member Scientific Advisory Committee (SAC) to draft conceptual models describing (1) natural resources in the NCRN, (2) their threats or agents of change, and (3) the resulting ecological effects. These draft models were generated in small workgroups that focused on broad resource topics including air; geology; landscape; terrestrial invertebrates; rare, threatened, and endangered species; vegetation; water; and wildlife. SAC participants were asked to be inclusive and consider any natural resource issue potentially relevant in the NCRN.

A three-day monitoring workshop of more than 100 individuals representing over 20 organizations and partnering agencies reviewed and refined the draft models to reflect their best current knowledge of the ecosystem. The resulting draft models identified nearly 200 resources, threats, and ecological effects that could be monitored (appendix F). Though comprehensive, there were too many potential vital signs to be monitored in a meaningful and efficient way.

3.3 PRIORITIZING MONITORING ISSUES

Each resource-specific workgroup was then asked to prioritize their comprehensive list of monitoring issues using a set of criteria based on Margoluis and Salafsky (1998) and NPS and TNC (2001) to rank the significance of threats or agents of change on the resource. The criteria included:

1. the amount of area affected by the issue (i.e. how many parks)

2. the intensity of the threat (i.e., will the threat destroy the resource completely or will it cause only minor damage)

3. the level of urgency (i.e., how important is it that immediate action take place to deal with the threat or agent of change?)

4. the feasibility of the threat or the resource to be monitored

5. the monitoring cost.

A quantitative approach was taken by some workgroups and a consensus approach was taken by others. A summary is presented below and details are documented in Koenen et al. 2002.

3.3.1 Quantitative Approach

Three workgroups (landscape, vegetation, and water) adapted point values for each criterion. The point values ranged from 1–5. The higher values reflect a more significant threat or agent of change. Each participant in the workgroup filled out a matrix (appendix J) independently. The ranks were totaled on each sheet and averaged among all participants. Threats with the highest scores were ranked as having the highest monitoring priority.

The RTE workgroup selected quantitative criteria where viable populations of federal and state listed species received the highest monitoring priority along with species with heritage ranks between G1–G3.

3.3.2 Consensus Approach

The air, geology, and wildlife workgroups considered the same criteria but prioritized threats based on a consensus approach instead of a ranking. This approach resulted in each workgroup identifying the most significant threats and feasible vital signs. Details of each workgroup's process are discussed in Koenen et al. (2002).

The invertebrate working group noted that there was a significant information gap to identify appropriate vital signs. Instead, the group recommended a series of projects based on consensus including additional inventories with emphasis on identifying invasive species and new research to evaluate useful indicators. Details of the proposed projects are presented in appendix K.

3.4 FIRST CUT OF VITAL SIGNS

The prioritization process resulted in first cut of 47 monitoring issues (appendix L). Participants at the monitoring workshop were then asked to identify potential vital signs for each priority issue in order to monitor long-term trends of the resource and/or the threat. Throughout the vital sign identification and prioritization process the term "vital sign" was used synonymously with "ecological indicator," and could be any measurable feature of the environment that provides insight into the state of an ecosystem. Vital signs were defined as those that possess the following criteria (Fancy 2002; Dale and Beyeler 2001; Kurtz et al. 2001; Barber 1994):

- have dynamics that parallel those of the ecosystem or component of interest
- are sensitive enough to provide an early warning of change
- have low natural variability
- provide continuous assessment over a wide range of stressors
- have dynamics that are easily attributed to either natural cycles or anthropogenic stressors
- are distributed over a wide geographical area and/or are very numerous (are harvested, endemic, alien, species of special interest, or have protected status)
- can be accurately and precisely estimated
- have costs of measurement that are not prohibitive
- have monitoring results that can be interpreted and explained
- are low impact to measure
- have measurable results that are repeatable by different personnel

In addition to identifying potential vital signs, participants developed broadly defined monitoring goals and objectives in order to define the information that the vital sign needed to provide. Goals were defined as "a very general statement about what you want to do" (e.g., monitor forest vegetation). Objectives were defined as "a more specific statement about a quality that you want to measure" (e.g., describe change in tree basal area within high elevation fir forest between 2003 and 2013). Participants were reminded that good objectives should state exactly which species or indicator would be monitored, location, attributes, action, state, and timeframe. Monitoring objectives may include adaptive management monitoring objectives (e.g., measure resource changes related to management goals and objectives) or ecosystem monitoring objectives (e.g., designed to measure resource changes over time).

3.5 SECOND CUT OF VITAL SIGNS

The prioritization process and first cut of vital signs resulted in a draft of 47 potential indicators (appendix L). A further refinement of the vital signs was conducted by peer reviewers and the I&M staff. Vital signs that did not meet the strict criteria above were removed. In addition, a detailed review of the vital signs indicated that different workgroups identified the same vital signs but had labeled them differently. These were combined and renamed following a standard naming convention developed by the Natural Resources Program Center. The review also identified which vital signs protocols should be developed first. While all vital signs were clearly important, it was also apparent that network funds would not be adequate to develop and implement protocols for all vital signs. Discussions with the SAC focused on which vital signs helped the most parks and which vital signs provided the most needed information to the parks. In some cases protocols development should be reconsidered when more scientific information becomes available. This review process resulted in shortening the list of 47 vital signs to 21 vital signs and provided the basis for the models presented in "Chapter 2: Conceptual Models."

3.5.1 Vital Signs Removed from the List

Vital signs that did not meet the full set of criteria were removed from the list of proposed vital signs (table 3-1). Detailed justifications for their removal are presented in appendix M.

3.5.2 Combining Vital Signs

In addition to removing vital signs, the I&M staff combined similar vital signs. Vital signs were combined if they addressed the same or similar monitoring goals and objectives. Vital signs identified by the different workgroups, for example, frequently addressed the same threats, monitoring goals, or monitoring objectives. A summary is provided below:

Vital Signs

Ozone — While chlorotic mottling was identified as a vital sign, the national vital sign framework identified it as a subset of the ozone vital sign. Monitoring ozone through chlorotic mottling at NCRN was tabled until more information becomes available. Although ozone sensitive species are known, foliar injury does not adequately indicate physiological or ecological impact. The issue will be revisited if future research indicates foliar injury monitoring is an appropriate indicator of ecological response.

Amphibians — The wildlife working group initially identified two separate vital signs relating to amphibians. One dealt with monitoring population dynamics including species diversity and abundance. The second vital sign dealt specifically with monitoring for amphibian disease. Adapting the Amphibian and Reptile Monitoring and Inventory (ARMI) protocols developed by USGS will be used to collect the information needed for both vital signs. The protocol is being developed to combine the two vital signs into one.

TABLE 3-1: SUMMARY OF VITAL SIGNS REMOVED FROM THE DRAFT LIST OF PRIORITY VITAL SIGNS

Vital Signs Removed	Reason for Removing
Impact of development on vegetation	Short-term and project-specific issue
Politics	Outside the scope of I&M Program
Change in land ownership	Land ownership and census data is already available
Urban soil profiles, soil structure (compaction, soil profile and structure, biodiversity)	Research project
Invertebrates	More baseline inventory data needed before ecologically meaningful monitoring can be identified

Forest Vegetation Monitoring — The vegetation working group identified a number of related metrics under different vital signs. A new vital sign was established that would address the identified threats including exotic and invasive species, deer impacts, fragmentation, and long-term vegetation change using permanent plots established throughout NCRN. A combined vital sign and protocol will include the following components:

- percent cover by species (native and non-native) and height class
- species composition
- forest structure over time, including snags, canopy gaps, and age parameters
- number of seedlings and saplings per height class
- deer browse impacts

Physical Habitat Index — Riparian habitats are generally rich in species diversity and provide critical ecological functions (Beatley et al. 2003). Riparian habitat may also represent a significant entry point for exotic/invasive plant species. Flooding and erosion, has significant impacts on riparian habitats in some areas in the NCRN. Monitoring is needed to identify trigger points to initiate management such as bank stabilization. Monitoring of riparian habitat was combined with Physical Habitat Indices, which are part of the Maryland Biological Stream Survey.

Landscape Level Habitat Change — Remote sensing tools such as aerial photography (Color Infrared - CIR) can provide fine scale information about a variety of vital signs identified by both the vegetation and landscape working groups. Some of these include habitat change, vegetation community change, forest canopy gaps, topographic and shoreline changes, habitat distribution, land use practices, and internal development. The remote sensing products provide the base data for the possible creation of numerous thematic layers that can be incorporated into geographic information systems for further modeling and analysis.

Landuse Change — Remote sensing tools such as satellite imagery (Sat 1-m IKONOS) can provide data to address large-scale information about a variety of vital signs identified by both the vegetation and landscape working groups, including forest fragmentation, edge ratio, size of contiguous patches, and connectivity (Wilcove et al. 1986).

3.5.3 Board Approval

As a final step in the prioritization process the Board of Directors were asked to provide a formal approval to the proposed 21 vital signs. All proposed vital signs were approved with one change. The vital sign for Gypsy Moths was expanded to Early Detection of Pest Species. While Gypsy Moths are a known problem in the National Capital Region, the pest is being monitored effectively through the U.S. Forest Service and the Integrated Pest Management Program. Developing protocols to monitor for new potential invasive species was considered a much higher priority. The approved set of 21 vital signs represent the priority vital signs for the NCRN (table 3-2). Figure 3-1 is a summary of the vital sign selection process.

3.5.4 Priority Vital Signs

Table 3-2 provides an overview of the 21 priority vital signs within a national vital sign framework. The framework was developed by a committee representing network and Natural Resources Program Center staff in order to apply a nationally standardized naming convention to the network vital signs. In addition to reducing confusion related to vital sign names, the framework also will allow NPS to roll up data summaries to any of the three national levels for reports to congress. The framework consists of three levels that all network vital signs are assigned to.

For example, the vital sign 'Mercury Deposition' is assigned to

Level 1 = Air and Climate
Level 2 = Air Quality
Level 3 = Air Contaminants

Table 3-2: Summary of Priority Vital Signs for the NCRN

Level 1 Name	Level 2 Name	Level 3 Name	Network Vital Sign Name	Vital Sign Measures	ANTI	CATO	CHOH	GWMP	HAFE	MANA	MONO	NACE	PRWI	ROCR	WOTR
Air and climate	Air Quality	Ozone	Ozone*	Atmospheric ozone concentration	●	●	●	●	●	●	●	●	●	●	●
		Wet and Dry Deposition	Wet deposition*	Wet deposition chemistry (pH, NO3-, SO4-), NADP	●	●	●	●	●	●	●	●	●	●	●
		Visibility and Particulate Matter	Visibility and particulate matter*	Visibility (PM 2.5 mass fraction)	●	●	●	●	●	●	●	●	●	●	●
		Air Contaminants	Mercury deposition*	Mercury Deposition Network	●	●	●	●	●	●	●	●	●	●	●
	Weather and Climate	Weather and Climate	Weather*	Ambient temperature, precipitation	●	●	●	●	●	●	●	●	●	●	●
Geology and soils	Geomorphology	Coastal / Oceanographic Features and Processes	Shoreline features	Rate of shoreline change	–	–	+	+	–	–	–	+	–	+	–
		Hillslope Features and Processes	Geo-hazards	Number of rock movements	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊
		Stream / River Channel Characteristics	Physical Habitat Index (PHI)	Stream habitat structure, river depth, vegetation composition on adjacent lands	+	+	+	+	+	+	+	+	+	+	+
Water	Hydrology	Surface water Dynamics	Surface water dynamics	Flow, discharge (CFS), gauge/stage height	+	+	+	+	+	+	+	+	+	+	+
		Groundwater Dynamics	Groundwater dynamics	Groundwater level	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊
	Water Quality	Water Chemistry	Water chemistry	Core parameters (pH, DO, conductance, temp), acid neutralizing capacity	+	+	+	+	+	+	+	+	+	+	+
		Nutrient Dynamics	Nutrient dynamics	Nitrate, Amonia, DON, Nitrite, Orthophosphate	+	+	+	+	+	+	+	+	+	+	+
		Aquatic macroinvertebrates and algae	Aquatic macroinvertebrates	Species composition and abundance	+	+	+	+	+	+	+	+	+	+	+

TABLE 3-2: SUMMARY OF PRIORITY VITAL SIGNS FOR THE NCRN (CONTINUED)

Level 1 Name	Level 2 Name	Level 3 Name	Network Vital Sign Name	Vital Sign Measures	ANTI	CATO	CHOH	GWMP	HAFE	MANA	MONO	NACE	PRWI	ROCR	WOTR
Biological integrity	Invasive Species	Invasive/Exotic Plants	Invasive/exotic plants	Detection of new species in sensitive areas	+	+	+	+	+	+	+	+	+	+	+
	Infestations and Disease	Insect Pests	Forest Insect pests	Presence of new pest species	+	+	+	+	+	+	+	+	+	+	+
	Focal Species or Communities	Forest/Woodland Communities	Forest vegetation	Species diversity, age and size classes, woody debris	+	+	+	+	+	+	+	+	+	+	+
		Fishes	Fishes	Spp. Composition and abundance	+	+	+	+	+	+	+	+	+	+	+
		Amphibians and Reptiles	Amphibians	Spp. Composition and Proportion of area occupied, malformations	+	+	+	+	+	+	+	+	+	+	+
		Birds	Landbirds	Spp. Composition and abundance	+	+	+	+	+	+	+	+	+	+	+
		Mammals	White-tailed Deer	Deer density	+	+	+	+	+	+	+	+	+	+	+
	At-risk Biota	T&E Species and Communities	T&E species and communities	Spp. Abundance, presence and absence, status, threats	+	+	+	+	-	+	+	+	+	+	–
Human use	Visitor and Recreation Use	Visitor Usage	Visitor Usage	Number of social trails	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊
Landscapes (Ecosystem pattern and processes)	Landscape Dynamics	Land cover / Land use	Land cover/land use	Area of dominant land cover types, connectivity, core/edge ratio of dominant forest communities, weighted average patch size, adjacency matrix	+	+	+	+	+	+	+	+	+	+	+
	Viewscape	Vowescape/Dark Night Sky	Viewshed	Photo evaluation	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊
	Energy Flow	Productivity	Landscape condition	Landuse intensity, disturbance status	+	+	+	+	+	+	+	+	+	+	+

Notes:

* Already being monitored.

+ Indicates that the network is developing or adapting protocols for this vital sign.

● Indicates that the vital signs are already being monitored by the NPS (park or national program) or by another agency.

◊ Indicates high priority vital sign with no current or planned protocol due to limitations in staff time and/or funding.

– Indicates that the vital sign does not apply to this park.

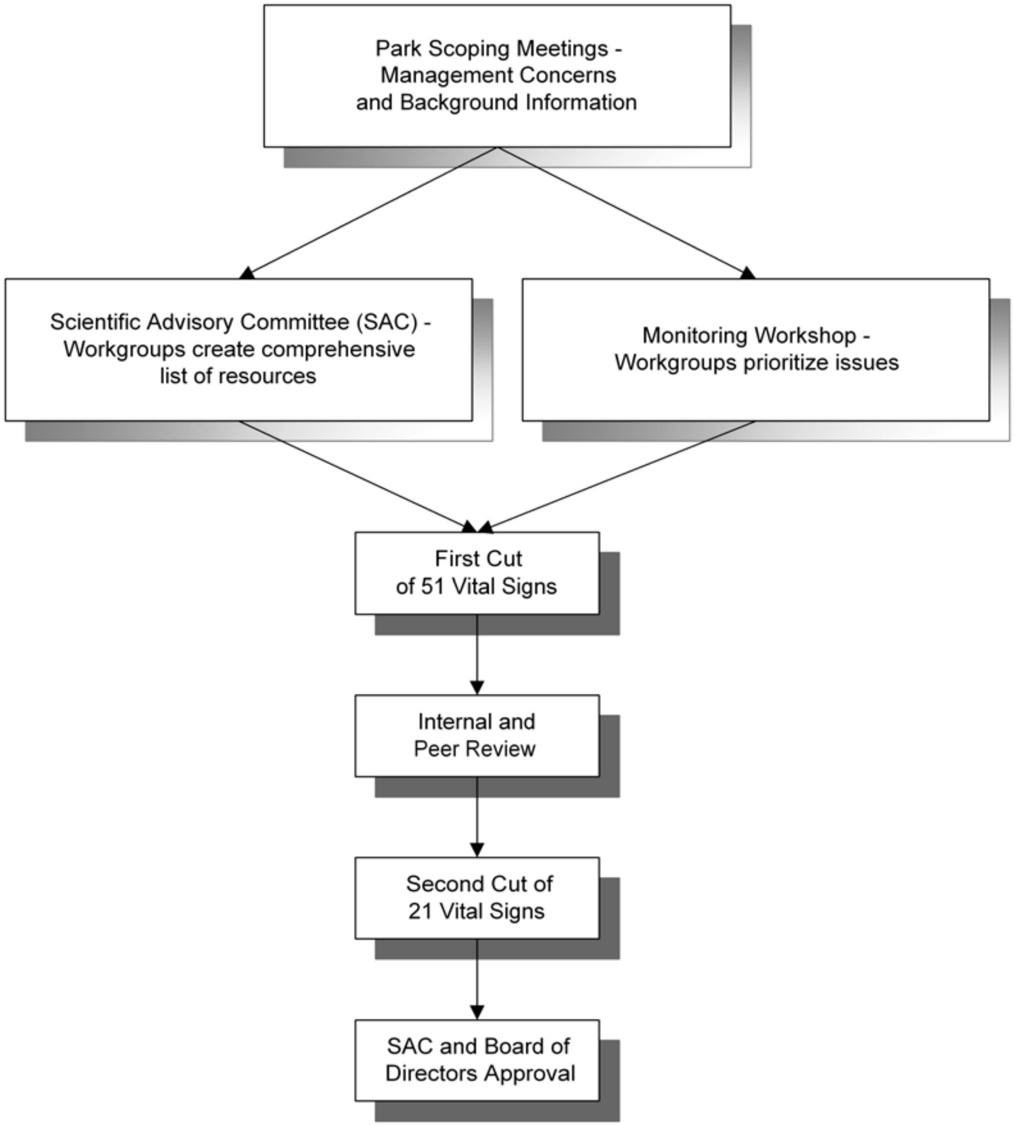


FIGURE 3-1: SUMMARY OF VITAL SIGN SELECTION PROCESS

Networks still have the flexibility of determining the vital signs and methodologies most relevant and useful to their particular parks and partners, but the framework helps to organize the monitoring effort nationally and facilitate communication, collaboration, and coordination of monitoring design and implementation. The justification, specific monitoring questions, objectives, and monitoring protocols for each vital sign are discussed in chapter 5.

It is expected that further prioritization may be warranted once protocols are fully developed and sampling sizes and frequency are understood along with full costs (Andreasen et al. 2001). Another factor influencing final monitoring will be an evaluation of partnerships that may be developed with other agencies interested in the results. Partnerships may be an effective tool to reduce monitoring costs and still meet park needs.

Chapter 4

Sampling Design

4.1 OVERVIEW

There are several challenges in creating sampling designs for the monitoring protocols. First, the sampling for each vital sign must be statistically valid. For each protocol, sample sites must be generated using appropriate random procedures so that inferences can be made to parts of the network that were not sampled. The number of samples must be large enough to insure sufficient statistical power to detect changes. Sampling sites need to be spread throughout the entire region, and all parks should be sampled.

Secondly, measurements from different vital signs should be collected in the same locations when possible. This will simplify the task of combining data collected under multiple protocols. Once the data is combined we will be able to determine if there are relationships among the various vital signs. For example, changes in one vital sign could lead to changes in other vital signs or multiple vital signs could respond to the same stressor. Understanding these types of relationships among the vital signs could be useful in setting priorities for management actions.

Finally, the sampling design needs to take into account the possibility that additional vital signs will be monitored in the future. Ideally new vital signs would be incorporated into the existing sampling design. This requires a design flexible enough to accommodate a wide variety of measurements. The design must also allow protocols to be targeted to specific habitats, geographic regions, etc., should this be needed.

This chapter describes the general sampling design used for monitoring the vital signs. Sampling protocols contain additional information detailing the sampling for each vital sign.

4.2 OVERALL SAMPLING DESIGN

The overall sampling design for NCRN divides the vital signs monitoring protocols into two groups, terrestrial and aquatic. This division is necessary, as terrestrial monitoring takes place over the entire park area, whereas aquatic monitoring takes place in streams that form linear corridors through parks and cover only a small area. A sampling design has been created for each of the two groups. By unifying terrestrial monitoring under one design and aquatic monitoring under another design, we will maximize our ability to synthesize data collected under different protocols.

Some vital signs, such as air quality and land use change, consist of regional assessments and do not include sampling of specific locations in the parks. Rare, threatened, and endangered species will be monitored where they occur to assess their status. For practical reasons, deer monitoring is restricted to park roadways. These vital signs are not considered in this chapter. Data collection methods for these vital signs are detailed in their individual protocols.

4.3 TERRESTRIAL SYSTEMS

Grid Sampling for Terrestrial Systems — Vital signs measured under the terrestrial sampling design will include forest vegetation, grassland birds, forest birds and terrestrial amphibians. Detection of pests and exotic species will take place in conjunction with forest vegetation monitoring. For terrestrial systems, the NCRN will use a grid based sampling scheme. In this scheme, a GIS is used to overlay a grid on the map of the region. The intersections of the grid are then used as sampling points for the various protocols.

The NCRN grid was created in ArcGIS 8.3 using a grid generation utility acquired from the ESRI website (http://arcscripts.esri.com/details.asp?dbid=12807).
The origin of the grid was randomly selected and the resolution (distance between adjacent points) is 250 meters. Sampling for terrestrial protocols will take place at points selected from the 4,683 intersections on the grid.

A 250-meter grid size provides several advantages to the NCRN. The grid size had to be small enough so that every park or park unit with natural resources contains one or more sampling locations. Some units such as WOTR cover a small area while others, such as the CHOH or the Baltimore-Washington Parkway in NACE are long and narrow. A larger grid size would under-represent these areas. A smaller grid size was not selected as this could create problems in protocol development and data analysis. If the grid size were smaller, measurements taken at one grid point might include data from adjacent grid points, which would complicate site selection and/or analysis. A 250-meter grid provides coverage for the entire NCRN without violating independence of measurements at adjacent points.

Site Selection within the Grid — Points on the grid will be selected at random for carrying out each terrestrial protocol. However, a simple random sample is not appropriate for selecting points. A simple random sample might result in some parts of the network being heavily sampled while other parts have few samples, which could skew the conclusions drawn from the monitoring.

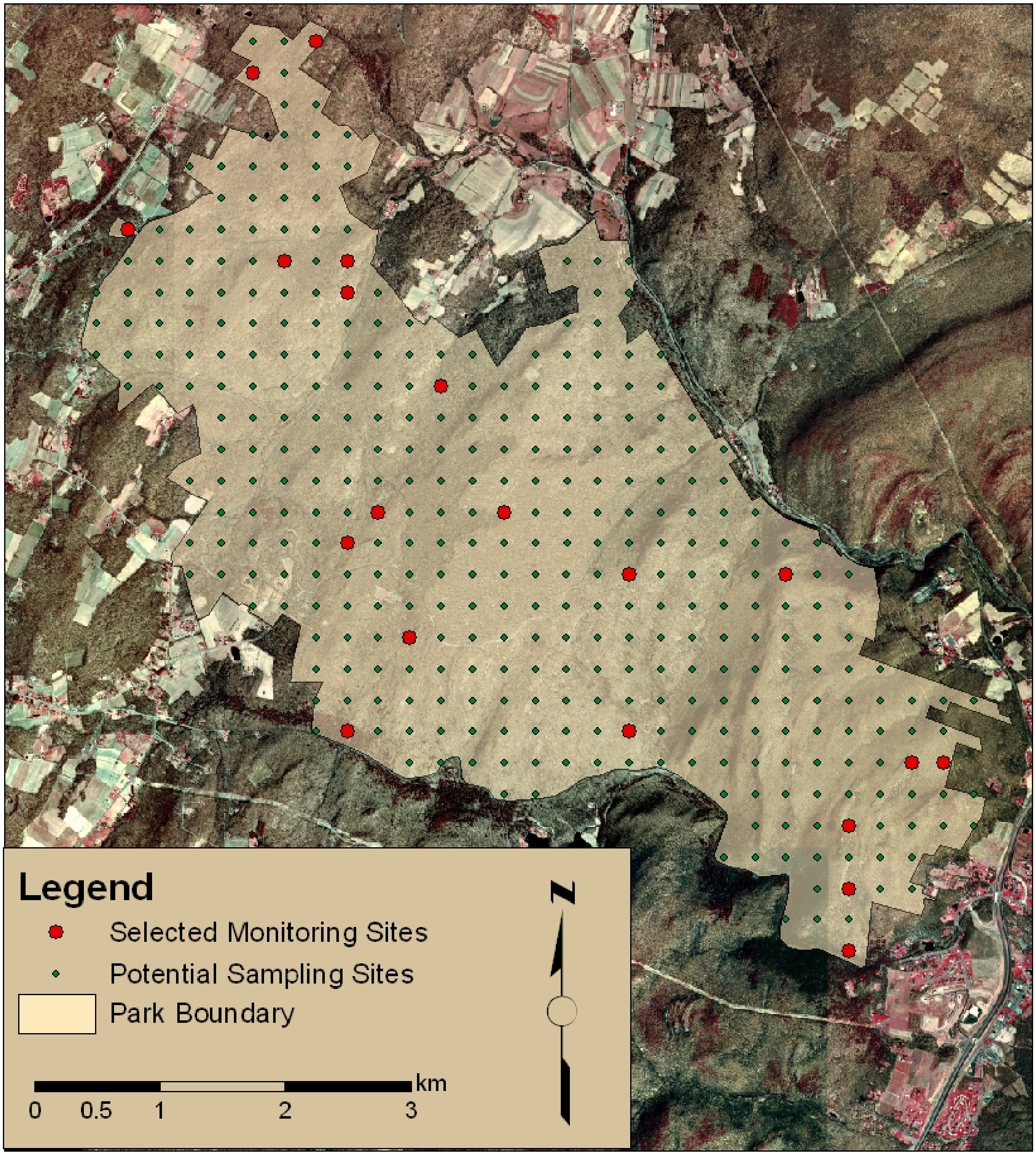
Points will be selected using a "Generalized Random-Tessellation Stratified" (GRTS) design (Stevens and Olsen 2004). GRTS is a procedure that can be used to pick points at random from the sampling grid, and has several advantages over a simple random sample. First, points selected using GRTS will be spatially balanced, that is, they will be scattered throughout the network. This will prevent the network from having areas that are over- or under-sampled, which will strengthen the inferences made from the monitoring. Secondly, it is possible to use "unequal probability" when selecting samples. This allows the I&M program to make some points more likely to be sampled than other. This can be useful if there is a need to ensure that rare conditions (vegetation types, physiographic provinces, etc.) are included in the sampling or if logistical constraints dictate that sites that are difficult to reach need to be sampled less intensively. Thirdly, the GRTS process is designed to work well when some of the points selected may not be suitable for monitoring, but it is difficult to determine that before they are visited. GRTS produces an ordered list of sampling locations, and can select more locations than are actually needed for a given protocol. If a particular location cannot be sampled, then the next location on the list can be used instead, and the spatial balance of the sampling design will be maintained. This is particularly important in the NCRN, where some parts of the parks are solely of historic or cultural interest but are interspersed with areas that have significant natural resources. Finally, as the GRTS points are all selected with a known probability, it will be simpler to combine the data from the vital signs program with data collected by the individual parks or other agencies. The regional gird could be expanded to include areas that are adjacent to the NCRN parks. Data collected in a manner compatible with NCRN monitoring could then be analyzed together with NCRN data. The expansion of the grid would allow us to calculate the new inclusion probabilities (weighting) of the combined data set. This will allow us to leverage outside data and improve our ability to detect trends.

An initial GRTS procedure has been run on the data, selecting all 4,683 points. In this procedure all points were given an equal probability to be selected. This list generated from this procedure can be used for any terrestrial monitoring where unequal probability is not needed, and proper care is taken that monitoring activities for one protocol do not interfere with other protocols (figure 4-1).

4.4 AQUATIC SYSTEMS

Sampling for Aquatic Systems — Vital signs measured under the aquatic sampling design include water chemistry, nutrient concentrations, aquatic macroinvertebrates, and fishes. The sample design for aquatic systems is based on the USGS National Hydrography Dataset (1:24,000 NHD, http://nhd.usgs.gov/). Each stream segment was assigned a stream order based on Strahler's (Strahler 1952) ordering methodology (perennial headwater streams are 1st order, two convergent 1st order streams form a 2nd order stream, etc.).

Once a map of the streams was developed, each stream segment was assigned a unique ID and classified according to watershed order. Based on consultation with park staff and reports from studies carried out in the parks, it was determined that many of the first order streams on the map were not actually perennial. The I&M staff will visit and verify all first order streams before performing any monitoring on them.



Notes:

Small green points indicate every potential sampling point in the park. Larger red points show the first 20 sites selected for monitoring. Note the dispersion of the selected sites throughout the park.

FIGURE 4-1: GRID POINTS AT CATOCTIN MOUNTAIN PARK

Current monitoring protocols only consider non-tidal streams. This may be reconsidered in the future if conditions warrant. For the purposes of sampling design, a stream is defined as a continuous length of the same stream order. Each stream was then divided into segments, where a segment is a length of stream between two nodes, or places where streams join. Sampling of streams will focus on those segments of streams that are the furthest downstream and still in park boundaries. Measurements downstream generally reflect conditions in the watershed upstream. Where possible, multiple steams within each watershed will be sampled to provide information at the watershed level.

Site Selection for Aquatic Systems — As with the terrestrial sampling, GRTS will be used to select sampling sites for aquatic sampling. Due to the small size of the segments considered for sampling, the center point of each stream segment will be input into the GRTS procedure. GRTS will then be run to generate a randomly ordered list of streams. To be considered for inclusion in sampling the stream also had to have at least 75 m of length in an NCRN park. Seventy-five meters was chosen as one of the protocols in development requires this length of stream for sampling. Furthermore, streams shorter than this will likely not have a large impact on natural processes within the park.

Unequal probability sampling can be used to weight sampling by stream order, length or any other stream characteristic. For example, it is anticipated that stream chemistry will be measured for every 2nd–4th order stream in every NCRN park each year (figure 4-2) with the exception of CHOH. CHOH is an exception because half of the streams in the network occur in this park, but they cross the park for only a short distance (typically < 250 meters). The NCRN I&M program does not anticipate that sufficient resources will be available to sample all of the 2nd–4th order streams in CHOH every year. Instead, a subset will be selected using GRTS.

4.5 INTEGRATION

Integration will occur at several levels including: (1) integration of data collection (collocation), (2) integration of data management, and (3) integration of data analysis and reporting.

4.5.1 Collocation

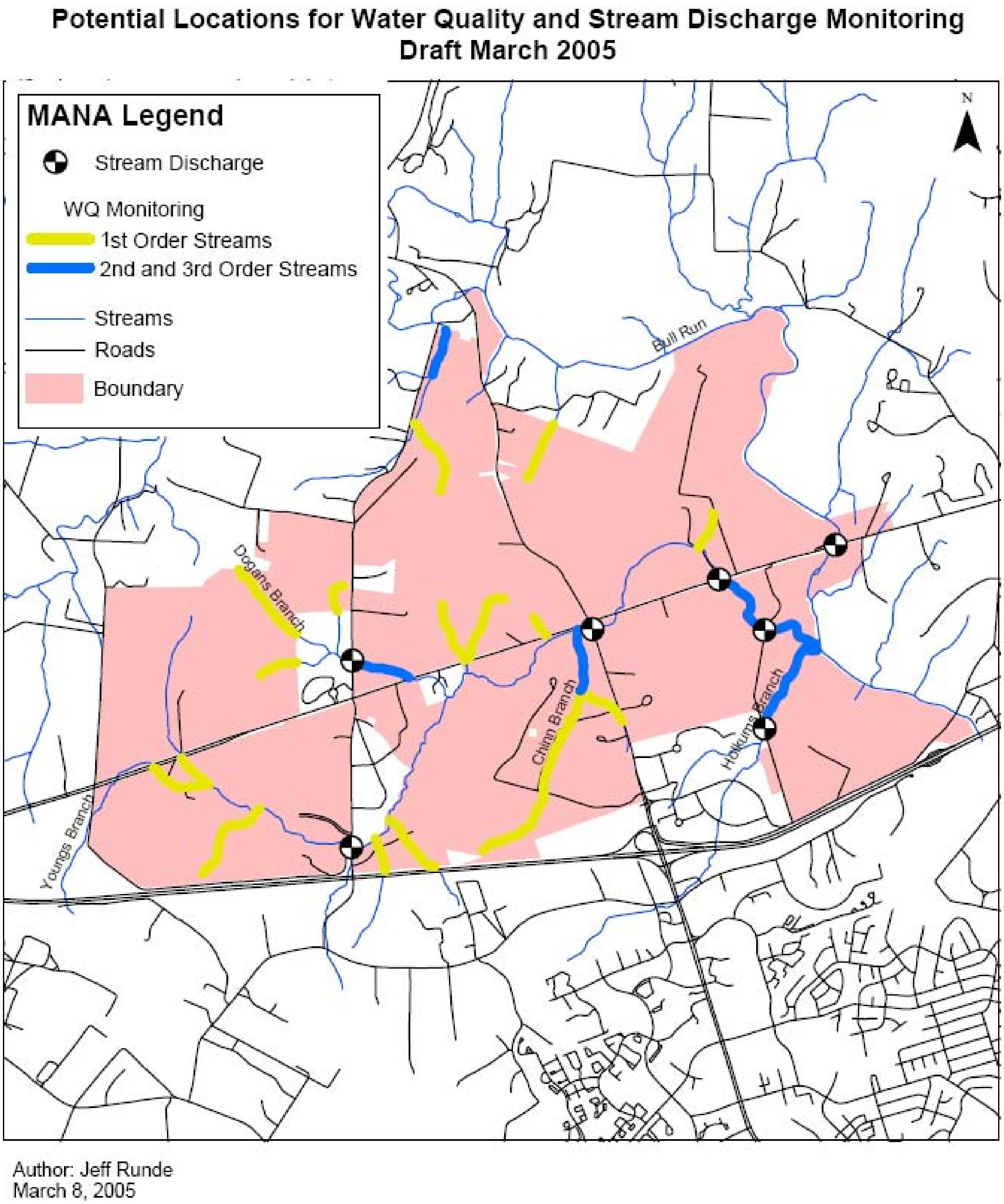
Partial collocation among monitoring protocols exists for three sets of vital signs: (1) surface water quality, stream level gauges, and benthic macroinvertebrates, (2) upland amphibians and terrestrial vegetation, forest birds, and to some extent exotic invasives and pest species. It is important to note, however, that for water quality and macroinvertebrates, as well as upland amphibians and terrestrial vegetation, complete collocation is unlikely to occur, thereby limiting our capacity for joint inference in some instances.

4.5.2 Integration of Data Management

The most direct integration exists among protocol datasets, wherein common field names and standardized data tables are used according to procedures outlined in the NCRN Data Management Plan (chapter 3; Sanders et al. 2004). Common tables include Park ID, Location ID (Park Code + Grid ID), and project name. Each protocol investigator has access to a common set of GIS data layers and standardized Microsoft Access field names. In this way, each investigator has access to standardized information upon which more detailed data collection and analysis can be based.

4.5.3 Integration of Data Analysis and Reporting

In many cases, data from multiple protocols will be analyzed together in order to address all monitoring objectives. For example, amphibian population trends will be correlated to weather data because rainfall has significant effects on existing habitat. The specific analyses will be outlined in each protocol to ensure that all monitoring objectives can be addressed. The products resulting from data analysis and reporting will be discussed in chapter 7.



Notes:

Blue lines indicate the 2nd-4th order streams, with monitored segments in bold.

Yellow lines are possible 1st order streams with monitored segments in bold.

FIGURE 4-2: EXAMPLE OF STREAM MONITORING LOCATIONS IN MANASSAS BATTLEFIELD PARK

Chapter 5

Sampling Protocols

Monitoring protocols detail how data are to be collected, managed, analyzed and reported. Standard monitoring protocols are being developed for each vital sign to ensure that changes in trends are the result of actual changes and not the result of different people taking measurements in different ways (Oakley et al. 2003). The servicewide Inventory and Monitoring (I&M) program and the Status and Trends program of the U.S. Geological Survey (USGS) have developed guidelines presented by Oakley and others (2003) to guide the content of new protocols. According to Oakley and others (2003) detailed protocols must include scientific justification for the vital sign's selection, clear monitoring objectives, suggested trigger points for management, and standard operating procedures. Standard operating procedures detail the sampling strategy, field methodology, data management, data analysis, and reporting schedules specific to the protocol.

5.1 PROTOCOLS

While this chapter provides an overview of the protocols that will be developed, detailed summaries of each protocol are presented in the form of Protocol Development Summaries (PDS) in appendix N. Each PDS provides a brief justification and rationale for selecting the vital sign. In addition, key monitoring questions and objectives are outlined, the principal investigator and National Park Service (NPS) contacts are identified, and cost of protocol development is provided. The protocols (table 5-1) will be attached as appendices to the Monitoring Plan as they are completed, and updates will be posted to the National Capital Region Network (NCRN) web page (http://www.nps.gov/cue/programs/i_and_m/i_and_m.htm).

5.1.1 Protocols for Existing Monitoring Efforts

A review of the 21 vital signs presented in chapter 3, indicates that six are already being monitored by other federal programs or agencies (table 5-2). The current plan for these protocols is to ensure that the data from these ongoing monitoring efforts are interpreted and that the information is available and useful to the parks.

5.1.2 Existing Protocols

In addition to existing monitoring efforts, various monitoring protocols have already been standardized, peer reviewed, and are widely accepted. These protocols can be evaluated and adapted to the needs of the NCRN. In most cases, efforts must be made to select appropriate sample sizes and sites; develop standard operating procedures; pilot test protocols for appropriateness in the NCRN; and develop standard databases, analyses, and reporting tools.

Ten of the 21 vital signs identified have standard protocols that can be adapted to the NCRN (table 5-3). See appendix N for more information about the protocols being adapted for each vital sign.

5.2 NEW PROTOCOLS

New protocols must be developed for only five of the 21 vital signs identified (table 5-4). The NCRN is working closely with principal investigators to ensure that the appropriate protocols are being developed. For more information see the PDS for each vital sign in appendix N.

5.3 FUTURE PROTOCOLS

A number of vital signs were identified but protocol development was put on hold (table 5-5) until additional funding and/or information becomes available. PDS have not yet been developed.

TABLE 5-1: THE NCRN HAS IDENTIFIED 16 PROTOCOLS TO MONITOR 21 VITAL SIGNS

Vital Sign	Protocol
Ozone	Ozone
Wet deposition	Wet Nitrogen and Sulfur Deposition
Visibility and particulate matter	Visibility and particulate matter
Mercury deposition	Mercury deposition
Weather	Weather and climate
Shoreline features	Landscape dynamics and landcover change
Physical Habitat Index (PHI)	NCRN Biological Stream Survey
Surface water dynamics	Surface water dynamics
Water chemistry	Water chemistry and water nutrients
Nutrient dynamics	Water chemistry and water nutrients
Aquatic macroinvertebrates	NCRN Biological Stream Survey
Invasive/Exotic Plants	Invasive and exotic species
Forest Insect pests	Insect pests
Forest vegetation	Forest vegetation
Fishes	NCRN Biological Stream Survey
Amphibians	Amphibian species diversity
Landbirds	Landbirds
White-tailed Deer	White-tailed deer
T&E species and communities	Rare, threatened, and endangered (RTE) species
Land cover/Land use	Landscape dynamics and landcover change
Landscape condition	Landscape dynamics and landcover change

TABLE 5-2: SUMMARY OF MONITORING PROTOCOLS THAT ARE ALREADY BEING IMPLEMENTED BY ANOTHER PROGRAM OR AGENCY

Protocol	Justification	Measurable Monitoring Objectives	Lead Program / Partner Agency	Parks
Ozone	This region experiences some of the highest ozone concentrations in the country and has been designated by the Environmental Protection Agency as a severe non-attainment area. Ozone damages human health, vegetation, and is a key component of urban smog. Monitoring ozone concentrations is the simplest way to begin to quantify trends in ozone damage.	• Report seasonal and annual status and trends of ozone concentrations in NCRN parks using metrics that are indicative of human health (e.g., 8-hour average) and plant response (e.g., SUM06).	NPS Air Resource Division/ EPA Air Status and Trends Network (CASTNet)	All NCRN parks
Wet Nitrogen and Sulfur Deposition	The Chesapeake Bay Watershed (which includes the NCRN) receives some of the highest fluxes of nitrogen (N) and sulfur (S) among the estuarine watersheds of the eastern seaboard. While S deposition has decreased since passing the Clean Air Act, it still contributes to acidification in upland streams. N deposition continues to increase in the region and leads to eutrophication at the bottom of watersheds. Changes in S and N cause significant effects on both vegetation and animal life. Wet deposition will provide an indicator for both atmospheric pollutants.	• Report on seasonal and annual status and trends of N and S concentration and deposition in precipitation in NCRN parks.	NPS Air Resource Division/ National Atmospheric Deposition Program (NADP)	All NCRN parks
Visibility and particulate matter	Atmospheric fine particles with diameter of less that 2.5 µm ($PM_{2.5}$) are known to be an important influence on the clarity of the atmosphere, due their light-scattering and light-absorbing properties. Fine particles are also known to be a human health hazard especially to active individuals (e.g., hikers and children) and to people taking medication for asthma and other respiratory disorders. Many of the precursors of $PM_{2.5}$ are also precursors of ozone and contribute to N and S deposition. Monitoring status and trends of $PM_{2.5}$ and other particles will allow NPS to document changes in air quality that should occur as a result of the recently-enacted Regional Haze Regulation.	• Report on seasonal and annual status and trends of fine particle concentrations and composition in NCRN parks as they pertain to visibility impairment and human health. • Track and interpret visual impairment with cameras.	NPS Air Resource Division/ IMPROVE	All NCRN parks
Mercury deposition	Mercury is a persistent, toxic, and volatile heavy metal that is globally distributed via the atmosphere. While its elemental form (Hg^{o}), is relatively harmless at ambient concentrations, its derivative organic forms (e.g., MeHg) are potent neurotoxins that bioaccumulate in aquatic food webs, directly harming humans, animals, and the ecosystem structure on which both depend. Although the NCRN experiences some of the highest fluxes of atmospheric mercury in the US (Mason et al. 2000a; Mason et al. 2000b), this mercury appears to be largely retained in NCRN watersheds. Until the factors controlling watershed-based methylation are better understood, it is prudent to track mercury deposition rates in the area.	• Report on seasonal and annual status and trends of mercury concentration and deposition in precipitation in NCRN parks.	NPS Air Resource Division/ Mercury Deposition Network	All NCRN parks

Table 5-2: Summary of Monitoring Protocols That Are Already Being Implemented by Another Program or Agency (continued)

Protocol	Justification	Measurable Monitoring Objectives	Lead Program / Partner Agency	Parks
Weather and climate	Temperature and precipitation, taken over time scales of years, decades or longer, are the basic components of climate. Climate provides the physical constraints that determine plant and animal survival and drives the basic processes that underpin ecosystems. Current climate models predict substantial climate related changes climate of this region, and in the ecology as a result. These include (1) changes in forest species composition (i.e., loss of sugar maples in the north, encroachment of savannah in the south); (2) increased frequency of heavy precipitation events and flooding; and (3) an overall increase in the heat index of 8–20ºF (National Assessment Synthesis Team 2000). Monitoring the basic components of climate will help to discern whether these predictions are accurate for the NCRN, and help managers to anticipate these changes in their management practices. For example, if the climate no longer supports sugar maples, management plans should allow for that.	• Determine variability and long-term trends in climate for all NCRN parks through monthly and annual summaries of descriptive statistics for selected weather parameters, including air temperature and precipitation. • Identify and determine frequencies and patterns of extreme climatic conditions for common weather parameters.	National Oceanic and Atmospheric Administration (NOAA)–National Weather Service	All NCRN parks

TABLE 5-3: SUMMARY OF VITAL SIGNS FOR WHICH PROTOCOLS EXISTS BUT NEED TO BE ADAPTED FOR NCRN

Protocol	Justification	Objectives	Protocol Being Adapted	Parks
NCRN Biological Stream Survey	Because impacts to water quality are so diverse and variable in duration, chemical monitoring alone may fail to detect many of them (Karr 1991, Karr 1981). A variety of biological parameters will be collected in addition to chemical data to provide an overall condition assessment of aquatic resources. Trends in macroinvertebrate and fish diversity serve as useful indicators of shifts in the condition of a stream ecosystem as it responds to anthropogenic actions. Physical habitat information provides additional necessary components of complex aquatic systems.	• Determine current conditions and track long-term trends in water resource condition as measured by physical habitat, benthic invertebrates, and fishes. • Determine trends in species composition and functional groups of benthic invertebrates and fishes. • Detect incipient populations (i.e., small or localized) and new introductions of non-native fish in NCRN streams.	Maryland Biological Stream Survey (MBSS) Protocol	All NCRN parks
Surface water dynamics	One of the basic water resource components that can be influenced by human development is the flow regime of a stream. The amount of water flowing through a cross section of a stream channel per unit time provides a measure of the stream influence on the distribution of suspended sediment, bed material, particulate organic matter, and other nutrients. Flow data provide key “support” data for other vital signs indicators including freshwater quality, groundwater dynamics, stream threatened and endangered species and fish assemblages, threatened and endangered amphibians and reptiles, erosion and deposition, wetlands, and riparian habitat.	• Determine long-term trends in seasonal and annual stream hydrology (velocity, discharge, and flood characteristics) at selected sites in NCRN streams.	USGS Protocol	All NCRN parks
Water chemistry and water nutrients	All NCRN parks contain one or more water bodies that drain into the Potomac River and ultimately into the Chesapeake Bay, both of which are of regional importance. Water chemistry is a major concern to the NCRN parks. It integrates many important ecological drivers and stressors, and can provide insights into ecological patterns and processes, including nutrient cycling, land use, soil erosion, air quality, vegetation communities, aquatic habitats, fish assemblages, and aquatic macroinvertebrates. Water chemistry parameters to be monitored in the NCRN include temperature, conductivity, pH, dissolved oxygen (DO), acid neutralizing capacity (ANC), nitrate, ammonia, DON, nitrite, and orthophosphate.	• Determine long-term trends in water temperature, pH, specific conductance, dissolved oxygen, Acid Neutralizing Capacity, nitrite, and orthophosphate in selected freshwater sites in NCRN parks.	USGS Protocol	All NCRN parks

TABLE 5-3: SUMMARY OF VITAL SIGNS FOR WHICH PROTOCOLS EXISTS BUT NEED TO BE ADAPTED FOR NCRN (CONTINUED)

Protocol	Justification	Objectives	Protocol Being Adapted	Parks
Forest vegetation	Each park in the NCRN has significant stands of or is dominated by Eastern deciduous forests. The riparian and upland forests include at least 28 unique vegetation communities identified by NatureServe. A variety of factors affect vegetation composition in the NCRN parks. Ecological factors include soils and geology, rain patterns, and nutrient availability. Anthropogenic stressors include air pollution, loss of habitat due to development (inside and outside of parks), erosion, and visitor use. The most significant threats, however, are recognized as exotic and invasive species and white-tailed deer.	• Determine long-term trends in species composition and community structure (e.g., cover, density by height class of woody species). • Determine long-term changes in percent cover of native and nonnative herbaceous species and woody vines in natural vegetation communities. • Determine long-term changes in stem density of native shrub and tree species in natural vegetation communities. • Determine long-term changes in stem density of exotic and invasive shrub and tree species in natural vegetation communities. • Determine long-term effects of deer browse on stem density of seedlings, saplings, shrubs, and pole trees.	USDA Forest Inventory Analysis (FIA)	All NCRN parks
Amphibian species diversity	Amphibian monitoring is a high priority because of their importance as indicators on a worldwide scale. Population declines have been noted throughout the world due to disease, introduced predators, loss of habitat, acidification, or ultraviolet-B radiation damage to eggs. The life histories, dispersal abilities and physiological tolerances of this clade of organisms and the introduction of multiple, synergistic stressors at many life history stages make them potentially more susceptible to environmental change than other species. Many researchers have urged greater attention to this taxon.	• Determine trends in proportion of area occupied for viable amphibian populations within wetland and upland habitats of NCRN parks • Determine long-term changes in amphibian species richness among all NCRN parks • Determine long-term changes in amphibian diversity in relation to landscape disturbance factors (distance to roads, percentage impervious surface or forest canopy cover within a watershed)	USGS Amphibian Research and Monitoring Initiative (ARMI)	All NCRN parks

TABLE 5-3: SUMMARY OF VITAL SIGNS FOR WHICH PROTOCOLS EXISTS BUT NEED TO BE ADAPTED FOR NCRN (CONTINUED)

Protocol	Justification	Objectives	Protocol Being Adapted	Parks
Landbirds	The region around the NCRN parks provides habitat for a high diversity of avian species. Biological inventories also indicate that the parks host a variety of species of conservation concern including grassland and forest species. Previous studies in the region also show that the urban landscape in and around Washington, including the downtown parks (e.g., ROCR, NACC), provides diverse habitats that host nearly as many species as the surrounding suburbs. Key reasons for monitoring birds in network parks are that they are protected under the (1) Migratory Bird Treaty Act; and (2) The Migratory Bird Executive Order signed by President Bill Clinton in 2000. In addition, birds represent a popular taxanomic group that can be readily sampled and comparable regional and national datasets exist including the Breeding Bird Surveys (BBS) and the Christmas Bird Counts (CBC).	• Determine long-term trends in species composition and abundance of birds in grassland and forested communities of NCRN parks.	Area surveys; adapt variable circular plot; protocols are being developed by USGS – Patuxent	All NCRN parks
White-tailed deer	The number of deer is increasing nationally and has significant ecological and economic impacts on the region. Deer ranked as a high priority for monitoring in this network because of their significant impacts on the spread of exotic species, prevention of tree regeneration, and impacts to small mammal, amphibian, and bird populations. In addition, the number of car collisions with deer have increased dramatically during the last 20 years and are a concern especially in parks that have commuter routes running through or adjacent to the parks including CHOH, GWMP, MONO, NACE, and ROCR. In many areas they are considered overabundant. The key reason for monitoring deer in NCRN is that data are needed to support development of environmental impact statements for management activities.	• Detect long-term changes in deer abundance in NCRN parks.	Distance sampling methodology being adapted. Pellet counts at HAFE.	All NCRN parks

Table 5-4: Summary of Vital Signs for Which Protocols Needs to be Developed

Protocols	Justification	Objectives	Protocol Being Developed	Parks
Rare, threatened, and endangered (RTE) species	National Parks are required under law to protect federally listed threatened and endangered species. Policy directs NPS to protect state listed species as much as possible (DO-77-8 Section 3.1 and 3.2; NPS 2002). In addition to legal and policy priorities, rare species often hold significant interest in the public eye. The parks of the National Capital Region offer some of the last remaining habitats for rare species in a rapidly urbanizing landscape. Monitoring these populations is a high priority to give parks the ability to plan management actions and preserve species according to the legal and policy mandates.	• Determine long-term trends in the abundance of rare, threatened, and endangered species at priority sites of NCRN parks. • Identify and quantify number of threats and estimate degree of threat to rare species at priority sites.	Species specific protocols being developed by Virginia Polytechnical Institute	All NCRN parks except HAFE and WOTR
Invasive and exotic species	Invasive non-native plants occur throughout the NCRN and have been identified as high management priorities. Alien species are considered to be one of the most critical threats to the resources in the Potomac Gorge, which is home to some of the most diverse and rare communities in the country (Cohn 2004; NPS and TNC 2001). In this region, invasive plants are reducing the indigenous biological diversity of the parks and disrupting natural ecological processes.	• Develop and maintain a list of target species that do not currently occur in the parks but occur in localized areas of parks and would cause major ecological or economic problems if they were to become established. • Develop and maintain a predictive “risk of occurrence” search model for target species based on life history attributes, dispersal modes, invasion corridors, vectors of spread, invasibility of areas and known locations. • Detect incipient populations (i.e., small or localized) and new introductions of selected non-native plants before they become established in areas of high and moderate management significance in a rotating panel design searching 1/3 of the park each year.	TBA; will be coordinated with Washington Support Office	All NCRN parks
Insect pests	A diverse range of exotic insect, fungal and bacterial forest pest species have been identified collectively as a priority vital sign for the NCRN. Known pests already include the hemlock-wooly adelgid, dogwood anthracnose, bacterial leaf scorch, and gypsy moths. Most of these are already monitored at the park and/or regional level. New pests, however, are constantly emerging. In 2004, for example, the emerald ash borer was first identified and treated just outside of Wolf Trap Farm Park, and sudden oak death has been identified by the associate director of natural resources as a potential threat in the near future. Constant vigilance is required to identify potential pests and enact management efforts.	• Develop and maintain a list of target species that do not currently occur in the parks but occur in localized areas of parks and would cause major ecological or economic problems if they were to become established. • Develop and maintain a predictive “risk of occurrence” search model for target species based on life history attributes, dispersal modes, invasion corridors, vectors of spread, invasibility of areas and known locations. • Detect incipient populations (i.e., small or localized) and new introductions of select insect pests before they become established in areas of high and moderate management significance in a rotating panel design searching 1/3 of the park each year.	TBA; will be coordinated with National Capital Region Integrated Pest Management Program	All NCRN parks

TABLE 5-4: SUMMARY OF VITAL SIGNS FOR WHICH PROTOCOLS NEEDS TO BE DEVELOPED (CONTINUED)

Protocols	Justification	Objectives	Protocol Being Developed	Parks
Landscape dynamics and landcover change	Changes in spatial patterns of land cover both within and adjacent to National Parks can greatly affect biological and physical processes within those parks. Specifically, landscape patterns related to disturbance, fragmentation, buffers, and land cover change have been shown to affect the abundance of rare and endangered species, levels of biodiversity, potential for invasion by exotic plants, habitat for birds, amphibians and other animals, water quality, and in-stream habitat for fish and other aquatic organisms. To address such concerns, aerial photography and satellite imagery (collectively, remote sensing) can be used to monitor the spatial extent of changes in land cover (i.e., conversion) or land condition. The benefit of remote sensing for monitoring is that it provides complete spatial coverage compared to point or plot samples. Remote sensing therefore complements survey data by providing information on the context of data sampled at points while also facilitating extrapolation of point measurements across landscapes. The results from remote sensing change detection analyses can also be used to identify areas of rapid change to target management efforts.	• Determine status and trends in the areal extent and configuration of land-cover types (Anderson Level II) on park lands. • Determine status and trends of key landscape metrics to determine land use patterns in the parks. • Determine status and trends of landscape patterns within each park and including a buffer outside of the park. • Determine status and trend of riparian buffers along streams in NCRN parks. • Determine status and trend of shoreline changes in parks along tidal portions of the Potomac and Anacostia Rivers. • Determine long-term changes in frequency and extent of insect and disease outbreaks (e.g., gypsy moth defoliation).	Protocols are being developed by the University of Maryland Center for Environmental Sciences (UMCES)	All NCRN parks

TABLE 5-5: SUMMARY OF VITAL SIGNS FOR WHICH PROTOCOLS NEEDS TO BE DEVELOPED

Vital Sign	Justification	Objectives	Parks
Geo-hazard	Geo-hazards are a management concern at three parks, including CHOH, GWMP, and HAFE. Rockfalls and slides represent serious risk to humans and potentially wildlife. Monitoring has already been implemented at HAFE with support from USGS. While locally important, protocol development was put on hold because this issue was not considered to be a significant issue for the entire network.	• Determine changes in the number of areas susceptible to rock slides. • Determine movements of rock formations of special management interest.	CHOH, GWMP, and HAFE
Groundwater	Consumption of groundwater for agricultural, residential, and commercial use in excess of replenishment can cause reduced groundwater quantity and quality. In addition, parks may face a loss of springs, seeps, and wetlands; altered soil saturation zones; and changes in soil moisture profiles. Impervious surfaces such as roads, buildings, and infrastructure can cause reduced water infiltration leading to reduced groundwater recharge and movement of water between watersheds. However, reviewing the groundwater monitoring program at USGS Coastal Ecosystems Water Resources Discipline Massachusetts-Rhode Island District Northborough, indicated that information on flow direction and groundwater contours is needed before effective monitoring can be implemented. This information first must be provided through research projects. Without flow and gradient information, it is impossible to determine the adequate sample size and one cannot extrapolate the data to a larger areas. Also, if existing wells are not sufficient, the construction of the necessary wells would be prohibitively expensive at this time.	• Determine long-term trends in groundwater chemistry and withdrawal through measurement of groundwater levels.	All NCRN parks
Visitor Usage	NCRN has the highest visitation of any region in the NPS. Visitor impacts, and especially the expansion of social trails, was named as a concern in various parks. Knowing the locations of social trails and prioritizing them by impact can help mitigate the negative impacts park visitors may have on the natural resources. The GWMP initiated a pilot project in 2004 to help identify impacts of visitor usage at the Potomac Gorge. Results will help identify potential indicators and evaluate the protocol's utility.	• Determine long-term changes in the number and length of social trails in each park • Detect occurrence of new social trails in areas of management interest.	All NCRN parks
Viewshed	Viewsheds are a significant cultural and natural resource at NCRN parks. Piscatway, for example, was set aside as a National Park to preserve the viewshed from Mt. Vernon across the river. Development adjacent to parks (and sometimes within parks) such as cell towers, office buildings, and amusement parks disrupt the viewshed and natural scenery of the parks.	• Determine and track annual changes to viewsheds of special management interest. • Detect occurrence of new visual disturbance in areas of management interest.	All NCRN parks

Chapter 6

Introduction to Data Management

Collecting data on specific natural resource parameters is our first step toward understanding the ecosystems within our national parks. These ecosystems are evolving, as is our knowledge of them and how they work. We use these "raw" data to analyze, synthesize, and model aspects of ecosystems. In turn, we use our results and interpretations to make decisions about the Park's vital natural resources. Thus, *data* collected by researchers and maintained through sound data management practices will become *information* through analyses, syntheses, and modeling. This can only be achieved through the development of a modern information management infrastructure (e.g., staffing, hardware, software) and procedures to ensure that relevant natural resource data collected by NPS staff, cooperators, researchers, and others are entered, quality-checked, analyzed, reported, archived, documented, cataloged, and made available to others for management decision making, research, and education.

Data Management Mission

The mission of the NCRN Data Management Program is to support to the NCRN Inventory and Monitoring Program by promoting:

- Data quality – Ensure that appropriate quality assurance measures are taken during all phases of project development, data acquisition, data handling, summary and analysis, reporting, and archival.
- Security – Our objective is to make certain that both digital and analog forms of source data are maintained and archived in an environment that provides appropriate levels of access to project managers, technicians, decision makers, and others.
- Interpretability – Sufficient documentation should accompany each data set and any reports and summaries derived from it, so as to ensure that users will have an informed appreciation of its applicability and limitations.
- Availability – Our objective is to expand the availability of natural resource information by ensuring that the products of inventory and monitoring efforts are created, documented and maintained in a manner that is transparent to the potential users of these products.
- Longevity – The longevity of a data set can be enhanced by thorough documentation, by maintaining the data in a widely interpretable format, and by appropriate archival measures.

This chapter summarizes the NCRN data management strategy, which is more fully presented in the NCRN Data Management Plan (DMP; Sanders et al. 2005). The NCRN DMP serves as the overarching strategy for achieving the goals noted above. The plan supports I&M program goals and objectives by ensuring that program data are documented, secure, and remain accessible and useful indefinitely.

6.1 NCRN DATA MANAGEMENT STRATEGY

The NCRN data management strategy holds that all data and derived information generated or otherwise used by the program will meet a high level of quality standards. Further, all data and information the NCRN program deems necessary to meet its objectives, and that are not otherwise maintained, will be archived, documented, and made easily available and accessible. Data and information will be managed in a transparent manner such that all components may be easily compared by location, time, and subject. Data and information will be accompanied by supporting documentation (metadata) that provide context, value, utility, and longevity, thereby facilitating broad understanding of NCRN program output to current and future end users.

6.1.1 Data Defined

The NCRN I&M Program works with data from various sources and defines different data types in this way:

Programmatic Data—*Data developed or acquired directly by the network as a result of inventory, monitoring, or other projects*. This category includes project-related protocols, reports, spatial data, and associated materials such as field notes and photographs. Also included in this category are collaborative efforts between the NCRN and other NPS or non-NPS entities.

Non-Programmatic Data—*Data developed by entities other than the I&M Program.* There are two types of non-programmatic data:

> NPS Data—*Data developed by other NPS entities.* The NCRN utilizes numerous datasets developed by parks (e.g., park based inventories or research, regional programs).
>
> Non-NPS Data—*Data acquired and/or maintained by non-NPS sources.* Datasets developed by other government agencies and/or non-government organizations. Examples of these data sources include air quality data from EPA, water quality data from county agencies, and remote sensing products such as satellite imagery and aerial photography.

6.2 DATA MANAGEMENT ROLES AND RESPONSIBILITIES

Collecting, analyzing and maintaining high quality data products require the combined efforts of numerous personnel. Therefore, proper data management standards must be understood and practiced by everyone involved in Network operations including regional staff, park staff and contractors and cooperators. Successful data stewardship requires that all Network personnel work together as a cohesive unit to ensure that data are collected using the appropriate methods and that all data sets are held to the highest quality standards. Table 6-1 lists the data stewardship roles and responsibilities of those involved in Network operation and data management.

TABLE 6-1: CATEGORIES OF DATA STEWARDSHIP INVOLVING ALL NETWORK AND PARK PERSONNEL

Stewardship Category	Related Activities	Principal jobs or positions
Note: Each position is listed in only one category according to overriding responsibilities. However, most positions contribute in each category.		
Production	Creating data or information from any original or derived source. This includes recording locations, images, measurements, and observations in the field, digitizing source maps, keying in data from a hardcopy source, converting existing data sources, image processing, and preparing and delivering informative products, such as summary tables, maps, charts, and reports.	Project Crew Member Project Crew Leader Data/GIS Specialist or Technician
Analysis	Using data to predict, qualify, and quantify ecosystem elements, structure, and function as part of the effort to understand these components, address monitoring objectives, and inform park and ecosystem management.	Quantitative Ecologist Resource Specialist
Management	Preparing and executing policies, procedures, and activities that keep data and information resources organized, available, useful, compliant, and safe.	Data Manager Project Leader GIS Manager IT Specialist
End Use	Obtaining and applying available information to develop knowledge that contributes to understanding and managing park resources.	Monitoring Coordinator Park Managers and Superintendents Public and others

Although data management is a combined effort, the Network data manger is responsible for coordinating the Network's data management program to ensure that standards are met and guidelines adhered to in all Network activities. Achieving the high standards of data quality the data manager must work closely with Network project leaders. Project leaders are usually Network ecologists responsible for managing individual projects. They are tasked with ensuring that project data management meets the Network standards. Figure 6-1 illustrates some of the specific data management tasks involved with I&M projects and how the responsibility for those tasks is divided.

6.3 NETWORK INFRASTRUCTURE AND DATA MANAGEMENT ARCHITECTURE

The foundation of the NCRN data management program is composed of a combination of computer hardware connected over local and national networks as well as the applications, tools, and repositories run on these computer systems.

- *Infrastructure* – represents the computers and servers connected through computer networking services.
- *Architecture* – the applications, system tools, databases, and repositories that make up the program data management enterprise.

Our digital infrastructure has three main components: park-based local area networks (LAN), network data servers, and servers maintained at the national level. This infrastructure is maintained by park, regional, and national IT specialists, who administer all aspects of system security and backups.

The NCRN I&M Program relies heavily on regional and national IT personnel and resources to maintain the computer infrastructure as well as assistance in developing and augmenting the program's data management architecture. Therefore, communication with regional IT specialists is essential to ensure adequate resources and service continuity.

To achieve an integrated information management system, three of the national-level data management applications (NatureBib, NPSpecies, and NR-GIS Metadata Database) utilize application architecture with both desktop and internet-accessible (master) components (Figure 6-2).

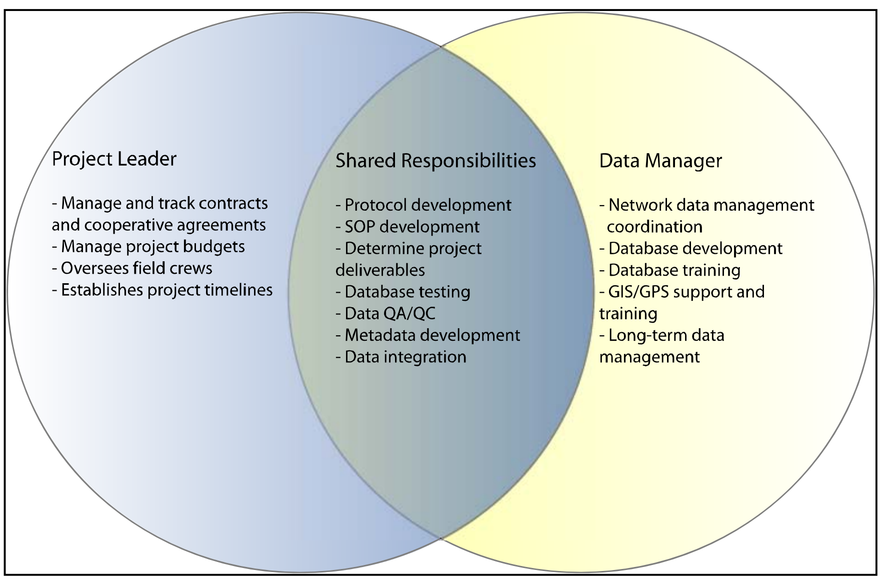


FIGURE 6-1: DIVISION OF PROJECT RELATED DATA MANAGEMENT TASKS
(adapted from the CAKN Data Management Plan)

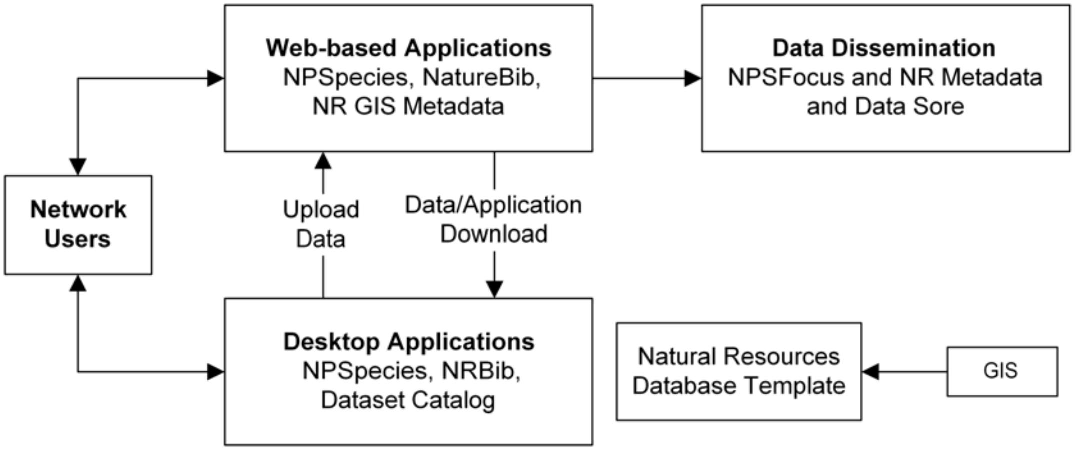


FIGURE 6-2: NATURAL RESOURCES DATABASE FRAMEWORK

An additional and integral component of the I&M data management infrastructure is the NPS STORET application for managing all data acquired during Network water quality monitoring. Water quality data collected as part of the network's monitoring program have distinct data management requirements. Data must be managed according to guidelines from the NPS Water Resources Division (WRD). This includes using the NPSTORET desktop database application at the parks to help manage data entry, documentation, and transfer to WRD. The NCRN will oversee the use of NPSTORET according to the network's integrated water quality monitoring protocol. Figure 6-3 illustrates the flow of information and data between the network, national program offices and EPA's main STORET repository.

Project Work Flow —All projects conducted by the NCRN have the same general workflow characteristics. Understanding the progressive stages of a project and the life cycle of the resulting data, we can more easily communicate the overall objectives and specific steps of the data management process. In addition, this awareness helps us to manage the staffing resources needed to produce, maintain, and deliver quality data and information. More details about data acquisition, quality assurance, documentation, dissemination and maintenance can be found in later chapters of this plan. Figure 6-4 illustrates the various project stages and highlights the data management tasks associated with each stage.

From the perspective of managing workflow, there are two main types of projects:

Short-term projects, which may include individual park research projects, inventories, or pilot work done in preparation for long-term monitoring.

Long-term projects, which will mainly be the implemented monitoring projects central to the I&M program, but which may also include multi-year research projects and monitoring performed by other agencies and cooperators. Long-term projects will often require a higher level of documentation, peer review and program support.

From a data management standpoint, a primary difference between short- and long-term projects is an increased need to adhere to standards for long-term projects to ensure internal compatibility over time. Both short-term and long-term projects share many workflow characteristics, and both generate data products that must be managed and made available.

6.4 DATA QUALITY ASSURANCE AND QUALITY CONTROL

Director's Order #11B states that all information (e.g., brochures, research and statistical reports, policy and regulatory information, and general reference information) distributed by the NPS (including information obtained from sources outside of the NPS) must be accurate, reliable and timely in nature. In order to disseminate accurate information, we must have confidence in the data we use. All data analyses, reports, and publications require data of

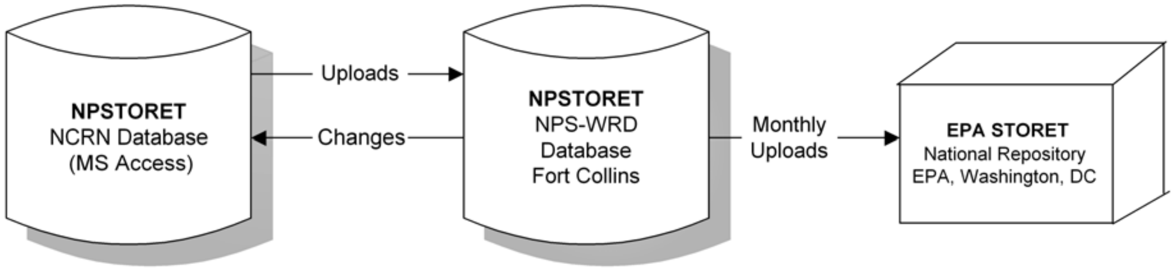


FIGURE 6-3: NATURAL RESOURCES DATABASE FRAMEWORK

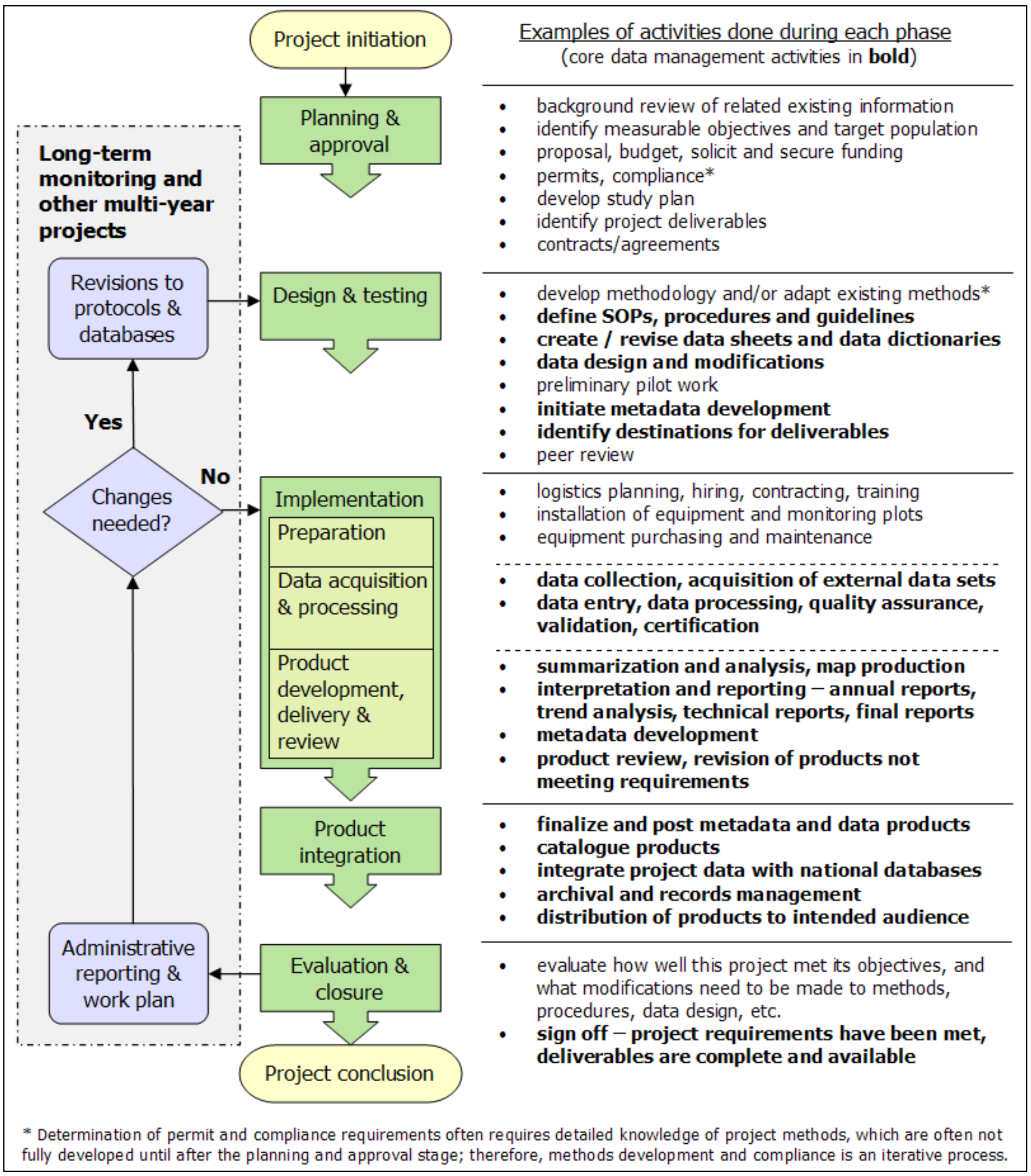


FIGURE 6-4: GENERAL STAGES OF PROJECT LIFE CYCLE

documented quality that minimize error and bias. Data of inconsistent or poor quality can result in incorrect interpretations and conclusions and improper management applications.

Palmer (2003) defines *Quality Assurance* (QA) as "an integrated system of management activities involving planning, implementation, documentation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the consumer." He defines *Quality Control* (QC) as "a system of technical activities to measure the attributes and performance of a process, item, or service relative to defined standards." Quality Assurance procedures maintain quality throughout all stages of data development. Quality Control procedures monitor or evaluate the resulting data products.

QA/QC mechanisms are designed to prevent data contamination, which occurs when a process or event other than the one of interest affects the value of a variable and introduces two fundamental types of errors into a data set:

- *Errors of commission* — include those caused by data entry and transcription errors or malfunctioning equipment. They are common, fairly easy to identify, and can be effectively reduced upfront with appropriate QA mechanisms built into the data acquisition process, as well as QC procedures applied after the data have been acquired.

- *Errors of omission* — often include insufficient documentation of legitimate data values, which could affect the interpretation of those values. These errors may be harder to detect and correct, but many of these errors should be revealed by rigorous QC procedures.

We appraise data quality by applying verification and validation procedures as part of the quality control process. These procedures are more successful when preceded by effective quality assurance practices.

Data verification checks that the digitized data match the source data (i.e., does the database match the field data sheets?).

Data validation checks that the data make sense (e.g., is an ambient temperature reading of 120°F in the middle of winter really accurate?).

It is essential that we validate all data as truthful and do not misrepresent the circumstances and limitations of their collection. Failure to follow SOPs for data entry, validation, and verification will render a data set suspect. Although data entry and data verification can be handled by personnel who are less familiar with the data, validation requires in-depth knowledge about the data.

Communicating Data Quality — The Network will use data documentation and metadata to notify end users, project managers, and network management of data quality. A descriptive document for each data set/database will provide information on the specific QA/QC procedures applied and the results of the review. Descriptive documents or formal FGDC-compliant metadata will document quality for spatial and non-spatial data files posted on the Internet.

6.5 DATA DOCUMENTATION

Data documentation is a critical step toward ensuring that data sets are useable for their intended purposes well into the future. This involves the development of *metadata*. FGDC defines metadata as:

Metadata — information about the content, quality, condition and other characteristics of data.

Additionally, metadata provide the means to catalog datasets, within intranet and internet systems, thus making their respective datasets available to a broad range of potential data users.

Purpose of Metadata—Data sets sometimes take on lives of their own. Some seem to have the ability to reproduce and evolve on multiple hard drives, servers and other storage media. Others remain hidden in digital formats or in forgotten file drawers. In addition, once data are discovered, a potential data user is often left with little or no information regarding the quality, completeness, or manipulations performed on a particular "copy" of a dataset. Such ambiguity results in lost productivity as the user must invest time tracking information down, or, worst case scenario, renders the dataset useless because answers to these and other critical questions cannot be found. As such, data documentation must include an upfront investment in planning and organization. Figure 6-5 illustrates the I&M Program's metadata system.

The importance for metadata is now universally accepted within the data management community. Recent legislative and policy efforts emphasize that data documentation must include and upfront investment in planning and organization.

Metadata Process/Workflow—The NCRN I&M Program deals with many different types of data sets from varying sources. The amount of documentation needed for different datasets may vary but the following is the basic steps to follow when documenting data sets.

Step 1. Identify Relevant Data Sets and Compile Pertinent Metadata

Step 2. Create Dataset Catalog Record

Step 3. Select Metadata Tool and Complete Record

Step 4. Make Information Available

6.6 DATA DISSEMINATION AND OWNERSHIP

The National Park Service defines conditions for the ownership and sharing of collections, data, and results based on research funded by the United States government. All cooperative and interagency agreements, as well as contracts, should include clear provisions for data ownership and sharing as defined by the National Park Service:

All data and materials collected or generated using National Park Service personnel and funds become the property of the National Park.

Any important findings from research and educational activities should be promptly submitted for publication. Authorship must accurately reflect the contributions of those involved.

Investigators must share collections, data, results, and supporting materials with other researchers whenever possible. In exceptional cases, where collections or data are sensitive or fragile, access may be limited.

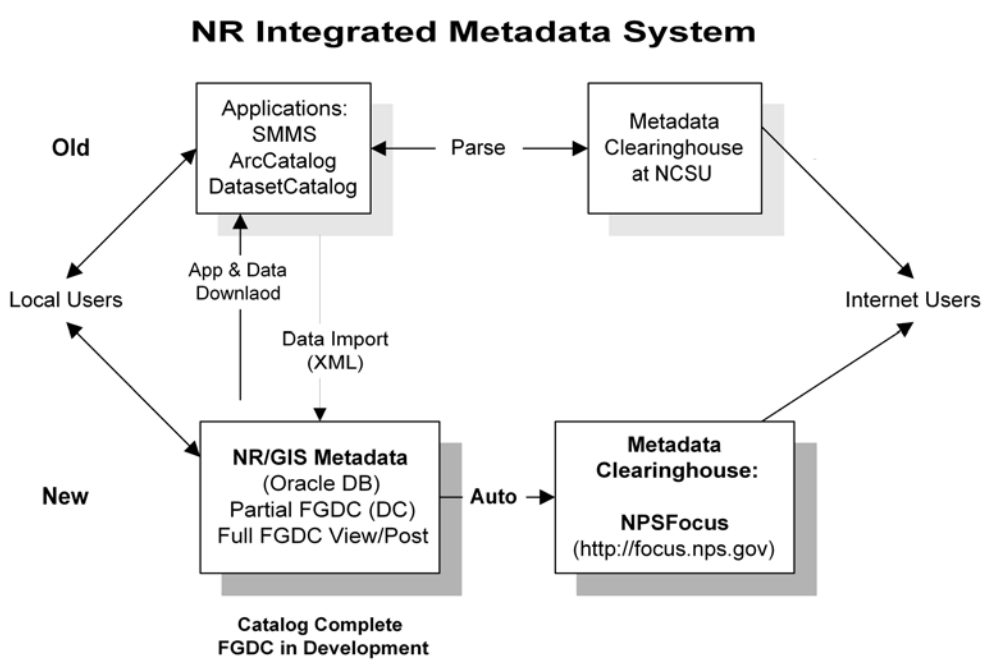


FIGURE 6-5: TAKEN AND MODIFIED FROM I&M DATA MANAGEMENT WORKSHOP, MARCH 2004

Data Classification: protected vs. public—All data and associated information from I&M activities must be assessed to determine their sensitivity. This includes, but is not limited to, reports, metadata, raw and manipulated spatial and non-spatial data, maps, etc. Network staff must carefully identify and manage any information that is considered sensitive. The Network must clearly identify and define those data needing access restrictions and those to make public.

The *Freedom of Information Act*, 5 U.S.C. § 552 (FOIA) stipulates that all US government agencies must provide access to data and information of interest, that are not protected from disclosure by exemptions, to the public. FOIA, as amended in 1996 to provide guidance for electronic information distribution, applies to records that are owned or controlled by a federal agency, regardless of whether or not the federal government created the records. Under the terms of FOIA, agencies must make non-protected records available for inspection and copying in public reading rooms and/or the Internet. Other records however, are provided in response to specific requests through a specified process. The Department of the Interior's revised FOIA regulations and the Department's Freedom of Information Act Handbook can be accessed at http://www.doi.gov/foia/ for further information. Network staff should consult their Regional FOIA Coordinator for more specific guidance whenever a particular instance of sharing information has the potential to involve protected information.

For example, information may be withheld regarding the nature and/or specific locations of the following resources recognized as 'sensitive' by the National Park Service. According to NPOMA, if the NPS determines that disclosure of information would be harmful, information may be withheld concerning the nature and specific location of:

- Endangered, threatened, rare or commercially valuable National Park System Resources (species and habitats)
- Mineral or paleontological objects
- Objects of cultural patrimony
- Significant caves

6.7 DATA MAINTENANCE

Data, documents, and anything that results from projects and activities that use Network data are all crucial pieces of information (figure 6-6). To ensure high-quality, long-term management and maintenance both digital and hard copy materials it is necessary to establish procedures that will permit a broad range of ers to easily obtain, share, and properly interpret both active and archived information while, at the same time, keeping the information secure.

6.7.1 Digital Data

In general, digital data maintained for lengthy periods of time will be one of two types: short-term data sets, for which data collection and modification have been completed (i.e., inventory projects); and long-term monitoring data sets, for which data acquisition and entry will continue indefinitely.

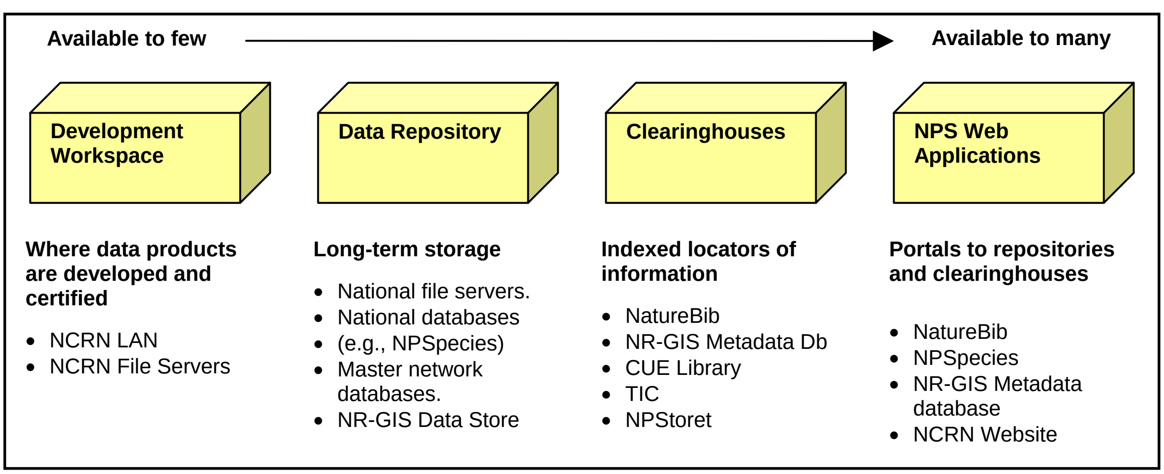


FIGURE 6-6: DATA DISTRIBUTION AND MAINTENANCE

Digital data will need to be stored in a repository that ensures both security and ready access to the data in perpetuity. All digital data sets are maintained on the NCRN file server under one of two directories depending on the depending on the status of the file.

Active Directory — used to house any file that is still in use or not yet considered complete. This includes datasets that have not yet undergone all of the necessary QA/QC procedures as well as draft documents.

Archive Directory — this directory contains all data sets that are complete (this mostly pertains to short-term projects such as inventories) along with completed reports, contracts and agreements. In the case of long-term monitoring data sets, because they will remain active indefinitely, the datasets will be archived periodically once the data have undergone QA/QC to preserve interim datasets. For data security purposes, this directory will be formatted as 'Read Only' for all personnel except the Data Manager and the Regional IT server support staff.

Digital Data Backup—The risk of data loss can come from a variety of sources, including catastrophic events (e.g., fire, flood), user error, hardware failure, software failure or corruption, and security breaches and vandalism. Performing regular backups of data and arranging for off-site storage of backup sets are the most important safeguards against data loss.

The NCRN I&M Program shares its file server with the National Capital Region Natural Resources and Science staff at the Center for Urban Ecology (CUE). Accordingly, backup procedures must be able to accommodate not only data produced by the I&M Program but all of the data and information stored by the regional staff as well. Due to the number of users utilizing the file server, the quantity of data included in the backup procedure quite large and constantly increasing.

Currently the NCRN backup plan calls for a complete daily backup of both the local directories and the shared directories (save two) that will enable a complete restoration of the file server for a period of thirty days. The two directories not included in the daily backup scheme are the GIS directory and the I&M Archive as the information in these directories changes infrequently. Data backups for these directories will take place once a week on a separate schedule.

6.7.2 Hard Copy Materials

The guidelines in this section apply to documents such as final reports prepared by staff or contractors, program administrative documents, contracts and agreements, memoranda of agreement, and other documents related to NCRN administration, activities and projects. These guidelines also apply to physical items such as natural history specimens, photographs, or audiotapes. In most instances, these documents and objects are essential companions to the digital data archives described earlier.

Documents—All paper documents managed or produced by the NCRN will be housed in one of two primary locations.

1. *NCRN central files*.
   The central files are maintained by the NCRN staff, at the Center for Urban Ecology. The NCRN will use acid-free paper and folders for all permanent records in the central files and store the documents in fire proof filing cabinets.

2. *Museum Resources Center (MARS)*
   MARS provides temperature and humidity-controlled facilities, a professional archival staff, and meets all museum standards set by NPS. This repository will be used for original documents and associated materials produced by the network (e.g., photographs, field notes, permits) that are a high priority to maintain under archival conditions.

For all materials submitted to MARS, NCRN will provide essential cataloging information such as the scope of content, project purpose, and range of years, to facilitate ANCS+ record creation and accession. NCRN will also ensure that materials are presented using archival-quality materials (acid-free paper and folders, polypropylene or polyethylene slide pages).

Specimens—It is recommended that all specimens collected under the auspices of the NCRN be archived at the regional Museum Resources Center (MARS); however, parks with the proper storage facilities reserve the right to maintain their specimens in house. The NCRN will provide Park curators with associated data required for cataloging each specimen. These data will be in comma-delimited format (.CSV) format for automated uploading into ANCS+.

Chapter 7

Data Analysis and Reporting

In this chapter, we describe approaches to how data collected by the monitoring program will be analyzed, including who is responsible and how often analysis will occur. We also describe the various reports and other products of the monitoring effort, including what they will include, who the intended audience is, how often they will be produced and in what format, and who is responsible for these products.

In summary, the NCRN strategy towards data analysis and reporting rests upon providing sufficient funding for these activities so that they occur promptly—that is, to report on the previous field season (October–September) by the following March. The NCRN will also focus on producing an annual integrated "State of the Parks" report that effectively communicates the changes and trends observed in each vital sign to our primary audience—the natural resource managers of each park.

7.1 DATA ANALYSIS

For the purposes of this chapter, we have defined data analysis as the processes by which observations of the environment are turned into meaningful information. We include all evaluations of data after the data are collected and entered into an electronic file. Thus, data analysis includes quality control checks that occur during summarization and exploratory data analysis and extends through to analytical procedures leading to conclusions and interpretations of the data. We present some general considerations for analysis of monitoring data and outline the general strategy that NCRN will take for all vital signs. We also describe the specific approaches currently planned for each vital sign.

7.1.1 Analysis of Monitoring Data—General Considerations and NCRN Strategies

The data collected during vital signs monitoring will be put to a variety of uses. These include determining the status of a resource at a particular time, detecting geographic trends across the region, comparing the parks that make up the NCRN and detecting trends through time. We anticipate that in the future, resource managers and the scientific community will find additional uses for these data. Therefore, the Inventory and Monitoring (I&M) program plans to collect data using sampling designs that can accommodate a wide variety of analyses.

Many of the potential difficulties in analyzing the data can be avoided by proper planning. For each vital sign, it is important to state an exact measurable objective (what the data is supposed to demonstrate), determine an adequate sampling design, and indicate potential statistical analyses. Analysis of the monitoring data should be directly linked to the monitoring objectives, the spatial and temporal aspects of the sampling design used, and management uses of the data. Analytical methods need to be considered when the objectives are identified and the sampling design is selected. Failure to adequately consider analytical methods during development of the monitoring program could result in use of sampling designs that either are inadequate to meet the monitoring objectives or are specialized to the point of limiting the usefulness of the data.

The network has developed several strategies to guide the development of data analysis for the NCRN vital signs program. Each monitoring protocol has a clear list of measurable objectives for the data being collected. These objectives are used to guide the sampling designs and potential analyses. GRTS is used as a sampling design for as many vital signs as possible (see chapter 4). GRTS provides a random, spatially balanced sampling design that can be used in a wide variety of analyses. Stratification is generally avoided as sampling designs that are highly structured (i.e., include many stratifications) make subsequent analyses difficult. An unstructured design allows more flexibility in the analysis phase (Overton and Stehman 1995, 1996; Nusser et al. 1998).

A central tenet of the NCRN program is that data will be analyzed and reported promptly. Mechanisms to support prompt analysis and reporting have been built into the data management plan (e.g., data must be entered into the database within one month of returning from the field). Additional mechanisms will be established in the Data Analysis SOP for each vital sign. One of the primary problems leading to long delays in analysis and reporting is a lack of explicit funding for this activity (Caughlan and Oakley 2001). The NCRN strategy includes providing adequate support to principal investigators (PIs) for data analysis. This will typically include hiring of staff to provide support so the PI has the time required for analysis.

The first step in analysis is summarization (Mulder et al. 1999). This step is a critical part of overall quality control. The data need to be summarized promptly to identify missing values, and other problems related to data collection procedures and the data entry process (Jeffers 1994; Reid 2001). Routines for summarization will be prepared and codified. The exact form of the summaries will vary depending on the vital sign. In general, however, the approach will include use of graphical techniques to show the data in space and time, using measures of central tendency and variation.

The second step in analysis will be to prepare annual reports for each vital sign. The data collected each year will be analyzed as detailed the monitoring protocol for each vital sign. Where appropriate, annual reports will examine geographic patterns in the vital signs and examine year-to-year changes. Water quality will be analyzed to determine if conditions in the parks are in compliance with relevant legislation.

The third step in analysis of NCRN data sets will be in-depth analyses of change over time. Specific methods of change, trend, or temporal pattern detection for each vital sign will be used and reported at predetermined intervals. When appropriate, we will use other analyses such as species-habitat relationships or community ordinations. The main approaches we currently intend to use for trend detection are time series analyses – the exact analysis depending on the data at hand.

We expect the analysis methods used in the program to change over time. During the first five to ten years of the program, focus will be on summary of findings for a given year across the spatial scale of the network. Comparisons to previous years will be made as data become available. Once measurements have been made over three points in time analysis of trends can begin.

7.1.2 Initial Analysis Approaches for NCRN Vital Signs

The initial analysis approaches to be used for each vital sign to be monitored are shown in table 7-1. We also identify, for each vital sign, the person who has the lead responsibility for data analysis. In some cases, the analysis may be conducted by a person outside of the National Park Service (NPS). In all cases, the person within the NPS designated to conduct the analysis or manage the agreement under which another person conducts the analysis, is identified.

In writing the standard operating procedures for data analysis for each vital sign, we have attempted to provide as much detail as possible about the initial steps of data analysis. When a particular analysis cannot be prescribed *a priori*, we suggest approaches that would be appropriate given the objectives and sampling designs used.

7.2 REPORTING

In 2001, I&M program staff conducted an analysis to identify stakeholders for implementing the I&M program and create appropriate communication tools. Key stakeholders include decision makers, information users, and the general public. Decision makers include members of congress and high-level administrators from the Department of Interior and NPS. Information users include the scientific community and park staff such as interpreters, rangers, maintenance workers, and resource managers. Other constituents included the public and special interest groups. A variety of reporting and outreach tools were developed to reach these various stakeholders (see table 7-1 for a summary). The annual reporting schedule is summarized in table 7-2.

TABLE 7-1: SUMMARY OF DATA ANALYSIS AND SYNTHESIS

Network Vital Sign	Data Analysis Approach	Report Lead	Reporting Cycle
Ozone	Regional concentration. Exceedances of the human health-based standard.	NCR Air Specialist	Ozone concentration available daily. Annual summary. Trend analysis every 5 years.
Wet and dry deposition	Regional deposition [(NO_3^-), ammonium (NH_4^+) and sulfate (SO_4^{2-})]	NCR Air Specialist	Annual summary. Trend analysis every 5 years.
Visibility and particulate matter	Regional concentrations	NCR Air Specialist	Data available daily. Annual summary. Trend analysis every 5 years.
Mercury deposition	Regional concentrations	NCR Air Specialist	Annual summary. Trend analysis every 5 years.
Weather	Daily temperature highs and lows; Daily precipitation; Monthly summaries	NCR Air Specialist	Data available daily. Annual summary. Trend analysis every 5 years.
Shoreline features	Conformational change to shoreline habitats	Remote Sensing Cooperator	TBA
Physical habitat index (PHI)	Index value per stream per park	Water Resources Specialist	Annual summary. Trend analysis every 5 years.
Surface water dynamics	Flow, stage, and discharge per stream per park	Water Resources Specialist	Annual summary. Trend analysis every 5 years.
Water chemistry	Temperature, specific conductance, pH, dissolved oxygen, Acid Neutralizing Capacity per stream per park.	Water Resources Specialist	Annual summary. Trend analysis every 5 years.
Nutrient dynamics	Orthophosphate, nitrate and ammonia per stream per park	Water Resources Specialist	Annual summary. Trend analysis every 5 years.
Aquatic macroinvertebrates	Species diversity and abundance per stream per park.	Water Resources Specialist	Annual summary. Trend analysis every 5 years.
Invasive/exotic plants	Observations by field crews.	Network staff, cooperators	New detections reported as they occur.
Pest species	Observations by field crews.	Network staff, cooperators	New detections reported as they occur.
Forest and grassland vegetation	Basal area, species diversity and density per park.	Vegetation Ecologist	Annual summary. Trend analysis every 5 years.
Fish Index of Biological Integrity (FIBI)	Fish diversity and abundance per stream.	Water Resources Specialist	Annual summary. Trend analysis every 5 years.
Amphibians	Species diversity and percent area occupied per park.	Network staff	Annual summary. Trend analysis every 5 years.
Landbirds	Species diversity and density in (1) forests, and (2) grasslands per park	Network staff	Annual summary. Trend analysis every 5 years.
White-tailed deer	Deer per square km per park	NCR Wildlife Biologist	Trend analysis conducted annually.
T&E species	Species density per site. Qualitative evaluation of threat (e.g., exotic species, social trails, etc.)	Network staff	Annual summary. New detections of significant threats reported as they are found.
Land cover/land use	Landscape metrics TBA using FRAGSTATS and RULE	Remote Sensing Cooperator	TBA
Landscape condition	Landscape metrics TBA using ISODATA and eCOGNITION	Remote Sensing Cooperator	TBA

TABLE 7-2: ANNUAL REPORTING SCHEDULE FOR NCRN

Vital Sign Name	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Annual Administrative Work Plan and Report								Due to BOD	Due to WASO			
Annual Progress Reports												X
Investigator Annual Reports			X									
Newsletter			X			X			X			X
One-Minute Update			X			X			X			X
Park Status Reports												X
State of the Park Report Card												X

7.2.1 Annual Administrative Reports and Work Plans

The I&M program is not only responsible for making data available for its projects but must also be held accountable for its funding. As a result, the I&M program has developed the Annual Administrative Report and Work Plan (AARWP) to provide an overview of the program's status. The AARWP consists of two parts: the first part is the administrative report, which should be an accurate accounting of how funds for the previous fiscal year were spent by the network; the second part is the work plan that outlines planned projects and budgets for the next fiscal year. The AARWP must be approved by the Board of Directors (BOD) and received by the Servicewide I&M Program and Water Resources Divisions by November 8 of each year to allow time for consolidating the reports and budgets into a single report to Congress. The work plan submitted to the NPS Washington Support Office on November 8 will be considered a draft. The final work plan must be approved by the network BOD and submitted to the Washington Support Office for approval by January 31 each year. The AARWP has an associated budget database. The standard database is updated annually by Washington Support Office and is designed to facilitate standard budget reports. Detailed guidelines for the AARWP are posted at: http://science.nature.nps.gov/im/monitor/index.htm.

7.2.2 Annual Progress Reports

Annual reports are required for all projects funded or implemented by the National Capital Region Network (NCRN) I&M program to justify funding levels. Annual reports are due by October 20 of each year, and cover the period of a fiscal year (October 1– September 31). The annual reports will be copied, in part, into the AARWP. The reports include a summary of work conducted including significant findings. The discussion section highlights public interest stories, research recommendations, and management implications. Guidelines for submitting annual reports are provided in Product Specifications Standard Operating Procedures found in the NCRN *Data Management Plan* (Sanders et al. 2004).

7.2.3 Park Status Reports

The Park Status Reports (PSRs) are park specific reports based on the AARWP (see section 7.2.1). A PSR is developed for each park and highlights all of the I&M activities pertaining to the park. Budget information is provided along with a summary of each project including interesting findings. The PSRs are completed and distributed within one month of the BOD's approval of the AARWP. The PSR includes public interest highlights, research recommendations, and management implications. For an example of the PSR, see appendix O.

7.2.4 Investigator Annual Reports

In addition to the annual reports outlined in section 7.2.2, investigators including I&M staff must submit Investigator Annual Reports (IARs) for any project requiring park permits. IARs cover the calendar year and must be submitted by

March 23 following each reporting year. IARs are mainly a tracking mechanism for ongoing projects wherein key findings are summarized and become part of the park's permanent record. Guidelines are published and updated on the internet:

http://science.nature.nps.gov/research/ac/ResearchIndex.

Passwords to access the sites will be distributed annually by the parks.

7.2.5 Final Project Reports

Final reports must be written for all completed projects. Reports must be provided in hard and electronic format. Guidelines for submitting final project reports are provided in Final Report Standard Operating. The discussion section highlights public interest stories, research recommendations, and management implications. Procedures found in the NCRN *Data Management Plan* (Sanders et al. 2004).

7.2.6 Analysis and Synthesis Reports

Data should be analyzed at least every five years for protocols where data is collected annually. The analyses are designed to determine status and trends of the resources and put them into a regional context. The reports may have management implications, identify protocol adjustments, or identify potential research projects. Specific analyses are protocol specific. The format should follow Final Report Standard Operating Procedures found in the NCRN Data Management Plan (Sanders et al. 2004). Results of the review may be considered for publishing if findings are significant or may be of interest to the wider scientific community (see table 7-3 for a summary)

Program and Protocol Review Reports

Each monitoring protocol is subject to review every five years. The review will be implemented by the project manager for the protocol or may be conducted by impartial reviewers outside of the program. The report should analyze data and protocols with the purpose of determining if changes are needed. Results of the review may be considered for publishing if findings are significant or may be of interest to the wider scientific community. The format should follow Final Report Standard Operating Procedures found in the NCRN *Data Management Plan* (Sanders et al. 2004).

7.2.7 Scientific Journal Articles, Book Chapter, or Conferences

Scientific journal articles and book chapters will be written when key findings are made and are worth publishing. Potential outlets include (but are not limited to): Park Science, George Wright Society, Ecology, Conservation Biology, Conservation Biology in Practice, among many others.

7.3 OUTREACH PUBLICATIONS

In addition to formal reports, the I&M program identified various outreach publications that are used to highlight recent events or to be of greater interest to the general public (see table 7-3).

7.3.1 State of the Park Report Card

The details for a national "State of the Parks Report" for natural resources and how parks will identify desired conditions and report to the Land Health Goals are being developed, but we expect to summarize condition assessments for each park and resource category using a clear, simple message as in figure 7-1. This graphic can also be used as an information gateway to the large body of detailed, complex scientific information that is used as the basis for the resource assessments.

7.3.2 I&M Quarterly Newsletter

In 2002, the I&M program initiated a quarterly newsletter distributed in paper format to the parks interpretation, ranger, and natural resource programs. The newsletter highlights recent finding by the I&M program and includes pictures. An example is included in appendix P.

TABLE 7-3: SUMMARY OF REPORTS DEVELOPED BY THE NCRN I&M PROGRAM

Report	Purpose of Report	Primary Audience	How Often?	Who Initiates?	Peer Reviewed?
Annual Administrative Report and Work Plan (AARWP)	Account for funds and FTEs expended Describe objectives, tasks, accomplishments, products of the monitoring effort Improve communication within park, network, region, program	Superintendents, network staff, regional coordinators, and Servicewide program managers; administrative report is used for annual report to Congress	Annual; due to Washington Support Office by November 8	Network coordinators; approved by network Board of Directors	Review and approval by regional office and servicewide program manager
Annual Project Reports (APR)	Highlight results from reporting year Archive annual data and document monitoring activities for the year Describe current condition of the resource Document changes in monitoring protocols Communication within the park or network	Park resource managers; network staff; external scientists; servicewide program managers	Annual; due to I&M office October 20	Project Manager (network staff or principal investigator)	Peer reviewed at network level
Investigator Annual Reports (IAR)	Permanently document investigations in the parks Summarize on ongoing projects Linked to park permits	Park staff and interested public	Annual; due to IAR system March 23	Project Manager (network staff or principal investigator)	Reviewed and approved by Park Resource Manager
Final Project Reports (FPR)	Document results from completed projects Describe current status or distribution of the resource	Park resource managers; network staff; external scientists; Servicewide program managers	At end of project (e.g., typically inventories or other short term monitoring projects)	Project Manager (network staff or principal investigator)	Peer reviewed at network level
Analysis and Synthesis Reports – Trends (see also table 7-1)	Determine patterns/trends in condition of resources being monitored Discover new characteristics of resources and correlations among resources being monitored Analyze data to determine amount of change that can be detected by this type and level of sampling	Superintendents, park resource managers, network staff, external scientists	3- to 5-year intervals for resources sampled annually	Project Manager (network staff or principal investigator)	Peer reviewed at network level

TABLE 7-3: SUMMARY OF REPORTS DEVELOPED BY THE NCRN I&M PROGRAM (CONTINUED)

Report	Purpose of Report	Primary Audience	How Often?	Who Initiates?	Peer Reviewed?
	Context – interpret data for the park within a multi-park, regional or national context Recommend changes to management of resources (feedback for adaptive management)				
Program and Protocol Review reports	Periodic formal reviews of operations and results (5-year intervals) Review protocol design and products to determine if changes needed Part of quality assurance – peer review process	Superintendents, park resource managers, network staff, Servicewide Program managers, external scientists	Recommend 5-year intervals	Project Manager (network staff or principal investigator)	Peer reviewed at regional or national level
Scientific journal articles and book chapters	Document and communicate advances in knowledge Part of quality assurance – peer review process	External scientists, park resource managers, network staff	Varies	Project Manager (network staff or principal investigator)	Peer reviewed at network level; peer reviewed by journal or book editor
Conferences	Review and summarize information on a specific topic or subject area Communication of latest findings with peers Helps identify emerging issues and generate new ideas	Park resource managers, network staff, external scientists	Varies	Project leaders, network staff or external scientists	May be peer reviewed by editor

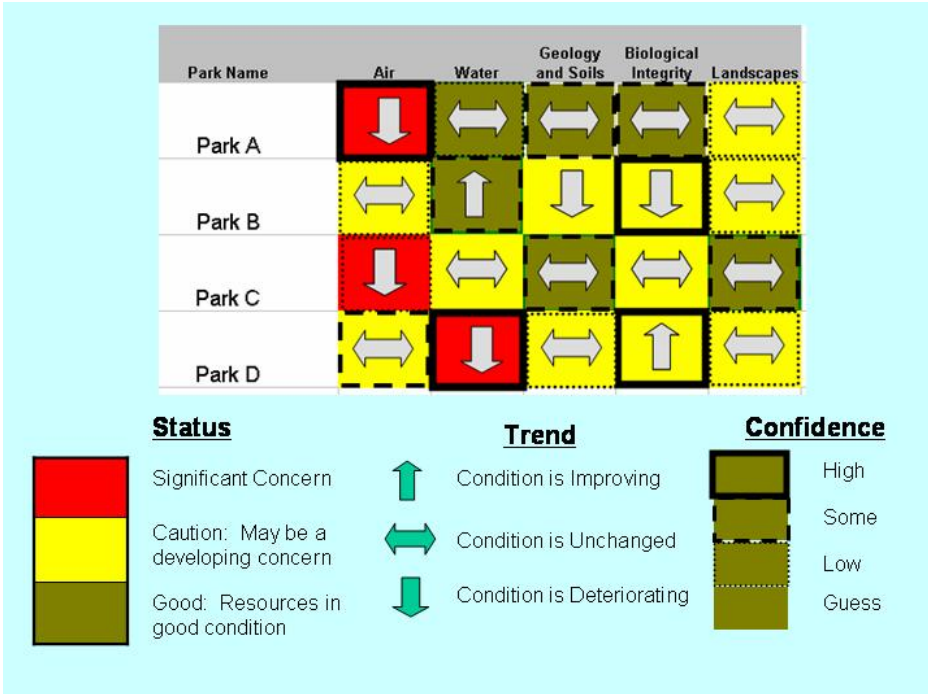


FIGURE 7-1: SAMPLE STATE OF THE PARKS REPORT CARD

7.3.3 Quarterly One-Minute Update

In addition to a formal newsletter, the I&M program creates a short e-mail update to participants in the I&M planning process including NPS staff and partnering agencies. The update is formatted to give three to four brief paragraphs of recent events. It is designed to reach people who are too busy to read the longer, more detailed I&M Quarterly Newsletter. The format should follow previous editions. An example is included in appendix Q.

7.3.4 Brochures or Fact Sheets

Interpretation and education staff at the NCRN parks are always looking for new information to provide to the public about the natural resources. The I&M program will work closely with the NCR Learning Center and Park Staff to develop topical brochures and fact sheet that are of interest to the public. The information will be developed as needed. Format should follow previous editions posted to: http://www.nps.gov/cue/programs/i_and_m/products.htm.

7.4 ORAL PRESENTATION

In addition to reports and outreach publications, oral presentations provide the I&M program with an opportunity to inform park staff, the scientific community, or special interest groups with up to date information about the status and trends of park resources. Oral presentations will also increase the visibility of the program, which can build support and increase the network of potential collaborators (see table 7-4).

TABLE 7-4: SUMMARY OF OUTREACH PUBLICATIONS DEVELOPED BY THE NCRN I&M PROGRAM

Report	Purpose of Report	Primary Audience	How Often?	Who Initiates?	Peer Review Process
Quarterly Newsletter	Provide a formal update for park staff including visitor centers	Superintendents, Partner Organizations, Public	Quarterly	Network Coordinator	Peer reviewed at network level
Quarterly One-Minute Update	Provide brief updates on I&M projects Provide a mechanism for parks to learn more about I&M projects and products	Park Staff (Superintendents, Park Rangers)	Quarterly	Network Coordinator	Peer reviewed at network level
Brochures and Fact Sheet	Support park interpretation and education programs Inform public about inventory and monitoring program and their findings	Park staff, visitors, school groups, special interest groups	As needed	Network staff	Peer reviewed at network level

7.4.1 Park Presentations

In response to requests from parks, the I&M program developed a slide presentation to highlight the I&M program to new staff or to provide recent findings to existing interpretation staff through site-specific presentations. The presentation is available to parks upon request. In addition, regular programmatic updates will be provided to the Board of Directors (biannually), the Natural Resource Advisory Team (NAT; bimonthly), Science Advisory Team (as needed), and the Interpretation Management Advisory Group (annually). In addition, project leads or principal investigators will be invited to attend NAT meetings in order to provide annual in-depth updates to natural resource staff.

7.4.2 Special Interest Groups Presentations

Given the strong interest in park management by the general public, the I&M program identified a need to highlight the program at meetings sponsored by a variety of special interest groups. Special interest groups potentially have strong influence on park management and can be a possible link to strengthen support among the general public. Topic specific presentations will be developed as time allows and as appropriate. I&M findings can be presented at a variety of local meetings including (but not limited to):

Fairfax Audubon Society

Friends of Dyke Marsh

Native Plant Society of Maryland

Native Plant Society of Virginia

Northern Virginia Bird Club

7.4.3 Scientific Presentations

In addition to reaching out to the parks, the I&M program identified a need to develop a strategy to present results to the scientific community. Topic specific presentations will be developed as time allows and as appropriate to reach out to both the local scientific and national scientific community. The following opportunities have already been identified as a high priority because of their visibility among partner organizations with which I&M interacts.

Local Meetings:

Botanical Society of Washington

Entomology Society of Washington

Patuxent Wildlife Research Center Annual Meeting

The Wildlife Society (Virginia Chapter)

National Meetings:

Conservation Biology

Ecological Society of America

George Wright Society

Chapter 8

Administration / Implementation of the Monitoring Program

This chapter describes our plan for administering the monitoring program. The network has developed a three-year (FY 2005–2008) plan under which vital sign monitoring will begin, while development of protocols for monitoring of the other vital signs will be initiated. In this chapter, we describe the makeup of the Board of Directors and Technical Committee and the decision-making process of the network; the staffing plan; how network operations are integrated with other park operations; key partnerships; how in-house field work will be carried out; and the periodic review process for the program.

8.1 I&M GUIDANCE

The Inventory and Monitoring (I&M) program receives guidance from both network and national levels. National guidance and direction is provided by the Associate Director of Natural Resources (ADNR), Inventory and Monitoring Advisory Council (IMAC), the Natural Resources Program Center (NRPC) Office of Inventory, Monitoring, and Evaluation. At the network level, the Board of Directors (BOD) provides administrative and budgetary guidance and approval, while the Science Advisory Committee (SAC) provided technical guidance during the initial planning process for the monitoring plan. A Technical Advisory Committee (TAC) was created to provide long-term guidance on the scientific underpinnings of the program (figure 8-1). In addition, the Natural Resource Advisory Team (NAT) provides a forum to solicit input from park and regional natural resource staff.

8.1.1 Associate Director of Natural Resources, Inventory and Monitoring Advisory Council, and Natural Resource Information Division

The ADNR is directed to implement the National I&M program. The IMAC meets twice a year to make recommendations to the ADNR and resolve issues affecting all networks. The IMAC has two representatives from each region of the National Park Service (NPS) including the regional I&M Coordinator and one other person selected by the region. In addition, the IMAC is regularly attended by staff from the Natural Resource Information Division which is charged with providing guidance, vision, and technical support to implement the network I&M programs. The Natural Resource Information Division also provide day-to-day guidance, policy interpretation, and technical assistance to the National Capital Region Network (NCRN) I&M program.

8.1.2 Board of Directors

The NCRN I&M program is guided by the I&M BOD. The BOD is composed of a superintendent or their designee from each park in the NCRN (table 8-1). The BOD meets biannually and approves the Annual Administrative Report and Work Plan (AARWP) as well as approving decisions regarding budget, staffing, and project implementation. Their work is guided by a charter (appendix C). Membership typically changes each year as staff changes occur in the parks; current membership is reported in the most recent AARWP. The most critical function of the BOD is to ensure that the monitoring program becomes integrated into the day-to-day activities of park planning and management including maintenance, interpretation, resource protection and resource management.

8.1.3 Science Advisory Committee

The SAC was established by the BOD in order to provide technical guidance to the monitoring planning process. The SAC meets when their input is needed from the I&M staff and is composed only of federal employees to comply with the *Federal Advisory Committee Act*. Participants include at least one representative from the resource management division of each park and employees from partner agencies (table 8-2) including U.S. Environmental Protection Agency,

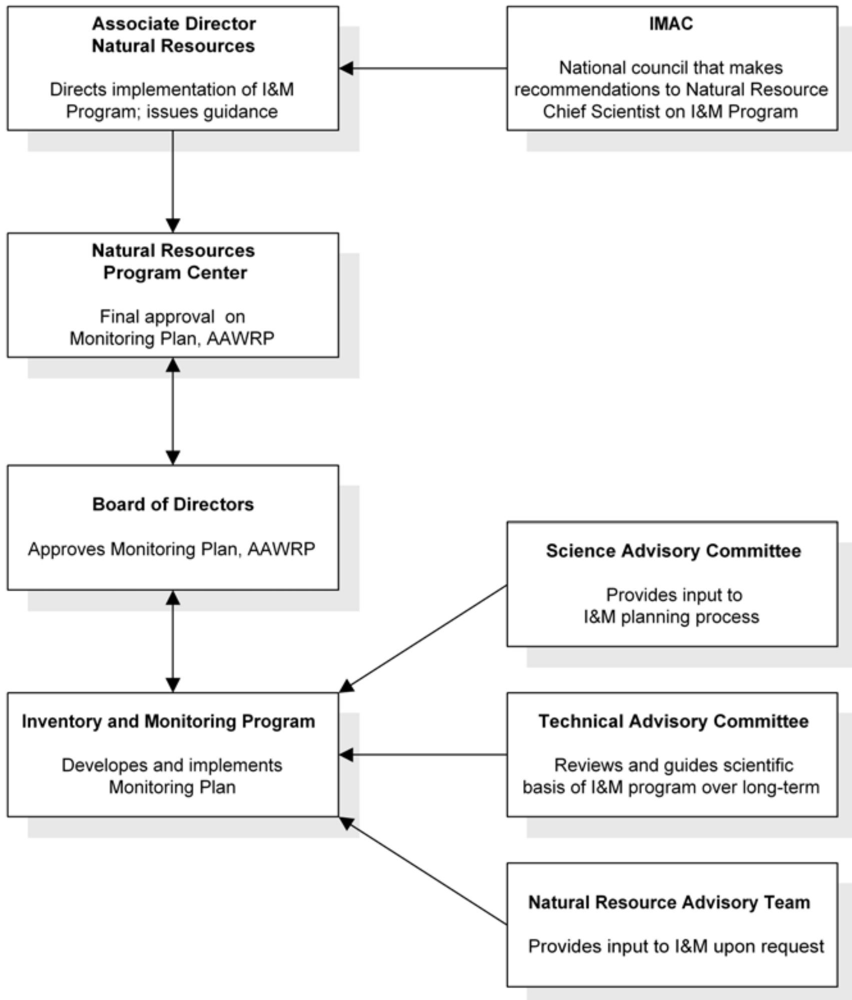


FIGURE 8-1: RELATION OF BOD, SAC, TAC, AND NAT WITH I&M PROGRAM

TABLE 8-1: NCRN BOARD OF DIRECTORS (LAST UPDATE 5/30/05)

Park	Title	Name
ANTI	Superintendent	John Howard
CATO	Superintendent designee, Resource Management Specialist	Jim Voigt
CHOH	Superintendent	Kevin Brandt
GWMP	Superintendent designee, Resource Management Specialist	Vince Santucci
HAFE	Superintendent designee, Resource Management Specialist	Bill Hebb
MANA	Superintendent designee, Resource Management Specialist	Bryan Gorsira
MONO	Superintendent designee, Resource Management Specialist	Andrew Banasik
NACE	Superintendent	Gayle Hazelwood
PRWI	Superintendent	Bob Hickman
ROCR	Superintendent	Adrienne Coleman
WOTR	Superintendent designee, Resource Management Specialist	Duane Erwin
National Capital Region	Chief of Natural Resources and Science	Dr. Jim Sherald
National Capital Region	I&M Coordinator	Dr. Shawn Carter
National Capital Region Network	Network Coordinator	Vacant

TABLE 8-2: NCRN SCIENCE ADVISORY COMMITTEE

Park	Title	Name
ANTI	Resource Management Specialist	Ed Wenschoff
CATO	Resource Management Specialist	Jim Voigt
CHOH	Resource Management Specialist	Marie Frias
GWMP	Resource Management Specialist	Brent Steury
HAFE	Resource Management Specialist	Bill Hebb
MANA	Resource Management Specialist	Bryan Gorsira
MONO	Resource Management Specialist	Andrew Banasik
NACE	Resource Management Specialist	Stephen Syphax
PRWI	Resource Management Specialist	Jennifer Lee
ROCR	Resource Management Specialist	Ken Ferebee
WOTR	Resource Management Specialist	Duane Erwin
National Capital Region	Chief of Natural Resources and Science	Dr. Jim Sherald
National Capital Region	Research Coordinator	Dr. Diane Pavek
National Capital Region	Wildlife Biologist	Scott Bates
National Capital Region	Aquatic Ecologist	Dr. Jeff Runde
National Capital Region	Integrated Pest Management Coordinator	Jil Swearingen
National Capital Region	Hydrologist	Doug Curtis
National Capital Region	Exotic Plant Management Team Leader	Sue Salmons
National Capital Region	Deputy Chief, Natural Resource and Science	Dan Sealy
National Capital Region	I&M Coordinator	Dr. Shawn Carter
National Capital Region Network	Network Coordinator	Vacant
National Capital Region Network	Quantitative Ecologist	Dr. John Paul Schmitt
National Capital Region Network	Data Manager	Geoffrey Sanders
National Capital Region Network	Water Resource Specialist	Marian Norris

U.S. Department of Agriculture Forest Service, U.S. Geological Survey, and the Smithsonian Institution. Subject matter experts (table 8-3) are brought in from time to time to share their knowledge on specific topics. The subject matter experts typically represent local universities, partnering agencies, and state or local government agencies. Current composition is listed in the most recent AARWP.

8.1.4 Technical Advisory Committee (TAC)

The TAC is a short-term ad hoc committee established to provide credible scientific review of I&M products and research. The TAC is composed of a small group of scientists who are well versed in the science of monitoring and represent various universities and agencies. The members are reimbursed for their time and effort. Current composition is listed in the most recent AARWP.

8.1.5 Natural Resource Advisory Team (NAT)

In addition to the formal guidance, the I&M program meets regularly with the NAT. The NAT is composed of natural resource management specialists from each park in the National Capital Region. The team meets every two months to share lessons learned and discuss current resource management issues. The I&M program attends the meetings to provide updates on the I&M planning and implementation process. In addition, the NAT provides input and guidance to the I&M program when it is solicited.

8.2 STAFFING

The NCRN I&M program is directed and supervised by the regional inventory and monitoring coordinator. The core network staff consists of two permanent positions including

TABLE 8-3: NCRN SCIENCE ADVISORY COMMITTEE AD-HOC PARTICIPANTS (SUBJECT MATTER EXPERTS)

Agency	Specialty	Name
Environmental Protection Agency	Landscape Ecology	Pat Bradley
George Mason University	Air Quality/Landscape Ecology	Dr. George Taylor
Georgetown University	Entomologist	Dr. Edd Barrows
National Park Service	Air Quality	Julie Thomas
National Park Service	Geology	Bob Higgins
Smithsonian Institution	Entomology	Dr. Gary Hevel
Smithsonian Institution	Wildlife Ecology	Dr. Bill McShea
Smithsonian Institution	Entomology	Cheryl Bright
The Nature Conservancy	Ecology/Rare species and communities	Dr. Doug Sampson
University of Maryland	Landscape Ecology	Dr. Steve Seagle
USDA Forest Service	Forest Ecology	Dr. Chip Scott
USGS	Aquatic Ecologist	Dr. Craig Snyder
USGS	Wildlife Ecologist	Dr. Allan O'Connell

the network coordinator and data manager. The core staff is supported by additional term and seasonal positions funded through the network. Various park and region staff also provide technical and administrative assistance to the program.

8.2.1 Regional I&M Staff

Regional Inventory and Monitoring Coordinator (GS-12/13)—This position supervises all I&M staff, provides direction, ensures the implementation of national guidelines, coordinates program review procedures including external peer review and coordinates with other I&M regions. The regional coordinator ensures that program is integrated into park management including planning, maintenance, and interpretation; and ensures that the program is integrated with other regional programs including the Exotic Plant Management Team, Integrated Pest Management, Learning Center, Water and Air Resources. This position supports region and park programs by coordinating with research coordinator. The regional coordinator is responsible for submitting the AARWP to the BOD and NRPC each year and serves as secretary to the BOD. This position also communicates I&M goals and objectives to other agencies and develops long-term partnerships through Cooperative Agreements, Inter-Agency Agreements, and Contracts. This position is supervised by the Chief of Natural Resources and Science.

8.2.2 Network Staff

The NCRN depends on a core of permanent staff members who work in coordination with park managers, regional staff, and cooperators to plan and develop the vital sign selection and prioritization process, create the monitoring plan document, and coordinate protocol development. The core staff is ultimately responsible for implementing the program and coordinating with the parks. The network is supplemented by term employees, seasonal staff and assistance from various park and regional staff (figure 8-2).

8.2.3 Core Staff

Network Coordinator/Vegetation Ecologist (GS-11/12)—This position develops and oversees the implementation of the Monitoring Plan. The network coordinator coordinates data collection with principal investigators, cooperators, park staff, and I&M staff, acts as Contracting Officer Technical Representative to ongoing projects and serves as chair to the SAC. Acts as the principal liaison to the Natural Resource Advisory Team and park resource managers. Works with rest of team to ensure that reports are completed and information reaches targeted audiences. In addition to overall coordination, the position is responsible for implementing the long-term vegetation monitoring. Hires and trains seasonal field crews.

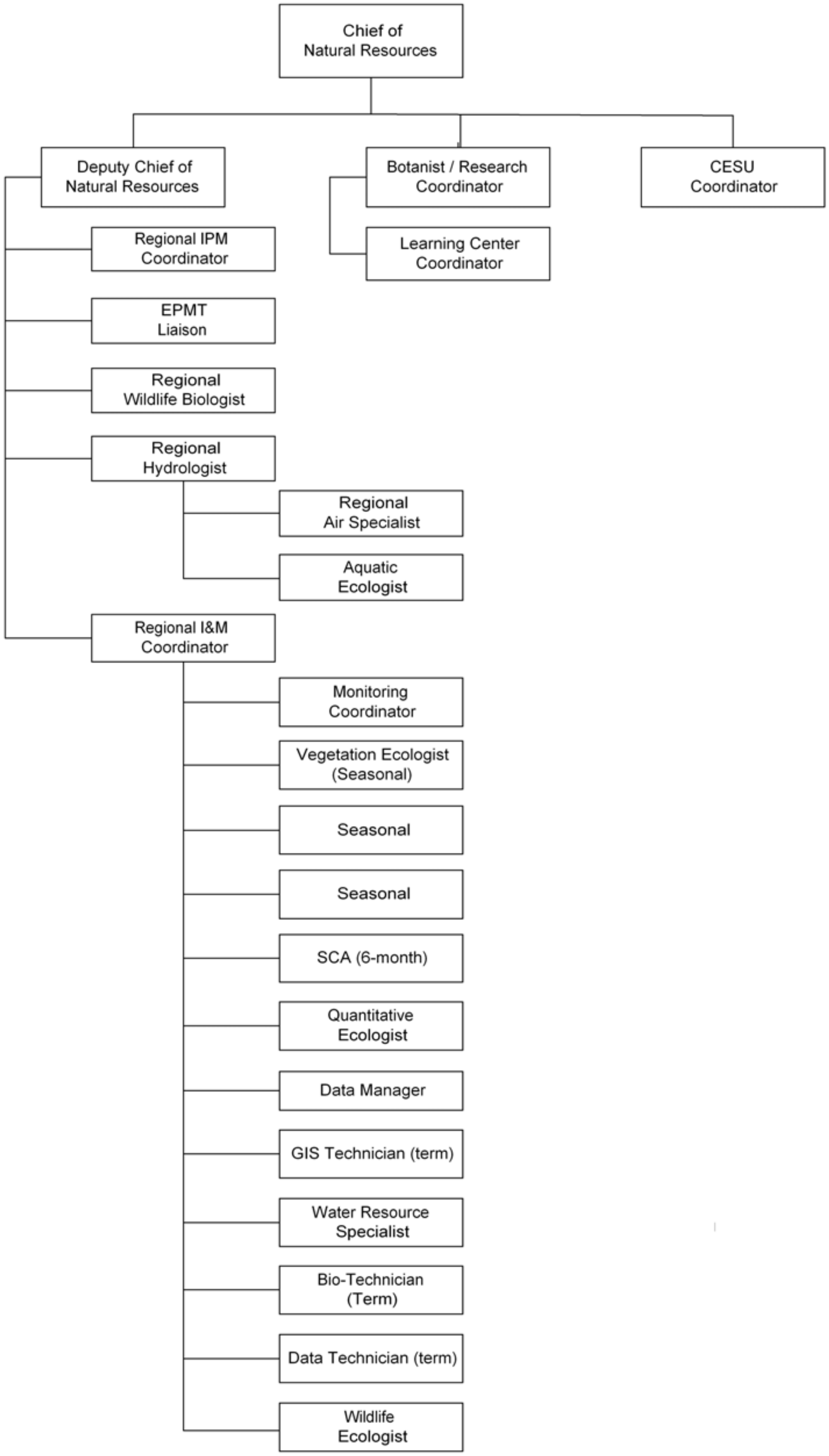


FIGURE 8-2: ORGANIZATIONAL CHART FOR NPS CENTER FOR URBAN ECOLOGY

Quantitative Ecologist (GS-12)—The ecologist develops portions of the monitoring plan relating to the overall sampling design. The ecologist coordinates sampling strategy with principal investigators developing monitoring protocols. In addition, the position is responsible for coordinating QA/QC with the data manager and data analysis with investigators.

Data Manager (GS-9/11)—The data manager is responsible for the development, management, coordination, and implementation of natural resource information systems, including databases, data archives, and Geographic Information System (GIS). Responsibilities include creating new databases consistent with NPS standards, quality assurance/quality control (QA/QC) for new data, and generating metadata that is Federal Geographic Data Committee (FGDC) compliant. This position also provides training to park data managers, organizes the certification of inventory data sets, makes data accessible to parks by summarizing data and generating standard reports as identified by protocols, and shares data through the internet or other media. Additional details of the responsibilities of the data manager are presented in the data management plan (Sanders et al. 2004). Supervises data technicians.

Water Resources Specialist (GS 9/11)—The specialist implements the portions of the monitoring plan dealing with aquatic resources. The specialist collects and analyzes water data following standard protocols, develops investigator annual reports and other reports as needed. The position is also in charge of data entry (NPStoret), coordinates QA/QC with data manager, and archives data.

8.2.4 Term Staff

Wildlife Ecologist (GS-7/9) – Term 1-4 years—This position assists regional wildlife biologist to implement field surveys year-round. Spring focus is on monitoring herps; summer focus is on monitoring birds; fall focuses on monitoring deer populations; winter focuses on data management and preparing for next field season. The position will be re-evaluated after the first four years.

GIS Technician (GS-7/9) – Term 1-4 years—The GIS technician provides general support to all aspects of the monitoring program especially to data management. Duties include data entry, quality assurance/quality control, GIS support. The focus is on entering legacy data. As time permits, the technician also supports writing newsletters, editing, maintaining web pages, and gives presentations.

Water Resources Bio – Technician (GS-7)—One bio-technician will work with the Water Resources Specialist to collect field data. Other responsibilities include data entry and lab analyses.

Water Lab Technicians (Water Specialist) (GS-7)—One bio-technician will work with the Water Resources Specialist to analyze water samples in the lab. Once protocols are well established it is expected that lab analysis can be conducted by the Water Resources Bio-Technician. It is expected that this position will end after four years.

8.2.5 Seasonal I&M Staff

Vegetation Ecologist (GS-9)—The seasonal ecologist leads field crews. Position will be May – September. The ecologist will also train seasonal field crews and act as lead on rare species monitoring and early detection of pest species.

Bio-Technicians (Botanist) (GS-5)—Up to two seasonal technicians work with vegetation ecologist to collect field data. May – August.

Student Conservation Association Volunteers—At least one seasonal technician will work with vegetation ecologist to collect field data. Additional SCAs may be hired to support data management as needed and as funds allow.

8.2.6 Regional Support Staff

The I&M program depends on support from the National Capital Region.

Administrative Technician—The assistant supports the I&M program administrative needs associated with payroll, travel, purchases, staff training, and hiring. The position is maintained by the region.

Air Resources Specialist—Coordinates data collection with ongoing regional air monitoring including NADP, IMPROVE, and CastNet. This position analyzes data and reports findings to the I&M program as well as assisting with the development of air vital sign protocol descriptions and contributing towards the air section of the monitoring plan.

Aquatic Ecologist—The NCR Aquatic Ecologist is shared with the Northeast Region. The ecologist provides technical and analytical support to I&M Water Monitoring Coordinator.

Chief of Natural Resources—The chief directs the operations of the Center for Urban Ecology including the I&M staff. In addition, the chief provides supervision along with technical and administrative guidance.

Cooperative Ecosystem Studies Unit (CESU) Coordinator—The coordinator acts as a liaison between I&M and CESU scientists. The position plays a critical role in identifying principal investigators, developing scopes of work, and implanting agreements.

Geographic Information Specialist—This is a regional position housed at the National Capital Region Headquarters building. This position supports data management needs relating to geographic information data sets, including the storage and archiving of park data.

Information Technology Specialist—This is a position shared with two parks, George Washington Memorial Parkway and Rock Creek Park. This person maintains computer software and hardware including system network infrastructure, supports IT purchases and software updates.

Research Coordinator—The regional research coordinator provides assistance is establishing agreements with principal investigators. In addition, the regional coordinator provides technical support on research project identification and implementation.

Urban Alliance Learning Center Education Coordinator—The Center for Urban Ecology hosts the region's learning center staff. The learning center is designed to provide a link between science and park interpretation and education efforts. I&M will work closely with this key position to identify appropriate interpretation and education outreach products.

Wildlife Biologist—The regional wildlife biologist guides the deer monitoring protocol development and implementation. The position also advises on additional wildlife monitoring needs. The wildlife biologist will also provide oversight to deer data collection, data analysis, and reporting.

8.2.7 Park Staff

Given staffing restraints, park support is extremely limited. Park staff including resource managers and bio-technicians, however, play a critical role in implementing the I&M program. Each park will be responsible for the following tasks:

Issue Park Permits—Along with issuing permits, parks are responsible for handling compliance issues.

Review and Approve Investigator Annual Reports (IAR)—Parks are responsible for reviewing IARs submitted by the I&M program or by cooperators working for the I&M program.

Park Access—Parks will be responsible for ensuring that sampling sites can be accessed.

Park Housing—For parks that have housing available, parks are responsible for making housing available to field crews as needed. Parks that have limited housing include: Antietam National Battlefield, Catoctin Mountain Park, Chesapeake and Ohio Canal National Historical Park, George Washington Memorial Parkway, Harpers Ferry National Historical Park, Manassas National Battlefield Park, Prince William Forest Park, and Rock Creek Park. Housing is not available at Monocacy National Battlefield, and National Capital Parks-East.

Field Assistance—Parks that are interested and have staff available are encouraged to participate in field work.

8.3 PROJECT IMPLEMENTATION

Each project associated with the NCRN I&M program has an assigned lead. For any contracts, cooperative agreements or inter-agency agreements, the official lead is the Key Official. Some projects may also have a project manager who oversees the day-to-day project oversight but works under the guidance of the key official.

8.3.1 Key Officials

The key official is the Contracting Officer's Representative (COTR) who signs all agreements and is ultimately responsible for the execution and administration of projects that fall under the scope of an agreement. The agreements may include contracts, cooperative agreements, or inter-agency agreements. Detailed guidance and documentation of duties are outlined in Management Concepts, Inc (2002).

8.3.2 Project Manager

The project manager provides day-to-day oversight on any inventory and monitoring project. Project managers can be either network, park, or regional staff. The incumbent coordinates and supervises of all phases of data collection, data entry, verification and validation, as well as data summary, analysis and reporting. They also create the documentation and criteria needed to properly use and interpret the data. As such, this person is the primary point of contact for information about the project. Their active involvement determines the quality of the project and the overall success of our inventory and monitoring program.

Specifically, project manager's role is to:

- Complete project documentation describing the "who, what, where, when, why and how" of a project.
- Coordinate field data collection with parks and principal investigators.
- Maintain concise explanatory documentation of all deviations from standard procedures.
- Ensure documentation of important details of each field data collection period.
- Ensure proper records management including archiving.
- Ensure adherence to protocol procedures including timeline for data collection periods, data processing target dates, and reporting deadlines.
- Produce or collect annual reports and final reports.
- Provide summary reports for outreach communications.
- Coordinate data management and archiving with data manager.
- Oversee periodic trend analysis of data, store the resulting reports, and make them available to users.
- Increase the interpretability and accessibility of existing natural resource information.
- Act as the main point of contact concerning the project.

For most projects the key official and project manager may be the same person. If a specific technical background is needed to manage a project, the key official may assign a project manager. It is however, still the key official's responsibility that the project is appropriately implemented.

8.4 FACILITIES

The core I&M staff is housed at the Center for Urban Ecology. The Center for Urban Ecology also houses the regional natural resource and science staff. The facility provides office space for the I&M staff and storage for field equipment.

The Museum Resource Center provides space for archives and voucher specimens if they are not maintained at other museums or parks. The facility is temperature and humidity controlled and is ideal for long-term storage.

8.5 PARTNERSHIPS

Several partnerships are already in place to accomplish some components of the monitoring program. Protocols, for example, are being developed through partnerships with the Cooperative Ecosystems Studies Unit, USGS Patuxent Wildlife Research Center, and the USDA Forest Service. Data collected for the air vital signs is already being conducted by various agencies including National Oceanic and Atmospheric Administration (NOAA), U.S. Environmental Protection Agency (EPA) through their CASTNet, and NADP programs. Due to the iterative process used in developing the program, we will continue to enlist more partners as our protocol development continues. Potential partnerships may be developed with volunteer organizations including Audubon Chapters or Native Plant Societies.

8.6 IMPLEMENTATION OF VITAL SIGN MONITORING

The vital sign protocols will be implemented by either by I&M staff or through partnerships, cooperative agreements, inter-agency agreements or contracts (table 8-4). In some cases park staff will provide a critical role for implementation.

8.7 PERIODIC PROGRAM AND PROTOCOL REVIEW

We have developed an all-encompassing review process (Table 8-5) to evaluate the myriad facets of the program. On an annual basis, the Annual Administrative Report and Work Plan (AARWP) provides the Science Advisory Committee and Board of Directors with an opportunity to review what has taken place and what is planned. This provides an annual opportunity to review and evaluate the program. What we must ensure is that evaluation takes place at this juncture, and that we do not adopt a mindset of 'business as usual'. This will be particularly important during the next three to five year period as the actual monitoring of vital signs and operation of the program are established.

Our second level of review for the program will take the form of our bi-annual updates to the Science Advisory Committee (SAC). This will be a day-long symposium at which all I&M staff and cooperators conducting any portion of the program will give a technical presentation on results and the status of the work they are conducting. The symposium will include a discussion of the presentations to evaluate the merit of the work scientifically and operationally. The results and decisions from this review will be codified by subsequent presentation to the Board of Directors for their endorsement. The first Report to the SAC will be held in fall 2005, and the next one will be held in fall of 2007 after the first two field seasons of program implementation.

TABLE 8-4: IMPLEMENTATION OF VITAL SIGN MONITORING PROGRAM

Vital Sign Name	Implementation of Data Collection	Implementation of Data Management, Analysis and Reporting
Ozone	Clean Air Status and Trends Network	Air Resource Division, I&M Staff
Wet and Dry Deposition	Environmental Protection Agency	Air Resource Division, I&M Staff
Visibility	National Atmospheric Deposition Program	Air Resource Division, I&M Staff
Mercury Deposition	Mercury Deposition Network	Air Resource Division, I&M Staff
Weather	National Oceanic and Atmospheric Administration	I&M Staff
Shoreline Features	I&M Staff – Data Manager	I&M Staff
Physical Habitat Index	I&M Staff – Water Resources Specialist	I&M Staff
Surface Water Dynamics	I&M Staff – Water Resources Specialist	I&M Staff
Water Chemistry	I&M Staff – Water Resources Specialist	I&M Staff
Nutrient Dynamics	I&M Staff – Water Resources Specialist	I&M Staff
Aquatic Macroinvertebrates	I&M Staff – Water Resources Specialist	I&M Staff
Invasive/Exotic Plants	I&M Staff – Vegetation Ecologist, Park Staff	I&M Staff
Pest Species	I&M Staff – Vegetation Ecologist, Park Staff	I&M Staff
Forest and Grassland Vegetation	I&M Staff – Vegetation Ecologist	I&M Staff
Fish Index of Biological Integrity	I&M Staff – Water Resources Specialist	I&M Staff
Amphibians	I&M Staff – Wildlife Technician, Regional Wildlife Biologist, Park Staff	Regional Wildlife Biologist, I&M Staff
Landbirds	Wildlife Technician, Regional Wildlife Biologist, Park Staff, Volunteer	Regional Wildlife Biologist, I&M Staff
White-tailed Deer	I&M Staff – Wildlife Technician Regional Wildlife Biologist, Park Staff	Regional Wildlife Ecologist, I&M Staff
T&E Species and Communities	I&M Staff – Vegetation Ecologist, Park Staff, Volunteers	I&M Staff
Land Cover / Use	I&M Staff – Data Manager, Regional GIS Specialist	I&M Staff
Landscape Condition	I&M Staff – Data Manager, Regional GIS Specialist	I&M Staff

TABLE 8-5: SUMMARY OF PERIODIC REVIEWS

Review	Timing	Who is Involved	Intent of Review
Annual Administrative Report and Work Plan	Annual	Regional Coordinator, I&M Staff, BOD, NRPC	Provide yearly accountability for program. Report on accomplishments and explain goals and projects for next fiscal year.
Report to Science Advisory Committee	Bi-annual	Regional Coordinator, I&M Staff, BOD, SAC, Park Staff	Provide technical details on results and status of all data collection within program. Evaluate if goals are being met appropriately and if focus of program is consistent with goals. Also evaluate if operations of program are working on concert with other aspects of program.
Five-year Program Review		Regional Coordinator, I&M Staff, Anonymous reviewers, BOD, SAC,	Provide synthesis of data collected by program, evaluate the utility to park management, evaluate administration/operations of program, make recommendations for improvement of all aspects of program.

Finally, our third level of review will be in the form of a 5-year program review. The review will be initiated by the Regional Coordinator and the BOD as indicated in the BOD Charter (appendix C) and will include a series anonymous peer reviews of the protocols along with in-depth discussions of the monitoring program as a whole. The program review shall provide the principal basis for any significant changes in program direction, and any recommendations will be forwarded to the National I&M office.

Peer Review—Each protocol will be reviewed after five years of data are available. The review will be performed by subject matter experts who are not involved in the data collection but who analyze data and make recommendations to protocols, including all aspects of the standard operating procedures. Recommendations will be presented to the I&M staff and the BOD for review.

Program Review— Every five years, the SAC will meet to hear a series of technical presentations from the I&M staff and discuss what we have learned from the data collected and its relevance to park management. Vital signs will be reviewed to make sure that they are still priorities. Data management will be reviewed to ensure that standards continue to be met and are adequate. The annual budgets and staffing plan will be revised if needed. All recommendations will be presented to the Regional Coordinator and the BOD for review.

8.8 INTEGRATION OF PROGRAM WITH PARK OPERATIONS

The NCRN I&M program has made a commitment to implement long-term monitoring, analyze data, and report findings to various audiences in the parks including resource management, park administration, and interpretation. Integrating science into park management, however, is more complex than simply reporting results. The NCRN I&M Program will be working closely with the Center for Urban Ecology to ensure that all science products, including those from the long-term monitoring program, are fully integrated and used by park management. The integration strategy consists of a four-pronged approach that emphasizes: (1) technical assistance, (2) coordination, (3) communication, and (4) data sharing. As part of the five-year review, I&M will analyze how well I&M integration strategy works to meet park needs and how well I&M products have been used by park management.

Technical Assistance—Given the extensive scientific and technical expertise at the Center for Urban Ecology and the I&M program, there are many opportunities to provide technical assistance to the parks.

Technical assistance will be offered to parks in order to help:

1. Identify clear objectives for research, monitoring, or management. Prioritize projects, solicit funding, and implement park projects.

2. Support park planning efforts including development of Resource Stewardship Plans (RSP), General Management Plans (GMP), Fire Management Plans (FMP), and compliance needs.

3. Review data collected in parks and provide support for analysis and reporting results.

Coordination: The inventory and monitoring program will closely coordinate implementation of the monitoring program with parks.

Emphasis will be placed on coordinating field work with resource managers and coordinating and reviewing inventory and monitoring research permits

Communication: Results from the monitoring program must be communicated in a timely manner and must be upheld to the rigorous scientific standards. In order to enhance communication, the I&M program will provide both oral and written communications to a variety of audiences.

1. Oral Communication

    - provide regular updates to NPS staff by attending and participating in Board of Directors (BOD), Natural Resource Advisory Team (NAT), Regional GIS Working Group, Interpretive Management Advisory Group (IMAG), and Center for Urban Ecology (CUE) Staff Meetings.
    - provide updates to park staff through informal meetings.
    - I&M staff members will also be available to attend meetings by other divisions such as Lands, Resources, and Planning or park based staff meetings in order to share results.

2. Written communication

    The I&M program will be generating a variety of reports including Annual reporting including AARWP, State of the Parks report cards. See chapters 6 and 7 for details on reporting and analysis. In addition, the I&M Program has made it a priority to work closely with the Urban Ecology Research Learning Alliance in order to develop outreach and education products such as fact sheets, brochures, or other products in order to promote the results and findings of long-term monitoring.

Data Sharing: Coordinate data sharing through regionally accessible online databases.

Chapter 9

Monitoring Schedule

This chapter describes the schedule for implementing the NCRN Vital Signs Monitoring program. For the protocols under development in the next three to five years (n = 21), we describe the key tasks or issues that must be addressed for each (table 9-1). The NCRN has already been monitoring one vital sign (deer) since 2001. In FY06, the network plans to initiate monitoring of 18 additional vital signs; an annual schedule of the frequency and timing of sampling for these vital signs is shown in table 9-2.

In table 9-1 we describe key issues that must be addressed in establishing protocols for each for the 21 vital signs. For some vital signs this may simply entail some coordination with an entity already collecting data we want (e.g., air quality parameters). For others this will require a more detailed scoping of the vital sign, pilot data collection efforts, and/or determining analysis methods for the data (e.g., forest vegetation).

Table 9-2 depicts the frequency and timing of sampling. While some data will be collected continuously (e.g., climate data), other data will be collected for several weeks at one time of year (e.g., deer surveys). It can also be seen from this table that our field efforts are not entirely weighted to one season but are distributed throughout the calendar year.

TABLE 9-1: SCHEDULE FOR DEVELOPMENT AND COMPLETION OF VITAL SIGN PROTOCOLS FOR NCRN

Vital Sign Name	Target Year for Protocol Completion and Implementation	Key Issue to be Addressed Before Implementation
Ozone	FY 2006	Data collection is being conducted through Clean Air Status and Trends Network (CASTNet). The protocol outlining data management, analysis, and reporting is being developed by the Air Resource Division.
Wet Deposition	FY 2006	Data collection is being conducted through National Atmospheric Deposition Program (NADP). The protocol outlining data management, analysis, and reporting is being developed by the Air Resource Division.
Visibility	FY 2006	Data collection is being conducted through Interagency Monitoring of Protected Visual Environments (IMPROVE). The protocol outlining data management, analysis, and reporting is being developed by the Air Resource Division.
Mercury Deposition	FY 2006	Data collection is being conducted through the Mercury Deposition Network (MDN). A draft protocol outlining data management, analysis, and reporting has been developed by Regional Air Specialist. I&M Staff will complete the protocol.
Weather	FY 2007	Data collection is being coordinated by National Oceanic and Air Administration (NOAA). A draft protocol outlining data management, analysis, and reporting has been developed by Regional Air Specialist. I&M Staff will complete the protocol with assistance from the Natural Resources Program Center.
Shoreline Features	FY 2006	The remote sensing protocol and analysis is being developed by UMCES. Expected completion in FY 2005.
Physical Habitat Index	FY 2006	Protocols are being developed through the Cooperative Ecosystems Studies Unit. Expected completion by end FY 2005.
Surface Water Dynamics	FY 2006	The protocol is being developed by the USGS in coordination with I&M Staff. Sampling design will vary by park. Flow meters will be installed in FY05
Water Chemistry	FY 2006	Protocol completed in FY04. Program will be implemented by I&M Staff.
Nutrient Dynamics	FY 2006	Protocol completed in FY04. Program will be implemented by I&M Staff.
Aquatic Macroinvertebrates	FY 2006	I&M Staff
Invasive / Exotic Plants	FY 2007	The protocol will be developed by I&M staff in coordination with the Exotic Plant Management Team. Once completed, the protocol will be implemented by vegetation field crews.
Pest Species	FY 2007	The protocol will be developed by I&M staff in coordination with Integrated Pest Management Coordinator. Once completed, the protocol will be implemented by vegetation field crews.
Forest Vegetation	FY 2006	Draft protocols were developed by USDA Forest Service in FY 2004. Peer review identified additional data analysis needed before finalizing protocol. Expected completion of protocol in FY 2005.
Fish Index of Biological Integrity	FY 2006	Protocols are being developed through the Cooperative Ecosystems Studies Unit. Expected completion by end FY 2005.
Amphibians	FY 2006	Protocols are being developed by Patuxent Wildlife Research Center. Expected completion by end FY 2005.
Landbirds	FY 2006	The protocol for monitoring forest species is being developed by Patuxent Wildlife Research Center. Expected completion by end FY 05. Need for grassland bird monitoring is being evaluated in FY 2004–2005. If monitoring need is established, protocol will be developed in FY 2006.
White-tailed Deer	FY 2001	Regional Wildlife Ecologist implemented monitoring in FY 2001. Protocols were enhanced to meet standards established by Oakley et al. 2003. Peer review resulted in additional modification that will be implemented in FY 2005.
Rare, threatened, and endangered species	FY 2006	Draft protocol developed by Virginia Polytechnical Institute (VPI) FY 2004–FY 2005. VPI will implement long-term monitoring plots and refine protocol in FY 2005–FY 2006. Protocols will be handed off to I & M staff and parks for monitoring in FY 2007.
Land Cover / Use	FY 2006	Remote sensing protocol and analysis is being developed by UMCES. Expected completion in FY 2005.
Landscape Condition	FY 2006	Remote sensing protocol and analysis is being developed by UMCES. Expected completion in FY 2005.

TABLE 9-2: ANNUAL SCHEDULE OF VITAL SIGN DATA COLLECTION

Vital Sign Name	Sample Type/ Interval	January	February	March	April	May	June	July	August	September	October	November	December
Ozone	Daily	X	X	X	X	X	X	X	X	X	X	X	X
Wet and Dry Deposition	Monthly	X[a]	X	X	X	X	X	X	X	X	X	X	X
Visibility	Daily	X[a]	X	X	X	X	X	X	X	X	X	X	X
Mercury Deposition	TBA												
Weather	Daily	X	X	X	X	X	X	X	X	X	X	X	X
Shoreline Features	TBA												
Physical Habitat Index	Monthly	X	X	X	X	X	X	X	X	X	X	X	X
Surface Water Dynamics	Monthly	X	X	X	X	X	X	X	X	X	X	X	X
Water Chemistry	Monthly	X	X	X	X	X	X	X	X	X	X	X	X
Nutrient Dynamics	Monthly	X[a]	X	X	X	X	X	X	X	X	X	X	X
Aquatic Macroinvertebrates	Spring			X	X	X	X						
Invasive/Exotic Plants	Monthly	X[a]	X	X	X	X	X	X	X	X	X	X	X
Pest Species	Monthly	X[a]	X	X	X	X	X	X	X	X	X	X	X
Forest Vegetation	Summer (species composition; each site sampled once every 3 years)						X	X	X				
	Winter (woody debris)										X	X	X
Fish Index of Biological Integrity	Summer						X	X	X	X			
Amphibians	Spring		X	X	X	X							
Landbirds	Summer						X	X	X				
White-tailed Deer	Fall										X	X	
T&E Species and Communities	Spring-Fall				X	X	X	X	X				
Land Cover / Use	TBD[b]												
Landscape Condition[c]	TBD[b]												

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Glossary

Abiotic — The nonliving physical and chemical aspects of an organism's environment. Abiotic refers to such factors as light, temperature, and topography.

Adaptive management — The 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 implementing management actions explicitly designed to generate information useful for evaluating alternative hypotheses about the system being managed.

Adsorbed — The accumulation of gases, liquids, or solutes on the surface of a solid or liquid.

Airshed — Those areas where significant portions of emissions result in deposition of the various air pollutants to a region. Many types of air pollution are carried by the wind from state to state, and are harmful to people and the environment, even in rural areas.

Attributes — 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 also Vital Sign.

Benthic — Relating to or characteristic of the bottom of a sea, lake, or deep river, or the animals and plants that live there.

Bioaccumulation — The accumulation of a harmful substance, such as a heavy metal or an organochlorine, in a biological organism, especially one that forms part of the food chain.

Biological integrity — 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).

Biota — The combined plant and animal life of a particular region.

Board of Directors (BOD) — The NCRN BOD is consists of a park superintendent or their designee from each of the NCRN parks. Other members include the region's Chief of Natural Resources and I & M Coordinator along with the network's monitoring coordinator. The BOD approves major decisions including the selection of vital signs, annual work plans, and the final monitoring plan.

Cladoceran — Any of an order (Cladocera) of minute chiefly freshwater branchiopod crustaceans that includes the water fleas.

Copepod — Any of a large subclass (Copepoda) of usually minute freshwater and marine crustaceans.

Cultural landscape — The battlefield parks in the NCRN, for example, are managed to maintain a landscape as it was during the time of the respective battles for which the parks were designated. These cultural landscapes establish how the natural resources are managed to some degree.

Cultural resources — Historic artifacts including buildings and landscape features.

Ecological effects — The physical, chemical and biological responses to drivers and stressors.

Ecological indicator — Synonymous with Indicator. See also Vital Sign (see below).

Ecological integration — The process which considers the ecological linkages among system drivers and the components, structures, and functions of ecosystems when selecting monitoring indicators.

Ecological integrity — 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 — A community of living organisms interacting with one another and with their physical environment, such as a forest, pond, or estuary.

Ecosystem drivers — Major external 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 — 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. It is based on the best understanding currently available as to how the ecosystem works. Ecosystem management includes a primary goal to sustain ecosystem structure and function, a recognition that ecosystems are spatially and temporally dynamic, and acceptance of the dictum that ecosystem function depends on ecosystem structure and diversity. The whole-system focus of ecosystem management implies coordinated land-use decisions.

Endemic, endemism — An adjective that describes species that occur only in a limited number of places. For example, the Maryland Terrapin is endemic to the Chesapeake Bay, because it is only found in this one region of the world.

Eurythermal — Tolerating a wide range of temperature.

Eutrophication — The process by which lakes and streams are enriched by nutrients and the resulting increase in plant and algae. The extent to which this process has occurred is reflected in a lake's trophic classification:

Eutrophic — Very productive and fertile.

Evapotranspiration — Loss of water from the soil both by evaporation and by transpiration from the plants growing thereon.

Exotic Species — A recently introduced species, or a species that is living in a location that is outside of its 'normal' or historical range.

Extirpation — A process or condition in which a population has gone extinct from a particular patch of suitable habitat, or has been driven away from a region. In order for such a region to support another population, it must be recolonized.

Focal resources — 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 suitability as an ecological indicator. 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.

Forms — Sub-categories within each ecosystem. Marine forms include ocean, sandy beach, rocky intertidal, bay/estuary; aquatic/wetland forms include running water, standing water, and ground water and apply to both freshwater and saltwater wetlands; and terrestrial forms include grassland, shrubland, woodland, and distinct landforms (e.g., serpentine).

Fragmentation — The process whereby a large patch of habitat is broken into many smaller patches of habitat, resulting in a loss in the amount and quality of habitat.

Habitat — Areas that meet the environmental requirements of a species.

Geospatial — A term used to describe a class of data that has a geographic or spatial nature.

Geosphere — The solid part of the earth.

Habitat — The location and the combination of biotic and abiotic surroundings that a particular kind or type of plant or animal occupies for part of its life cycle. It typically includes the substrate (soil, rocks, water), other nonliving features, vegetation, and often, other organisms.

Hydrosphere — The aqueous envelope of the earth including bodies of water and aqueous vapor in the atmosphere.

Indicators — 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.

Inventories — Extensive point-in-time efforts to determine location or condition of a resource, including the presence, class, distribution, and status of plants, animals, and abiotic components such as water, soils, landforms, and climate. Inventories contribute to an assessment of park resources, which is best described in relation to a standard condition such as the natural or unimpaired state. Inventories may involve both the compilation of existing information and the acquisition of new information. They may be relative to either a particular point in space (synoptic) or time (temporal).

Karst — An irregular limestone region with sinks, underground streams, and caverns.

Macroinvertebrates — Aquatic invertebrate organisms that can be seen clearly with the naked eye.

Measure — The specific feature(s) used to quantify an indicator, as specified in a sampling protocol.

Mesoscale — Of intermediate size; especially : of or relating to a meteorological phenomenon approximately 10 to 1000 kilometers in horizontal extent.

Monitoring — Differs from inventory in that it adds the dimension of time. The general purpose of monitoring is to assess status and to detect changes or trends in a resource. Elzinga et al. (1998) defined monitoring as "The collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a management objective". Natural resource monitoring is conducted primarily for two purposes: (1) to detect significant changes in resource abundance, condition, population structure, or ecological processes; or (2) to evaluate the effects of some management action on population or community dynamics or ecological processes. Detection of a change or trend may trigger a management action, or it may generate a new line of inquiry. Monitoring is often done by sampling the same sites over time, and these sites may be a subset of the sites sampled for the initial inventory. 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. The key points in the definition of monitoring are that: (1) the same methods are used to take measurements over time; (2) monitoring is done for a specific purpose, usually to determine progress towards a management objective; and (3) some action will be taken based on the results, even if the action is to maintain the current management.

National Capital Region Network (NCRN) — The NCRN includes 11 parks with significant natural resources including Antietam National Battlefield (ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield (MANA), Monocacy National Battlefield (MONO), National Capital Parks East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap Park for the Performing Arts (WOTR). The NCRN also supports monitoring activities of National Mall and Memorial Parks.

Natural resources — Biotic and abiotic components of the environment. Examples include abiotic components such as soils, water, and geologic features. Biotic examples include vertebrates, invertebrates, vascular, and non-vascular plants.

Networks — A grouping of parks designated to implement the NPS Inventory and Monitoring Program. NPS has designated 32 networks that have been phased in over a five-year period starting in 2000. Each network has permanent staff, including a monitoring coordinator and a data manager who lead the development and implementation phase of the program.

Phenology — Periodic biological phenomena (as of a kind of organism) that are correlated with climatic conditions.

Physiographic — Refering to the character and distribution of landforms.

Piscivorous — Mammals and birds that feed frequently or mainly on fish.

Programmatic integration — The coordination 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.

Research — Is generally defined as the systematic collection of data that produces new knowledge or information on relationships and usually involves an experimental approach, in which a hypothesis concerning the probable cause of an observation is tested in situations with and without the specified cause. Research has the objective of understanding ecological processes and, in some cases, determining the cause of changes observed by monitoring, This information is needed to determine the appropriate management response to threats. In general, monitoring is the tool used to identify whether or not a change occurred and research is the tool to determine what caused the change. While it is often hoped that ecological monitoring can help to explain complex relationships in ecological systems, such understanding often requires a more focused research investment. The design of sampling protocols for various types of park resources at different locations and spatial scales requires a research effort, and is incorporated into the NPS approach for planning and designing long-term monitoring of park resources.

Resource realms — Include four major categories— biosphere, hydrosphere, atmosphere, and lithosphere. These realms were used to conceptualize broad categories of interrelated ecosystem processes and components.

Riparian — Vegetation found along waterways and shorelines that is adapted to moist growing conditions and occasional flooding.

Science Advisory Committee (SAC) — The NCRN SAC is composed of natural resource staff from the parks and the region. Other federal agencies are also represented including USGS and EPA. Subject matter experts have been invited to participate when their expertise was desired to identify appropriate vital signs. The SAC was actively involved in the development of conceptual models and the selection of vital signs.

Sculpin — Any of a family (Cottidae) of spiny large-headed broad-mouthed often scaleless bony fishes.

Socio-political forces — The laws, mandates, economic pressures and environmental perceptions influencing political decisions that bear upon anthropogenic stressors, and thereby, have a cascading effect on ecosystem function. These can include environmental laws (ESA, CWA, etc.), budgets, and changing social values.

Sources — Sources of stress are the causes of the degradation of important resources. Stresses may have multiple sources (for example, nutrient loading resulting from residential/commercial/office development, wastewater treatment and agricultural practices), and a source often causes multiple stresses (for example, park facilities/operations/maintenance/use leading to habitat fragmentation, sedimentation and toxins/contaminants).

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., NPS or other national and regional programs).

Species — A group of individual plants or animals (including subspecies and populations) that have common characteristics and interbreed among themselves and not with other similar groups.

Stressors — 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 of natural systems. Examples include water withdrawal, pesticide use, timber harvesting, traffic emissions, stream acidification, trampling, poaching, land-use change, and air pollution. Anthropogenic stressors are those perturbations to a system that directly result from human activity. The monitoring of stressors and their effects, where known, will ensure short-term relevance of the monitoring program and provide information useful to resource management.

Stenothermal — Capable of surviving over only a narrow range of temperatures.

Substrate — The nonliving material or base upon which plants or animals live or grow.

Taxon (plural taxa) — Category of organisms. Any of the groups to which organisms are assigned according to the principles of taxonomy, including species, genus, family, order, class, and phylum.

Temporal integration — The establishment of linkages between measurements made at various temporal scales. It requires nesting the more frequent and, often, more intensive sampling within the context of less frequent sampling.

Threats — Combined stressor and source.

Trophic — Relating to processes of energy and nutrient transfer from one or more organisms to others in an ecosystem.

Trophic levels — The various positions of a food web that are occupied by specific organisms, from the lowest-level organisms, such as phytoplankton, to top predators, such as amphibians or fish.

Umbrella species — Are typically large-bodied, wide-ranging species that require large patches of habitat and corridors connecting these patches to maintain viable populations. By protecting areas large enough to maintain these species, sufficient habitat can also be maintained to ensure the viability of most other species in that area.

Viewshed — A physiographic area composed of land, water, biotic, and cultural elements which may be viewed and mapped from one or more viewpoints and which has inherent scenic qualities and/or aesthetic values as determined by those who view it.

Vital signs — Refers to the subset of indicators chosen a by park or park network as part of the National Park Service Vital Signs Monitoring Program. They 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, 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).

Watershed — The area drained by a river system. It includes the whole region or extent of country that contributes to the supply of a river or lake; the natural boundary of a basin.

Wetland — Areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, wet meadows, and similar areas.

Appendix A

Summary of Legislation, National Park Service Policy and Guidance Relevant to Development and Implementation of Natural Resources Monitoring in National Parks

PUBLIC LAWS*	
National Park Service Organic Act (16 USC 1 et seq. [1988], Aug. 25, 1916)	The *National Park Service Organic Act* (1916) is the core of park service authority and the definitive statement of the purposes of the parks and of the National Park Service mission. The Act establishes the purpose of national parks: "…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."
Migratory Bird Treat Act of 1918 (16 USCS 703)	The *Migratory Bird Treat Act* of 1918 provides that it is unlawful to pursue, hunt, take, capture or kill; attempt to take, capture or kill; possess, offer to or sell, barter, purchase, deliver or cause to be shipped, exported, imported, transported, carried or received any migratory bird, part, nest, egg or product, manufactured or not.
Wilderness Act of 1964 (16 USC 1131 et seq.)	The *Wilderness Act of 1964* establishes the National Wilderness Preservation System. In this Act, wilderness is defined by its lack of noticeable human modification or presence; it is a place where the landscape is affected primarily by the forces of nature and where humans are visitors who do not remain. Wilderness Areas are designated by congress and are composed of existing federal lands that have retained a wilderness character and meet the criteria found in the Act. Federal officials are required to manage Wilderness Areas in a manner conducive to retention of their wilderness character and must consider the effect upon wilderness attributes from management activities on adjacent lands.
National Historic Preservation Act of 1966, as amended (16 USC 470 et seq.)	Congressional policy set forth in *National Historic Preservation Act* (NHPA) includes preserving 'the historical and cultural foundations of the Nation' and preserving irreplaceable examples important to our national heritage to maintain 'cultural, educational, aesthetic, inspirational, economic, and energy benefits.' NHPA also established the National Register of Historic Places composed of 'districts, sites, buildings, structures, and objects significant in American history, architecture, archeology, engineering, and culture.' NHPA requires federal agencies take into account the effects of their actions on properties eligible for or included in the National Register of Historic Places and to coordinate such actions with the State Historic Preservation Offices.

PUBLIC LAWS*	
National Environmental Policy Act of 1969 (42 USC 4321-4370)	The purposes of the *National Environmental Policy Act of 1969* (NEPA) include encouraging 'harmony between [humans] and their environment and promote efforts which will prevent or eliminate damage to the environment… and stimulate the health and welfare of [humanity].' NEPA requires a systematic analysis of major federal actions that includes a consideration of all reasonable alternatives as well as an analysis of short-term and long-term, irretrievable, irreversible, and unavoidable impacts. Within NEPA the environment includes natural, historical, cultural, and human dimensions. Within the National Park Service (NPS) emphasis is on minimizing negative impacts and preventing "impairment" of park resources as described and interpreted in the *NPS Organic Act*. The results of evaluations conducted under NEPA are presented to the public, federal agencies, and public officials in document format (e.g., Environmental Assessments and Environmental Impact Statements) for consideration prior to taking official action or making official decisions.
Environmental Quality Improvement Act of 1970 (42 USC 56 § 4371)	This Act directs all federal agencies, whose activities may affect the environment, to implement policies established under existing law to protect the environment.
General Authorities Act of 1970 (16 USC 1a-1—1a-8 (1988), 84 Stat. 825, Pub. L. 91-383	The *General Authorities Act* amends the *NPS Organic Act* to unite individual parks into the 'National Park System.' The Act states that areas of the National Park System, "though distinct in character, are united through their inter-related purposes and resources into one national park system as cumulative expressions of a single national heritage; that individually and collectively, these areas derive increased national dignity and recognition of their superb environmental quality through their inclusion jointly with each other in one national park system preserved and managed for the benefit and inspiration of all the people of the United States…"
Coastal Zone Management Act of 1972 (16 USC 33 § 1452)	"Congress finds and declares that it is the national policy - to preserve, protect, develop, and where possible, to restore or enhance, the resources of the Nation's coastal zone for this and succeeding generations."
Clean Water Act 1972 (33 USC 1251-1376)	The *Clean Water Act*, passed in 1972 as amendments to the *Federal Water Pollution Control Act*, and significantly amended in 1977 and 1987, was designed to restore and maintain the integrity of the nation's water. It furthers the objectives of restoring and maintaining the chemical, physical and biological integrity of the nation's waters and of eliminating the discharge of pollutants into navigable waters by 1985; establishes effluent limitation for new and existing industrial discharge into U.S. waters; authorizes states to substitute their own water quality management plans developed under sec. 208 of the Act for federal controls; provides an enforcement procedure for water pollution abatement; requires conformance to permit required under sec. 404 for actions that may result in discharge of dredged or fill material into a tributary to, wetland, or associated water source for a navigable river.

PUBLIC LAWS*	
Endangered Species Act of 1973, as amended (16 USC 1531-1544)	The purposes of the *Endangered Species Act of 1973* (ESA) include providing "a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved. According to the ESA 'all federal departments and agencies shall seek to conserve endangered species and threatened species ' and '[e]ach federal agency shall…insure that any action authorized, funded, or carried out by such agency…is not likely to jeopardize the continued existence of any endangered species or threatened species." The USFWS (non-marine species) and the National Marine Fisheries Service (NMFS) (marine species, including anadromous fish and marine mammals) administers the ESA. The effects of any agency action that may affect endangered, threatened, or proposed species must be evaluated in consultation with either the United States Fish and Wildlife Service (USFWS) or NMFS, as appropriate.
Forest and Rangeland Renewable Resources Planning Act of 1974 (16 USC 36 § 1642)	Mandates that the Secretary of Agriculture inventory and monitor renewable natural resources in National Forests, and has been cited as congressional authorization for the inventory and monitoring of natural resources on all federal lands. While this is not specifically directed in the Act it is perhaps indicative of a national will to account for and manage the nations natural heritage in manner that sustains these resources in perpetuity.
National Parks and Recreation Act of 1978	"Congress declares that…these areas, though distinct in character, are united…into one National Park System… The authorization of activities shall be construed and the protection, management, and administration of these areas shall be conducted in light of their 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, except as may have been or shall be directed and specifically provided by Congress."
Redwood National Park Act (16 USC 79a-79q (1988), 82 Stat. 931, Pub. L. 90-545	This Act includes both park-specific and system-wide provisions. This Act reasserts system-wide protection standards for the National Park System. This Act qualifies the provision that park protection and management "shall not be exercised in derogation of the values and purposes for which these areas have been established" by adding "except as may have been or shall be directed and specifically provided for by Congress." Thus, specific provisions in a park's enabling legislation allow park managers to permit activities such as hunting and grazing.

PUBLIC LAWS*	
Clean Air Act (42 USC 7401-7671q, as amended in 1990)	The *Clean Air Act* establishes a nationwide program for the prevention and control of air pollution and establishes National Ambient Air Quality Standards. Under the Prevention of Significant Deterioration provisions, the Act requires federal officials responsible for the management of Class I Areas (national parks and wilderness areas) to protect the air quality related values of each area and to consult with permitting authorities regarding possible adverse impacts from new or modified emitting facilities. The Act establishes specific programs that provide special protection for air resources and air quality related values associated with NPS units. The Environmental Protection Agency (EPA) has been charged with implementing this Act.
Federal Advisory Committee Act	This Act creates a formal process for federal agencies to seek advice and assistance from citizens. Any council, panel, conference, task force or similar group used by federal officials to obtain consensus advice or recommendations on issues or policies fall under the purview of the *Federal Advisory Act* (FACA).
Government Performance and Results Act 1997	This Act requires the NPS to set goals (strategic and annual performance plans) and report results (annual performance reports). The NPS *Strategic Plan* contains four *Government Performance and Results Act* (GPRA) goal categories: park resources, park visitors, external partnership programs, and organizational effectiveness. In 1997, the NPS published its first GPRA-style strategic plan, focused on measurable outcomes or quantifiable results.
National Parks Omnibus Management Act, 1998 (P.L. 105-391)	The *National Parks Omnibus Management Act* (NPOMA) requires the Secretary of Interior to continually improve NPS' ability to provide state-of-the-art management, protection, and interpretation of and research on NPS resources. The secretary shall assure the full and proper utilization of the results of scientific study for park management decisions. In each case where an NPS action may cause a significant adverse effect on a park resource, the administrative record shall reflect the manner in which unit resource studies have been considered. The trend in NPS resource conditions shall be a significant factor in superintendent's annual performance evaluations. Section 5939 of NPOMA states that the purpose of this legislation is to: (1) More effectively achieve the mission of the National Park Service; (2) Enhance management and protection of national park resources by providing clear authority and direction for the conduct of scientific study in the National Park System and to use the information gathered for management purposes; (3) Ensure appropriate documentation of resource conditions in the National Park System; (4) Encourage others to use the National Park System for study to the benefit of park management as well as broader scientific value, and (5) Encourage the publication and dissemination of information derived from studies in the National Park System.

NPS POLICIES AND GUIDANCE	
NPS Management Policies – 2001 (NPS Directives System)	This is the basic NPS servicewide policy document. It is the highest of three levels of guidance documents in the NPS Directives System. The Directives System is designed to provide NPS management and staff with clear and continuously updated information on NPS policy and required and/or recommended actions, as well as any other information that will help them manage parks and programs effectively.
NPS Directors Orders	NPS Directors Orders comprise the second level of the NPS Directives System. Directors Orders serve a vehicle to clarify or supplement *NPS Management Policies 2001* to meet the needs of NPS managers. Relevant Directors Orders: DO-2.1 "Resource Management Planning" DO-12 "Environmental Impact Assessment" DO-14 "Resource Damage Assessment & Restoration" DO-24 "Museum Collections Management" DO-41 "Wilderness Preservation & Management" DO-47 "Sound Preservation & Noise Management" DO-77 "Natural Resource Protection"
NPS Handbooks and Reference Manuals	This is the third tier in the NPS Directives System. These documents are issued by Associate Directors. These documents provide NPS field employees with a compilation of legal references, operating policies, standards, procedures, general information, recommendations and examples to assist them in carrying out *Management Policies* and Director's Orders. Level 3 documents may not impose any new servicewide requirements unless the Director has specifically authorized them to do so. Relevant Handbooks and Reference Manuals: NPS-75 Natural Resources Inventory and Monitoring NPS-77 Natural Resources Management Guidelines NPS Guide to Fed. Advisory Committee Act Website: Monitoring Natural Resources in our National Parks, http://www.nature.nps.gov/im/monitor

* Additional information about resource laws can be found at: http://laws.fws.gov/lawsdigest/reslaws.html (available online: 21 September 2004).

Appendix B

Summary of the National Capital Region Network Seven-Step Planning Process

This appendix describes how the NCRN implemented the seven-step planning process recommended by Fancy (2000). See also table 1.

Step 1: Form a Board of Directors and Science Advisory Committee—In order to ensure that parks and their staff were fully involved in the planning process and that resource management needs were properly addressed, a Board of Directors (BOD) and a Science Advisory Committee (SAC) were established at the onset of the program. Park representatives on the BOD and SAC helped summarize legal mandates and societal pressures exerted on the parks as well as an understanding of park natural resources. Scientists invited to the SAC meetings would represent additional knowledge about ecosystem function (Harwell et al. 1999).

The NCRN BOD is composed of 12 superintendents (or designee - assistant superintendent or natural resource manager), the regional I&M coordinator, the monitoring coordinator, and the chief of natural resources and science. The role of the BOD is to oversee the planning process; approve major decisions (including the formation of the SAC); adopt monitoring goals and network objectives; approve an annual administrative work plan and report, the monitoring plan, staffing, and budget. A charter was developed to outline procedural matters for the BOD (appendix C). The BOD meets twice per year.

The SAC was established by the BOD to assist with the planning process. The SAC was composed of 27 participants including one resource manager from each park, regional NPS staff (botanist, wildlife biologist, exotic plant management team coordinator, integrated pest management coordinator, chief of natural resources and science, the region's hydrologist and air specialist), I&M staff (regional I&M coordinator, monitoring coordinator, biological inventories coordinator, data manager, biological science technicians), and scientists from partnering agencies (USGS and EPA). Additionally, 27 ad-hoc participants were invited to some SAC meetings to provide technical expertise including representatives from USGS, Smithsonian Museum of Natural History, The Nature Conservancy, Department of Defense, Maryland Department of Natural History, District of Columbia Council of Governments, and three universities including George Mason University, Georgetown University, and University of Maryland.

The SAC met regularly and was charged with developing conceptual models of key resources in the NCRN parks. Early in the planning stage, eight broadly defined resources were identified in the NCRN. SAC participants were divided into subject specific workgroups:

- Air Resources
- Geology
- Invertebrates
- Landscape
- Rare, Threatened and Endangered Species
- Vegetation Communities
- Water Resources
- Wildlife

Each workgroup developed draft conceptual models that noted resource components, their stressors and ecological responses.

Step 2: Summarize existing data and current understanding—An extensive effort was undertaken to synthesize and summarize existing information about the parks and region. The summaries provided background information to SAC and Monitoring Workshop Participants (see Step 3) who were not familiar with all of the parks.

- *Park Summaries*—Park-specific descriptions (see appendix D) highlight key natural resources, enabling legislation, current and past monitoring efforts, and management priorities. The summaries were generated by reviewing the most recent resource management plans, general management plans, project management information system statements, and investigator annual reports for each park. I&M staff also conducted intensive interviews with each park to identify current critical natural resources, management issues, threats, and monitoring needs. The information was synthesized in table format to provide an overview of issues important among the parks. Supplemental information was summarized for aquatic and geological resources in each park. Air resources were summarized by the air resources division for each park (see appendices G and H).

- *Regional Monitoring Efforts*—Internet searches and follow-up interviews were conducted with scientists and partner agencies to develop a comprehensive understanding of all ongoing monitoring programs in the region covering both biotic and abiotic resources (appendix I). The effort identified a wide variety of monitoring programs. Many are localized, such as those implemented by volunteers (e.g., District of Columbia Audubon), and some are part of national efforts (e.g., USGS Breeding Bird Survey, Amphibian Research and Monitoring Initiative). In addition, there are statewide ecosystem health monitoring efforts such as the Maryland Biological Stream Survey (MBSS) (Wolf et al. 1998) and regional efforts such as those conducted by the EPA Mid-Atlantic Integrated Assessment (EPA 2002a) or the U.S. Forest Service's Forest Inventory Analysis (USDA 2002).

- *Literature Review*—Through the effort associated with the biological inventories, the I&M program located more than 3,000 articles and documents relating to the natural resources in the NCRN. These are being entered into the standard online databases including NPSpecies and NPBib. The literature also provides background information on monitoring efforts and identifies existing protocols. Data relating to important vegetation communities were identified by Natural Heritage programs and rare, threatened and endangered species and communities were identified by park personnel, heritage programs, and regional experts.

Step 3: Hold monitoring workshop—The NCRN Monitoring Workshop: Planning for the Future was held July 9–11, 2002 at the U.S. Fish and Wildlife Service's National Conservation Training Center in Shepherdstown, West Virginia (Koenen et al. 2002). The workshop was designed to provide a forum to exchange technical ideas on what should be monitored in the NCRN and how the program could be implemented. It was also designed to foster partnerships among NPS divisions and between regional conservation groups and agencies to enhance and protect the region's most valuable natural resources.

Approximately 100 participants attended the monitoring workshop. Almost half represented the NCRN parks, including park resource managers, rangers, assistant superintendents, superintendents, and regional Natural Resources and Science staff. NPS scientists from Air Resource Division, Water Resource Division, Geology Resource Division, Natural Resource Information Division, and a prototype park also participated. Additional participants represented over 20 organizations and partnering agencies including universities, The Nature Conservancy, NatureServe, USGS, EPA, Department of Defense, U.S. Department of Agriculture Forest Service, and the Smithsonian Institution.

At the workshop, drafts of conceptual models developed by the SAC (appendix F) were presented to a larger workgroup, which expanded and refined the models to include as many potential ideas as possible. The revised models are presented in a spreadsheet format in Koenen et al. (2002). Participants were asked to identify potential vital signs that met rigorous scientific criteria such as those laid out by Dale and Beyeler (2001), Fancy (2002), and the National Research Council (2002):

- are sensitive enough to provide an early warning of change
- have low natural variability
- can be accurately and precisely estimated
- have costs of measurement that are not prohibitive
- have monitoring results that can be interpreted and explained
- are low impact to measure

- have measurable results that are repeatable with different personnel

In addition, each workgroup reviewed the models and prioritized vital signs based on (1) criteria relevant to the most park units; (2) significant threats, and (3) feasibility and cost effectiveness (appendix J). As a result of the prioritization process, 51 vital signs were identified including the highest priorities from each workgroup.

Step 4: Write a workshop report and have it reviewed—A detailed report summarizing the results of the monitoring workshop was completed and circulated among participants and other interested parties for feedback (Koenen et al. 2002).

Step 5: Decide on priorities and implementation approaches—Upon receiving feedback on the Monitoring Workshop Report, the NCRN I&M staff and SAC committee met to discuss priorities among monitoring goals and objectives. The staff devised various ways to further prioritize the 51 vital signs. One prioritization attempt included various criteria and point values that would be assigned by reviewers. Criteria focused on ecosystem function (e.g., is the vital sign sensitive enough to provide an early warning of change?), implementation (e.g., Does the vital sign has measurable results that are repeatable with different personnel?) or resource (e.g., Does the vital sign convey information meaningful to park decision making?) (see table 2). Although the criteria were proposed to the SAC, there was no consensus on which questions should be included and how to assign point values that would weigh some questions as more important than others. This process was abandoned because reviewers would not be able to rank each vital sign objectively. It was obvious that people with different knowledge and experience would be able to rank some vital signs but not others.

Further review of the 51 vital signs demonstrated that many could be combined because they were either very similar or could be addressed by the same monitoring protocol. For example, satellite imagery could be used to address the needs of more than five vital signs. The analysis resulted in a synthesis of 21 vital signs for which protocols could be developed.

Step 6: Draft a monitoring strategy—Draft chapters of the monitoring plan are scheduled for completion as follows:

> Phase I Report (completed October 1, 2002) included chapters 1 and 2, which focused on the region's important resources, the planning process, and conceptual models. This report was reviewed by the Washington Support Office Natural Resource Information Division, which oversees implementation of the I&M program servicewide. Appendix R includes the Phase 1 review comments and responses.
>
> Phase II Report (completed October 1, 2003) included revisions of chapters 1 and 2 along with chapter 3, which discussed the selection of vital signs. This report was reviewed by the Washington Support Office Natural Resource Information Division and scientists external to the NPS. Appendix S includes Phase II review comments and responses.
>
> Phase III Report (completed December 1, 2004) included revisions of previous chapters, an executive summary, monitoring protocols with content following Oakley et al. (2003), a data management plan with outlines of database structures, field data sheets, a discussion of how data will be analyzed, budgets, staffing needs, and implementation schedule. This report was reviewed by the Washington Support Office Natural Resource Information Division and scientists external to the NPS. Appendix T includes Phase III review comments and responses.

Step 7: Review and approve the monitoring plan—The NPS Natural Resource and Information Division was be responsible for conducting the Phase I and Phase II Report peer reviews and sending the Phase III out to for external peer review. The final Monitoring Plan was completed (October 1, 2005) and approved by the BOD and the NPS Natural Resource and Information Division for final approval.

A periodic review will be scheduled for approximately every 5 years starting in October 1, 2010 to evaluate the entire monitoring strategy. Adaptive management will be implemented as determined by monitoring results.

TABLE 1: STEPS OUTLINING THE PROCESS USED TO IDENTIFY FINAL SET OF VITAL SIGNS PHASE

A.	Establish a Board of Directors (BOD) and Science Advisory Committee (SAC). Synthesize background information by conducting literature review, interviews with resource managers, superintendents, and subject matter experts. Review legal mandates including enabling legislation.	Background material (appendices A and D)
B.	SAC and Subject Matter Experts identify key resources and create eight workgroups (air; geology; invertebrate; landscape; rare, threatened and endangered species [RTE]; vegetation; water; and wildlife).	
Draft Phase I Completed	**(September 31, 2002)**	
C.	Workgroups generate draft conceptual models to identify significant resources, agents of change, and their ecological effects.	Comprehensive list (appendix F)
D.	Peer review of draft models at Monitoring Workshop. Workgroups review and refine prioritization process (consensus or quantitative method); each group identifies 5–10 priority vital signs with monitoring goals and objectives.	First cut (51 vital signs; appendix J)
Draft Phase II Completed	**(31 September 2003)**	
E.	Inventory and Monitoring (I&M) staff reviews vital signs and weighs input from peer reviewers, subject matter experts, and literature. Similar vital signs identified by different workgroups were combined. Conceptual models and vital signs are refined. SAC and BOD approve vital signs.	Second cut (draft vital signs)
F.	Data management plan is developed.	
G.	Eight draft protocols including standard operating procedures (SOPs) are developed.	
Draft Phase III Completed	**(15 December 2004)**	
H.	Peer review conducted by anonymous reviewers including representatives from Air Resource Division, Geological Resource Division, Water Resource Division, USGS, and an academic institution.	
I.	Revisions incorporated.	Third cut (21 vital signs; see chapter 3)
J.	Draft protocols undergo internal review and revision.	
K.	Initiate development of remaining protocols.	
L.	Washington Support Office and BOD Approval.	
Monitoring Plan Completed	**(31 September 2005)**	
M.	Monitoring implemented.	

TABLE 2: CRITERIA CONSIDERED FOR RANKING AMONG ALL VITAL SIGNS

Criteria Related to Ecosystem Function	
Criteria 1	The first criterion was pre-assigned by each workgroup during the July monitoring workshop workgroup. The number was assigned in reverse order from 11 to 1. For example, a vital sign that received the highest priority by a workgroup received an 11 and lowest receives a 1. If there were only 7 vital signs listed by a workgroup, the highest priority was assigned an 11 and lowest received a 5.
Criteria 2	Does the vital sign have dynamics that parallel those of the ecosystem or component of interest (i.e., the indicators are indicative of ecosystem change)? (1 = yes; 0 = no)
Criteria 3	Is the vital sign sensitive enough to provide an early warning of change (e.g., canary in the coal mine)? (1 = yes; 0 = no)
Criteria 4	Does the vital sign provide continuous assessment over a wide range of stress (e.g., a species may have a continuous and stable decline rather than meeting a threshold when it would completely disappear)? (1 = yes; 0 = no)
Criteria 5	The vital sign has low natural variability? (1 = yes; 0 = no)
Criteria 6	The vital sign has dynamics that are easily attributed to either natural cycles or anthropogenic stressors? (1 = yes; 0 = no)
Criteria 7	Does the vital sign respond to stress in a predictable way? (1 = yes; 0 = no)
Criteria Related to Implementation	
Criteria 8	Can the vital sign be accurately and precisely estimated? (1 = yes; 0 = no)
Criteria 9	Is the cost of monitoring the vital sign reasonable (i.e., not prohibitive)? (1 = yes [<50 K]; 0 = no [>50 K])
Criteria 10	Will monitoring the vital sign have a low impact and keep the resource in tact (i.e., will not damage the resource)? (1 = yes; 0 = no)
Criteria 11	Does the vital sign have measurable results that can be repeated by different personnel? (1 = yes; 0 = no)
Criteria Related to Park Management	
Criteria 12	Is the Vital Sign relevant and important to management concern? (5 = relevant to >6 parks; 3 = relevant to 3–5 parks; 1 = relevant to < 2 parks).
Criteria 13	Does the vital sign convey information meaningful to park decision making? (1 = yes; 0 = no)
Criteria 14	Can a management threshold be established? (1 = yes; 0 = no)

Appendix C

Charter for the Board of Directors of the National Capital Region Network

INTRODUCTION

The purpose of this document is to describe the basic practices that will be used to plan, organize, manage, and evaluate the efforts of the National Capital Region Inventory and Monitoring (I&M) Program with respect to the National Park Service Natural Resource Challenge.

The I&M Program is being implemented at eleven parks within the National Capital Network of the National Park Service. The parks are: Antietam National Battlefield (ANTI); Catoctin Mountain Park (CATO); Chesapeake and Ohio National Historical Park (CHOH); George Washington Memorial Parkway (GWMP); Harpers Ferry National Historical Park (HAFE); Manassas National Battlefield (MANA); Monocacy National Battlefield (MONO); National Capital Parks – East (NACE); Prince William Forest Park (PRWI); Rock Creek Park (ROCR); and Wolf Trap Farm Park (WOTR).

RESPONSIBILITIES OF THE BOARD OF DIRECTORS

The major responsibilities of the Board of Directors shall be to:

- Promote accountability and effectiveness for the I&M Program by reviewing progress and quality control for the Network and oversee spending of Network funds.
- Consult with and solicit professional guidance from the Network's I&M Science Advisory Committee (SAC), the Natural Resource Advisory Team (NAT), and other individuals and organizations on the design and implementation of vital signs monitoring related to the Natural Resource Challenge.
- Decide on strategies and procedures to best accomplish the I&M goals.
- Consult on the hiring of personnel with funds provided to the Network through I&M Program funds.
- Seek additional funding to leverage the funds provided through the I&M Program.

MEMBERSHIP

The Board of Directors is comprised of:

1. A superintendent or their designee from each I&M park with one superintendent being appointed as Chairperson.
2. The National Capital Network I&M Coordinator, Monitoring Coordinator, and Chief of Natural Resources and Science.
3. Any member deemed appropriate by the Board.

PROCEDURES

Board Meetings

The Chairperson and the I&M Coordinator will coordinate and prepare a formal agenda for a minimum of two meetings annually. Any member may call for a special meeting of the Board if they determine a need or may request conference calls to deal with specific issues.

Alternates and Quorums

Any park superintendent or their designee who cannot attend or otherwise participate in a meeting of the board may assign an alternate from the park. Eight Board members constitute a quorum.

Decision Making

All decisions will be consistent with the I&M and Natural Resource Challenge requirements and finalized by a majority vote. All decisions will be documented with responsible individuals and deadlines identified, as appropriate. Such decisions will be distributed to all Board members.

Monitoring Plan

A plan that identifies what natural resources will be monitored, where they will be monitored and how they will be monitored shall be prepared by the I&M Coordinator and Monitoring Coordinator in conjunction with the SAC. The plan will be reviewed and approved by the Board before implementation. A final plan will be completed no later than January 2003.

Annual Work Plan

The I&M Coordinator will present a proposed Annual Work Plan to the Board for discussion, modification and approval no later than September 1 of each year. The Annual Work Plan will identify goals to be accomplished, responsible individuals, assigned deadlines, I&M Program budget and funding sources.

Annual Report

The I&M Coordinator will prepare and present an Annual I&M Report to the Board for discussion, modification, and approval. The Annual Report will detail specific accomplishments, issues to be addressed, recommendations, and a cost summary for the program. The Annual Report will be released no later than December 31 of each year.

Five-Year Program Review

At the end of fiscal year 2004, the Board will undertake a comprehensive Program Review. The purpose of this review will be to evaluate accomplishments and products, protocols used for gathering data, data management, fiscal management, and staffing. The Program Review shall provide the principal basis for any significant changes in program direction and any recommendations will be forwarded to the National I&M office.

Funding

Available I&M Program funds will be distributed as directed through the Annual Work Plan. All I&M Program funds must be strictly accounted for using a specific PWE code and disclosed in the Annual Report. Additionally, other funds contributed by parks, other NPS programs and other sources will be carefully tracked and reported.

Staff hired under this program will be supervised and administratively supported through the Natural Resources and Science Program.

SUBGROUPS

The SAC comprised of natural resource managers and scientists, including scientists from outside of the NPS who work in the parks and are familiar with park issues, will be formed to provide technical assistance and advice to the Board. The Board will approve its composition. The I&M Coordinator will chair its meetings and coordinate its efforts. It will be responsible for:

- Identifying existing information sources about park resources.
- Participating in the identification of monitoring objectives and development of the Network Monitoring Plan.
- Assisting in the selection of indicator species, communities, and processes.
- Evaluating initial sampling designs, methods and protocols.
- Reviewing annual data reports and interpretation as well as participating in the preparation of the Annual Work Plan and Annual Report.

The recommendations of the SAC will be presented to the Board for discussion, modification, and approval.

When needed the Board, SAC, I&M Coordinator or Monitoring Coordinator may form groups of specialists to work on a particular task or a particular sub-program area. No such group will be formed without inclusion of a specific “sunset” provision.

COORDINATION

The Board Chairperson will work closely with the I&M Coordinator, Monitoring Coordinator and Chairpersons from the SAC and the NAT to share information on issues needing to be resolved and decisions that have to be made. The I&M Coordinator will be expected to provide regular briefings by memoranda, electronic mail or telephone conference to the Board.

PARTNERSHIPS

The Network's I&M Program may evolve to include other land and resource managers within the greater landscape of the Network. In no case will this be done without approval of the Board and the National Capital Regional Director. Non-NPS participants will not have decision authority granted to the Board.

REPORTING

Minutes of Board and SAC meetings will be circulated by the I&M Coordinator and Monitoring Coordinator to all members. Copies of the Monitoring Plan, Annual Work Plan, and Annual Report will be circulated to all Board members. The I&M Coordinator will be responsible for maintaining the Administrative Record.

AMENDMENT

The Board may make amendments to this Charter at any time. The I&M Coordinator will be provided a 30 day advanced notice of any proposed amendments before they will take effect.

Approval Signatures

John Howard, Superintendent Antietam and Monocacy National Battlefields	Date
Mel Poole, Superintendent Catoctin Mountain Park	Date
Doug Faris, Superintendent Chesapeake and Ohio Canal National Historical Park	Date
Audrey Calhoun, Superintendent George Washington Memorial Parkway	Date
Don Campbell, Superintendent Harpers Ferry National Historical Park	Date
Robert Sutton, Superintendent Manassass National Battlefield	Date
John Hale, Superintendent National Capital Parks/East	Date
Robert Hickman, Superintendent Prince William Forest Park	Date
Adrienne Coleman, Superintendent Rock Creek Park	Date
William Crockett, Superintendent Wolf Trap Farm Park	Date

AMENDMENTS TO THE CHARTER
OF THE NATIONAL CAPITAL INVENTORY AND MONITORING NETWORK

Amendment 1. This amendment recognizes that the Appalachian National Scenic Trail has become a part of the National Capital Network Inventory and Monitoring Network Board of Directors.

Passed by Board of Directors: 9/15/02

Amendment 2. This amendment recognizes a change in the name of the National Capital Network identified in the Introduction - second paragraph of the Charter. The name of the network is now formally recognized as the National Capital Region Network.

Passed by Board of Directors: 3/18/03

Amendment 3. This amendment recognizes that new due dates have been established for the completion of the National Capital Region Network Monitoring Plan. The Draft Phase 2 Report will be due to the Washington Support Office on 10/31/03. The Draft Phase 3 Report will be due to Washington Support Office on 12/15/04. The final Monitoring Plan will be due 10/1/05. The content of the phases are described in the Memo and its attachment to Regional Directors dated 2 May 2002 from Abigail Miller, Associate Director, Natural Resource Stewardship and Science /s/ Abigail Miller.

Passed by Board of Directors: 3/18/03

Amendment 4. This amendment designates a Point of Contact for the National Capital Region Network Databases as follows:

I. NCRN Point of Contact Justification — The National Park Species database ("NPSpecies") is one of a suite of Service-wide databases developed by the Inventory and Monitoring Program. NPSpecies is designed to document the occurrence of vertebrate and vascular plant species in national park units, and to substantiate these occurrence records by scientifically credible, high-quality references, vouchers, and observations. The master version of NPSpecies is a password-protected, web-based system; this is accompanied by a PC-based version that can be run from an individual computer using Microsoft Access.

   The National Park Service, Service-wide Inventory and Monitoring Program has requested that parks designate Points of Contact (POC) for managing NPSpecies data for each park. This agreement establishes the NCRN Data Manager as the POC for all 11 park units within the National Capital Region Network. As of early 2003 network staff are continuing to populate the database and verify information. By the end of FY 2005 it is anticipated that a good first iteration of vascular plant and vertebrate species lists will be completed for most network parks. At this point the lists can reviewed and certified.

II. NCRN NPSpecies Point of Contact Responsibilities — Following is a description of NPSpecies Point of Contact responsibilities.

   1. *Manage web-based NPSpecies access.* The POC will acquire login and password codes for all network park staff needing access to NPSpecies via the Internet, and will ensure that the appropriate level of database permissions and control are granted (e.g., read only, read-edit, or read-edit-delete access). The POC will cancel permissions in the event staff employment, duty station, or responsibilities change.

   2. *Provide orientation, training, and technical support to park staff on NPSpecies use.* The POC will instruct NPSpecies users on the overall structure and function of NPSpecies (both web-based and local versions), provide explanations and documentation on its use; and assist with questions users may have on how to query or manipulate NPSpecies data.

3. *Convert legacy data sets into formats compatible with NPSpecies.* The POC will work with park staff to locate data sets containing NPSpecies-related information, and to merge any appropriate portions of these data sets into NPSpecies.

4. *Ensure that voucher data obtained by the* Washington Support Office *from national data mining efforts is accurately converted to NPSpecies and reviewed.* As the Washington Support Office staff obtains park-specific data from national and regional museums and herbaria, the POC will ensure that these data are accurately converted to NPSpecies and that these data are made available for review by park-based staff.

5. *Ensure any new NPSpecies-related data collected from I&M or park projects are incorporated into NPSpecies.* The POC will work with I&M cooperators and park resource management staff to ensure that NPSpecies is properly updated to reflect any new data collected in the course of park research or management projects.

6. *Ensure that sensitive data are designated as such, and that access to these data is restricted to the appropriate level.* The POC will request that park resource management staff identify those species that may be vulnerable to disturbance if information from NPSpecies on their location or status is made available outside the park unit, or outside the National Park Service. The POC will ensure that these sensitive records are appropriately coded in NPSpecies and that distribution of the data is limited appropriately.

7. *Ensure that species lists are reviewed by appropriate individuals and certified.* The completeness and accuracy of species-list data in NPSpecies will be assessed by qualified reviewers (park staff or other) on a regular basis (DO #11B: Ensuring Quality of Information Disseminated by the National Park Service). The POC will be responsible for ensuring this review and certification process is undertaken and completed.

8. *Ensure that new species vouchers destined for entry into ANCS+ are also entered into NPSpecies.*

   Data associated with species vouchers are now compatible between ANCS+ and NPSpecies. The POC will coordinate with parks so that, to the extent possible, voucher data are entered directly into NPSpecies then exported electronically to ANCS+, thus avoiding duplication of data entry.

9. *Ensure that species nomenclature used for park species lists is referenced and accepted by leading authorities, and, to the extent possible, is compatible among network parks.*

10. *Ensure that all sources of NPSpecies records are documented, and that additions, changes or deletions to records are substantiated and performed with the concurrence of park staff.*

    Successful NPSpecies development and administration depends on ongoing coordination and good communication between the POC and park staff. A close working relationship between the POC and park resource management and curatorial staff will be emphasized at all times.

III. NPSpecies Point of Contact Designation — By this agreement, the National Capital Region Network, Inventory and Monitoring Program Data Manager is designated as the NPSpecies 'Point of Contact' (POC) on NPSpecies issues and management for each of the 12 park units within NCRN. As POC for each park the NCRN Data Manager will meet the responsibilities listed under Section II of this agreement. A centralized effort at the network level helps ensure high quality control standards and relieves park resource management staff from many of the ongoing tasks related to NPSpecies database management. Database work will be closely coordinated between the NCRN Data Manager and individual park staff and NPSpecies data will be readily accessible and available to park personnel. The NCRN Data Manager will serve in the POC role for each park until such time that park species list development and certification is complete. At this juncture individual parks will have the choice of taking over the role of POC or continuing with designation of the NCRN

Data Manager as the park POC. It is anticipated that most parks within the network will want the NCRN Data Manager to continue as their POC over the long-term. However, some park units with sufficient natural resource staff and expertise may desire to take over the POC role and on-going data base maintenance and quality control once individual park species lists have been developed and certified. In this case a park may request that the POC designation be changed. The NCRN Data Manager will keep track of POC designations for network parks if they change in the future.

Passed by Board of Directors: 3/18/03

Appendix D

National Capital Region Network – Park Summaries

The National Capital Region Network (NCRN) includes eleven national park units with significant natural resources (tables 1 and 2). The parks range in size from 53 to 7,788 hectares (ha) and encompass the Ridge and Valley, Blue Ridge, Piedmont, and Coastal Plain physiographic provinces. All parks in the network have active relationships with local entities including other state and federal government agencies, educational and non-profit institutions, municipalities, and the general public. Park summaries are based on reviews of *Resource Management Plans*, Project Management Information System (PMIS), Investigator Annual Report and interviews with Park Superintendents and Resource Management staff (last update: September 2002).

TABLE 1: SUMMARY OF SIZE, PHYSIOGRAPHIC PROVINCES, AND OFFICIAL PARK CODE FOR PARKS IN THE NATIONAL CAPITAL REGION NETWORK

Park	Park Code	Size (acres)	Size (ha)	Physiographic Province
Antietam National Battlefield	ANTI	3,255	1,318	Ridge and Valley
Catoctin Mountain Park	CATO	5,770	2,336	Blue Ridge, Ridge and Valley
Chesapeake and Ohio Canal National Historical Park	CHOH	19,236	7,788	Coastal plain, Piedmont, Blue Ridge, Ridge and Valley
George Washington Memorial Parkway	GWMP	7,899	3,198	Coastal Plain, Piedmont
Harpers Ferry National Historical Park	HAFE	2,287	926	Ridge and Valley
Manassas National Battlefield Park	MANA	5,098	2,064	Piedmont
Monocacy National Battlefield	MONO	1,647	667	Piedmont
National Capital Parks – East	NACE	10,814	4,378	Coastal Plain, Piedmont
Prince William Forest Park	PRWI	18,569	7,518	Coastal Plain, Piedmont
Rock Creek Park	ROCR	2,717	1,100	Coastal Plain, Piedmont
Wolf Trap Farm Park	WOTR	131	53	Piedmont
Total		**77,425**	**31,346**	

TABLE 2: SUMMARY OF SIGNIFICANT NATURAL RESOURCES AND KEY MANAGEMENT ISSUES AT EACH NCRN PARK

Park	Significant Natural Resources	Significant Management Issues
ANTI	Unique limestone forest (Snavely woods). Karst landscape. Rare species.	Landscape maintained as civil war battlefield. Invasive plant species. Agricultural run-off. White-tailed deer abundance. Pest species (e.g. gypsy moth, hemlock wooly adelgid). Development inside and adjacent to park.
CATO	Forest, riparian, wetland, stream habitat. Brook trout. Timber rattlesnake. Rare species.	Invasive plant species. White-tailed deer abundance. Pest species (e.g. gypsy moth, hemlock wooly adelgid, dogwood anthracnose). Ginseng poaching. Development inside and adjacent to park.
CHOH	Biologically significant Potomac Gorge. Rare species. Riparian habitat. Viewshed. Caves.	Invasive plant species. White-tailed deer abundance. Development inside and adjacent to parks. Recreation.
GWMP	Biologically significant Potomac Gorge. Upland and swamp forests. Viewshed. Tidal wetlands (Dyke Marsh). Seeps. Rare species. Rare old growth forest.	Invasive plant species. White-tailed deer abundance. Development inside and adjacent to parks. Traffic. Erosion of Dyke Marsh. Air pollution. Recreation.
HAFE	Upland and riparian forest. Wetland habitat. Rare species. Peregrine falcon. Caves. Geologic resources. Viewshed.	Invasive plant species. White-tailed deer abundance. Development inside and adjacent to parks. Pest species (e.g. gypsy moth, hemlock wooly adelgid, dogwood anthracnose). Canada goose abundance. Recreation.
MANA	Rare species. Rare vegetation communities including shrub meadow, oak/hickory, white pine, piedmont swamp forest.	Landscape maintained as civil war battlefield. Invasive plant species. White-tailed deer abundance. Development inside and adjacent to parks. Pest species (e.g. gypsy moth, hemlock wooly adelgid.
MONO	Forest habitat (Triangle woods). Open fields. Rare species.	Landscape maintained as civil war battlefield. Invasive plant species. Agricultural run-off. White-tailed deer abundance. Development inside and adjacent to parks. Pest species (e.g. gypsy moth, hemlock wooly adelgid).
NACE	Deciduous forest and mixed deciduous-pine forest. Tidal wetlands. Rare communities including shell-marl ravine and magnolia bog. Rare species. Gravel shoreline.	Invasive plant species. White-tailed deer abundance. Development inside and adjacent to parks. Canada goose abundance. Feral cats. Soil compaction. Sedimentation.
PRWI	Piedmont forest. Rare species. Seepage swamp. Rare old growth forest.	Invasive plant species. White-tailed deer abundance. Development inside and adjacent to parks. Pest species (e.g. gypsy moth). Visitor impacts. Soil compaction. Water quality. Recreation.
ROCR	Upland forest. Riparian and meadow habitat. Rare species. Seeps.	Invasive plant species. White-tailed deer abundance. Development inside and adjacent to parks. Boundary incursions. Urban runoff. Feral cats. Poaching (e.g. turtles). Traffic.
WOTR	Upland forest. Riparian habitat.	Invasive plant species. White-tailed deer abundance. Development inside and adjacent to parks. Water quality.

ANTIETAM NATIONAL BATTLEFIELD

OVERVIEW

Antietam National Battlefield is managed within the historical context of General Robert E. Lee's first invasion of the North in September 1862 during the Civil War. The battle claimed more than 23,000 men (killed, wounded, and missing) in one single day, September 17, 1862, and led to Lincoln's issuance of the Emancipation Proclamation. The 1,318 ha park is located in the heart of Maryland surrounded by rolling hills dotted with farm fields and pastures reminiscent of the day of the battle.

Patches of forests, open meadows, and croplands are found within the park. Significant natural resources include sensitive habitats along Antietam Creek, unique limestone upland forests (Snavely Woods), and three state rare, threatened, and endangered species, including the loggerhead shrike (*Lanius ludovicianus*), goldenseal (*Hydrastis canadensis*), and the butternut (*Juglans cinerea*). Possible white-tailed deer (*Odocoileus virginianus*) overabundance and the presence of the gypsy moth (*Lymantria dispar*) and woolly adelgid (*Adelges tsugae*) are management concerns.

SUMMARY OF ENABLING LEGISLATION

An act of the 30 August 1890, appropriated monies for the purpose of “surveying, locating, and preserving the lines of battle of the Army of the Potomac and the Army of Northern Virginia at Antietam, and for marking the same, and for locating and marking positions of the forty-three different commands of the regular Army engaged in the Battle of Antietam, and for the purchase of sites for tablets for marking such positions.

Additional clarification was provided in Public Law 86-438 of 22 April 1960, in which Congress directed the Secretary of Interior to “preserve, protect, and improve the Antietam Battlefield…to insure the public a full and unimpeded view thereof, and to provide for the maintenance of the site in, or its restoration to, substantially the condition in which it was at the time of the Battle of Antietam.”

The *1992 General Management Plan* calls for the restoration of the historic scene to the conditions existing at Antietam on the eve of the battle in 1862. This includes restoring historic road traces, farmhouses, farm fields, replacing fence lines, and reestablishing 345 acres of woodlands and 35 acres of orchards that existed at the time. The *General Management Plan* also proposes efforts to increase habitat for the threatened and endangered flora and fauna, restoration of vegetation patterns, and soil conservation.

PARK RESOURCES AND SPECIES OF CONCERN

Most Valuable Resources

Landscape that is Composed of Cultural and Natural Resources — The *General Management Plan* calls for maintaining the 1860 landscape, which includes the forest, orchard, and agricultural setting. Current crops grown include corn, soybeans, wheat, barley, oats, and hay crops, including alfalfa, clover, timothy, and orchard grass.

Aquatic resources including Antietam Creek and tributaries, spring heads, and wetlands

Beech/tulip poplar and oak/hickory in the Snavely Woods

Karst landscape of groundwater systems, riparian areas, creeks (Antietam Creek), springs, tributaries (Sharpsburg Creek, Mumma Run), and wetlands

Vegetation Communities — Beech/tulip poplar forest

Species of concern have been identified and include species that are overabundant or invasive, as well as rare/threatened/endangered species. 23 species of concern for Antietam National Battlefield were identified. This subject will be discussed by workgroup(s) in greater detail at a later date.

Threats and Resource Management Issues

Threats —

Exotic vegetation (especially ailanthus, garlic mustard, multiflora rose, Japanese barberry, tartarian honeysuckle, Japanese honeysuckle).

White-tailed deer overabundance. The current population density estimate for fall 2000/spring 2001 = 66.95 deer/sq mile; 90% CI: 59–76 deer/sq mile.

Agricultural runoff – this may be a problem to both surface waters and groundwater.

Pollution to Antietam Creek (industrial, sewage, street and commercial runoff).

Threat Abatement —

Easements (for example, to keep land in agricultural use).

Spring protection (buffering, establishing no-chemical zones, education of farmers and employees).

Restoration of native grasses and oak / hickory forest.

Tree Preservation (Burnside Sycamore).

Exotic plant control of ailanthus and honeysuckle – some exotics like garlic mustard are a bigger problem but there is no treatment available yet. The park also monitors and keeps track of treatments and their effectiveness. The focus has been on roads, fencerows and reforestation of treated areas.

Pest control (crop pests, hemlock wooly adelgid, Anthracnose, and Japanese beetles are being treated).

Nutrient management plans and use of best management practices are integrated into all agricultural operations.

Resource Management Issues —

The overall goal of the park is to maintain the general landscape as it was during the Civil War including natural and cultural resources.

More funding and equipment are necessary.

Deer abundance.

Up-to-date resource management plan needed for newly acquired lands.

SUMMARY OF EXISTING MONITORING PROGRAMS AND NEEDS

Air — An ozone monitoring program was completed during the summers of 1984, 1985, and 1986. The program was organized by the Air Quality Division, Washington Office and monitored ozone damage on milkweed plants.

Amphibian — None.

Birds — Mark Raabe of NA Bluebird Society monitors nest boxes annually. ANTI gets a paper report every year.

Fire — There is a fire weather monitoring station at C&O Canal, Sharpsburg headquarters. In addition, Don Bouche (NPS – FMO) and Alan Biller (NPS) are working on fire management plans for the parks. They are incorporating air quality and smoke monitoring needs. This wildland management plan covers prescribed fire and research burns. They plan to do a literature search on fire effects on eastern species. In addition, they plan to do research burns next spring. There will be a monitoring component of the fire plan.

Fish — None.

Geology — None.

Mammals — Deer distance sampling started in FY-2001 and is planned twice a year in spring and fall. In addition, transects are run through the park to count deer (and all other mammals) in areas not covered by distance sampling. Roadkill data are collected in the park October through March. Woodchuck monitoring is limited to identifying structural damage to historic buildings and the cemeteries.

Meteorology — The park records rainfall in Hagerstown where there is an official NOAA station.

Pests — Structural pests, Woolly Adelgid, West Nile Virus and Gypsy Moths (NPS and USDA).

Pesticides Use — Pesticide logbook on file.

Reptiles — None.

Soils — None.

Sound — None.

Vegetation —

Exotics – the park looks for new species. Invasive species are mapped by the Exotic Plant Management Team.

Historical trees – the park started a project few years ago to collect seeds from historical tree species. A SCA volunteer implemented the project but it is not complete. The volunteer was also tagging trees as part of Historical and Commemorative Areas monitoring.

Wildflowers – an informal survey resulted in a brochure. There is no systematic monitoring.

Goldenseal – visually surveyed but there is no systematic monitoring.

Crops – farmers collect yield data as an indicator of health. In addition, farmers report soil fertility including soil nutrients.

Snavely Woods – six, 20 × 20 m long-term vegetation plots have been set up in 1998.

Visitors — None.

Visual Landscape — Photomonitoring (past).

Water Quality —

USGS Water Resources Division in cooperation with states monitors the discharge of the Antietam Creek near Burnside Bridge (August 1928–present). From June 1897 to September 1905, discharge was measured about 1/2 mile upstream near "Middle Bridge."

An actively maintained USGS gauging station is located downstream of Burnside Bridge. This is Station #01619500. Records are confusing; however, hard copy files indicate that various bureaus within the MD DNR monitored bacteriological levels and other parameters from 1986–1995. The data is included in the NPS Water Resources Division publication of water data for ANTI.

USGS Water Resources Division in cooperation with MD DNR – MD Geological Survey monitors discharge at the Mumma Spring. This was done in May 1969, April 1987, and January 1991–present. This is Spring # WA Di 103. Hard copy files indicate that MD DNR – MD Geological Survey monitored biological and chemical parameters periodically from 1990 until the present.

In 1997, six sites were established by NPS ANTI to monitor DO, nitrates and phosphates to look at run-off from agricultural fields. In addition, they are looking for herbicide contamination to see how well forest buffers are working.

A water quality education project ("Water Watchers") for high school collects some water quality data. The project was started in 1995.

The NPS Water Resources Division will be completing a scoping report for ANTI in 2001/2002.

Most Important Monitoring Needs

Additional exotic plant monitoring needed (Japanese barberry, garlic mustard, honeysuckle sp.).

White-tailed deer (already implemented).

Ground and surface water quality and their impacts on agricultural landscape (limited ongoing).

Forest health.

Monitoring of aquatic biota is needed (macroinvertebrates, fish, mussels).

Basic weather monitoring.

Surveys for Amphipods are needed.

Species of concern.

Fire monitoring.

Wildlife habitat evaluation.

Current Research Projects and Needs

Existing Research Projects — Alison Dibble of USDA Forest Service is developing a model to predict where invasive species may colonize.

Research Needs — (1) Map groundwater sinkholes, subsurface Karst resources, (2) How can fire be used to manage exotic species?

PARTNERING AND NEIGHBORING AGENCIES AND INDIVIDUALS

Partnering Agencies/Individuals

- Maryland Department of Environmental (Water Quality).
- Maryland Department of Natural Resources (works with ANTI on exotics control; Don Warback has been in contact with ANTI on managing warm season grasses and fire).
- Washington County Cooperative Extension Service (Crop management).

Neighboring Land Management Agencies

- South Mountain State Park. This is a new park that is part of South Mountain Recreation Area.
- Indian Springs Wildlife Management Areas.
- Greenridge State Forest.
- Gaflin State Park.
- Four county parks in Sharpsburg.
- Washington Monument State Park.

CATOCTIN MOUNTAIN PARK

OVERVIEW

Catoctin Mountain Park originated as a Recreation Demonstration Area (RDA) under the National Industrial Recovery Act of 1933. Catoctin was transferred to the National Park Service in 1936 and has remained under its jurisdiction due to the historical events of national and international interest associated with the Presidential Retreat, Camp David, contained within. Although the area is managed by the National Park Service for its recreational use and the conservation of its cultural and natural resources, existing enabling legislation does not provide clear and concise management goals.

The park encompasses 2,336 ha of forested landscape located in the mountains of the Catoctin Ridge in the north-central portion of Maryland. Unique geological formations consisting of metamorphic sandstones and greenish-gray metabasalts forming cliffs occur in the park. Several overlooks illustrate the forces of volcanism, folding, faulting, and weathering. Catoctin has a maturing forest of chestnut oak (*Quercus prinus*), hickories (*Carya* spp.), and maples (*Acer* spp.) and over 650 species of vascular plants. It has two diverse aquatic streams crossing the park.

Management issues include the effects of white-tailed deer overpopulation, exotic invasive plants, gypsy moth (*Lymantria dispar*), hemlock woolly adelgid (*Adelges tsugae*), and dogwood anthracnose. Forest health and structure are being affected by these threats. Numerous plant species have already become extirpated or run the risk of being eliminated from the park's plant community. Also, water quality degradation is a concern as residential and agricultural activity increase along the park's 35 km of boundary.

SUMMARY OF ENABLING LEGISLATION

There is no enabling legislation directing the management of this park. Since its beginning, the "The park has since been administered under the guidelines established and defined in the basic operations declaration as follows:

- as a public park.
- for recreational purposes.
- to conserve all resources.
- to protect the presidential retreat.
- to record and protect the historically significant resources identified as the buildings and grounds within Camp David, the cabin camp facilities at Misty Mount and Greentop, and two historically significant buildings in Round Meadow known as the Country Store and the Blacksmith Shop."

In addition, the 1985 Statement of Management Purpose and Significance, however, notes: "The primary purpose of Catoctin Mountain Park is to administer the area for '... public park, recreation and conservation purposes.'"

PARK RESOURCES AND SPECIES OF CONCERN

Most Valuable Resources

Streams and Water Quality.

Landscape (Mountain Forest).

Forest/streams/seeps and wetlands/rare plants in the seeps and wetlands.

Greenstone glade, Owens Creek Swamp.

Biologically diverse steep tallus slope on the northeast side of park.

Species of concern, including threatened and endangered species and state listed species.

Air quality/visibility/vistas.

Cultural Resources – Historic Cabins and Landscapes

Species of concern have been identified and include species that are overabundant or invasive, as well as rare/threatened/endangered species. Forty-eight species of concern for Catoctin Mountain Park were identified in the following taxonomic groups: 15 birds, 3 mammals, 1 herps, 1 fish, 3 invertebrates, 24 plants, and 1 vegetation community.

This subject will be discussed in greater detail by workgroup(s) at a later date.

Threats and Resource Management Issues

Threatened Resources —

Lack of tree regeneration.

Hemlocks threatened because of Wooly Adelgid. No replanting is planned.

Dogwood most threatened. 85% of dogwoods were lost in the mid-1980s.

Timber Rattlesnakes.

Air Quality, possibly. Potential future threat more than a current threat.

Ginseng appears to have decreased in recent years.

Threats —

Alien Species (Wooly Adelgid, Gypsy Moth, and plants).

White-tailed Deer browse.

Sedimentation and water quality.

Few people on Natural Resource Management staff.

Snake collectors.

Development outside of park and inside (e.g., cell towers).

Threat Abatement —

Control for exotic plants is ongoing.

Dogwood reforestation is ongoing.

Stream improvements along Hunting Creek for trout (wild brook and brown trout).

Fish management – catch and return only. State is restocking fish inside and outside of the park.

Controlling Gypsy moths.

Treated Adelgid at Round Meadows.

NPS monitors the water quality to adjust the release from the state park's lake.

Purple-fringed orchid and landscaping trees are being caged to prevent deer predation.

EIS for deer management is planned.

Resource Management Issues —

Update and re-evaluation of management plans for deer, fire, and trout are needed.

Park-wide survey for exotic plants is needed.

Outside park boundary concerns.

Air quality may be a concern.

SUMMARY OF EXISTING MONITORING PROGRAMS AND NEEDS

Air — (1) Ozone – during 1992 and 1993. (2) Visibility - in 1986.

Amphibians — North American Amphibian Monitoring Program (NAAMP) conducted by Wayne Hildebrand (graduate student, Hood College) in 2001.

Birds — Christmas Bird Count (CBC). Park data available for 2000.

Fire — None.

Fish — (1) Trout population survey by CATO and MD DNR (1978–present). (2) NPS monitors a few higher tributaries to evaluate effectiveness of stream improvements. Data goes back to 1980s. (3) Trout Fry Survey: Done by CATO, started about mid 1980s. Data available in spreadsheet format.

Geology — None.

Mammals — (1) Deer – Distance Sampling has been implemented in 2000. (2) Informal Deer Mortality Survey by CATO.

Meteorology — The park is an official reporting station for NOAA (1966- present).

Pests — (1) Wooly Adelgid/Hemlock – Intermittent data from 1994 – present. (2) West Nile Virus – Monitored in 2001 as part of regional monitoring effort. (3) Gypsy Moth – overflights and egg mass surveys conducted annually. (4) Dogwood anthracnose – informal windshield survey along the central road. (5) Termites.

Pesticide Use — Log on file.

Reptiles — Timber Rattlesnake den checks conducted every two years since 1981.

Soils — None.

Sound — None.

Vegetation Monitoring — (1) Vegetation Plots (1990–1992). Modified in 2000 to measure regeneration. (2) Rare Plants–Informal surveys. (3) Exotic Plants–Monitor treatment. Post treatment is not monitored. (4) Flowering Dogwood – Informal surveys, reforested trees are tagged and checked each May.

Visitors — None.

Visual Landscape — None.

Water Quality —

Gauging station on Monocacy River.

State park has a flow gauge below lake.

U.S. Geological Survey monitors surface waters.

Monitoring planned at Owens Creek.

Macroinvertebrates sampling at Big Hunting Creek and Owens Creek by MD DNR since about 1980.

Stream Habitat Assessment – CATO used EPA protocol for a stream habitat assessment; done twice in 1990s.

Most Important Monitoring Needs

Air quality/vista.

Neotropical migrants.

Global warming maybe.

The park has little baseline data on heavy metals and no pesticide information for surface waters.

Herps.

Invertebrates (not just aquatic macroinvertebrates).

Fungi, especially morels that are heavily harvested here.

Alien species including gypsy moths, wooly adelgid, and alien plants.

Timber rattlesnake appears to be declining; data collected in the park is not shared with the park.

Bats.

Regional Monitoring — State tracks hunting permits and number of deer shot in the region and monitors crop damage.

Current Research Projects and Needs

Existing Research Project — None.

Research Needs — (1) Fire History, (2) Prescribed Fire to evaluate impacts on vegetation.

PARTNERING AND NEIGHBORING AGENCIES AND INDIVIDUALS

Partnering Agencies/Individuals

None.

Neighboring Land Management Agencies

Gambrill State Park.

CHESAPEAKE AND OHIO CANAL NATIONAL HISTORICAL PARK

OVERVIEW

The Chesapeake and Ohio Canal National Historical Park stretches along the Potomac River for 297 km (184.5 miles) from Washington, DC to Cumberland, MD making it unique in the National Capital Region as the largest and longest. The park's 7,788 ha cut through four geographic provinces and include riparian and upland habitat. From the beginning of construction in 1828 to the end of operation in 1924, the canal functioned as a transportation route, primarily hauling coal from western Maryland to the port of Georgetown in Washington, DC. In 1938, the Federal government acquired the defunct C&O Canal Company property, focusing on the lower 23 miles of the canal for restoration. In 1971, legislation authorized the National Park Service to preserve and interpret the park's historic and scenic features and designated Chesapeake and Ohio Canal as a National Historical Park. Hundreds of original structures, including 74 lift locks, lock houses, and aqueducts, serve as reminders of the canal's role as a transportation system during the Canal Era. The park also supports a great variety of recreational opportunities from the highly urbanized area in Washington, DC to more the rural communities in western Maryland serving 3.1 million visitors in 2000.

As of 2001, at least 243 rare species occur in the park, including 9 wildlife species and over 100 plant species. Harperella (*Ptilimnium nodosum*), a federally endangered vascular plant, is found in the park. The main management concerns focus on the rapid spread of exotic and weedy species invading natural areas along the canal.

SUMMARY OF ENABLING LEGISLATION

Public Law 91-664 91st Congress, H.R. 19342 January 8, 1971 Section 3 a) "In order to preserve and interpret the historic and scenic features of the Chesapeake and Ohio Canal, and to develop the potential of the canal for public recreation, including such restoration as may be needed, there is hereby established the Chesapeake and Ohio Canal Historical Park, in the States of Maryland and West Virginia and in the District of Columbia."

The management goals stated in the *1987 Resource Management Plans* include: 2) "Preserve the atmosphere of past times and enduring natural beauty and safeguard historic remains and natural features."

PARK RESOURCES AND SPECIES OF CONCERN

Most Valuable Resources

Over 100 state/federal listed rare, threatened and endangered species

Over 23 identified significant rare plant habitats, such as nationally significant bedrock terrace habitat, and 86 individual rare plant sites documented

Water resources in and adjacent to the park (Potomac River) (Note: The Potomac itself is not in the park and falls under the jurisdiction of the state of Maryland. The CHOH boundary only goes to the high water line).

Geologic Resources —

Potomac Gorge, one of the most significant natural areas in the National Park system, including noteworthy stands of upland forest, numerous seeps and springs, wetlands, and over 400 occurrences of 200 rare species and communities.

Park provides riparian zone protection to Potomac River while development increases on the park boundary and on the other side of river.

Recreational values and opportunities that are increasing in importance as human population increases (does not include recreation on the Potomac but does include access to the Potomac River).

High quality viewsheds.

Species of concern have been identified and include species that are overabundant/invasive, as well as rare/threatened/endangered. 125 species of concern for Chesapeake and Ohio Canal National Historical Park were identified in the following taxonomic groups: 13 birds, 3 mammals, 1 herp, 3 invertebrates, 82 vegetation, and 23 vegetation communities. This subject will be discussed in greater detail by the workgroup(s) at a later date.

Threats and Resource Management Issues

Threats —

Floods – an all-encompassing threat to park natural, cultural and recreational resources, to park operations and budget for extended periods of time (last 2 major floods occurred in 1996).

Exotic plants – 68 identified as important invasive species.

Population growth/adjacent development (roads, fragmentation), and internal and adjacent land use.

Rights-of-way/utility crossings (internal, external).

Potomac interceptor sewer line, power plants, telecommunication sitings.

Deer over-browsing.

Runoff of pollutants, sedimentation.

Concentrated visitor use areas – official and social trails, climbing, fishing, etc.

Opposing values (i.e., cultural vs. natural resources) such as the historic leasing program that may issue an historic lease to provide an avenue for restoration of an historic building that may propose removing surrounding natural resources or planting exotics.

Threat Abatement —

Exotic Plant Management Team is focusing control efforts on the Potomac Gorge.

The CHOH has a number of scenic easements, although these could be rewritten to be more resource protective.

Resource Management Issues —

People and/or dollars in the park to plan and conduct monitoring, manage and analyze data, and provide information to park management.

People and/or dollars in the park to evaluate NEPA related issues and produce NEPA related documents for internal and external projects/impacts.

Exotic–mapping and treatment of exotic plants; study/monitor/address exotic plant impacts to important rare plant communities.

Rare, threatened, and endangered habitats (species)–need to identify threats, develop and implement monitoring Scheme, and implement actions to minimize threats.

Water quality (surface and subsurface)–need to develop and implement monitoring program; identify and implement protection/restoration actions. (Subsurface gets at drinking water wells and important springs/caves that support rare aquatic invertebrates.)

Deer – study/monitor/address deer damage to important rare plant communities and agricultural crops/lands.

Issues related to servicing 3.5 million users and how to maintain resources under these conditions.

Boundaries – Although the canal and towpath length is 184.5 miles long, the park manages over 350–400 miles total of boundaries.

Cell tower issues – CHOH needs information on the impacts of cell towers.

Need to digitize existing data on springs and their locations.

Determine if and where historic and non-historic culverts impact fish migrations, and how to fix culverts to mitigate their effects where impacts exist.

Summary of Existing Monitoring Programs and Needs

Air — None.

Amphibian — Dr. Ed Thompson is in the process of developing amphibian monitoring protocols for Washington and Allegany Counties. Final Report is due in December 2001.

Birds — CHOH established a breeding bird count along length of canal – count conducted every 3 years; DC Audubon coordinates annual mid-winter bird count along the length of the canal.

Fire — None.

Fish — None.

Geology — None.

Mammals — Distance sampling is being employed to monitor deer populations. The regional wildlife biologist coordinates effort.

Meteorology — Weather station, installed in 1994, is monitored daily by Branch of Visitor and Resource Protection at park headquarters. Data is stored and analyzed in Weather Information Management System (WMIS).

Pests — Regional IPM coordinator and USDA monitor Gypsy Moths; West Nile Virus was monitored in 2000 as part of a regional monitoring program; the park surveys Hemlock Wooly Adelgid annually.

Pesticides Use — Logbook is on file.

Reptiles — None.

Soils — Farmers are supposed to monitor soils but most are not doing this well.

Sound — None.

Vegetation — Maryland Heritage has surveyed CHOH for rare plants but a systematic monitoring program has not been established. On-going exotic vegetation program includes EPMT control and monitoring in the Potomac Gorge, and several park-managed projects.

Visitors — None.

Visual Landscape — None.

Water Quality — Stream Water. The Potomac is managed and monitored by MD and other entities; monitoring water quality of the Potomac River is not a priority nor responsibility for the park. The park monitors drinking water wells and NCR monitors groundwater contamination sites.

Most Important Monitoring Needs

- Identify vital signs and protocols
- Monitor flood impacts on resources, long-term
- Water quality (surface and subsurface)
- Rare, threatened and endangered species/habitats, long-term
- Deer impacts to native plants and to crops
- Visitor use impacts to natural and cultural resources, site specific
- Exotic weed impacts on native plants
- Monitor human impacts at camping and climbing areas (especially in POGO)
- Monitor invasion of Asiatic clam and develop action plan
- Rare groundwater invertebrates found in park springs and caves

Current Research Projects and Needs

Existing Research Projects — None.

Research Needs —

- List of projects currently in PMIS (not prioritized):
- Evaluate and identify exotic plants impacting rare plant sites.
- Map and quantify water subterranean recharge zones
- Research forest ecology- floodplain forest
- Monitor beaver populations and mitigate impacts
- Inventory exotic plant invasions
- Exotic plant species management plan

Wetland delineation

Contemporary vegetation map

Evaluate impacts of white-tailed deer on resources

Implement best management practices, agricultural lands

Study habitat selection and nesting success of Cerulean Warbler

Document changes in land use/land cover on Cerulean Warbler

Hire seasonal staff to develop GIS data layers for I&M

PARTNERING AND NEIGHBORING AGENCIES AND INDIVIDUALS

Partnering Agencies/Individuals

None.

Neighboring Land Management Agencies

- Fort Frederick State Park
- Sideling Hill WMA (3,000 acres, Western part of state) - There is harperella in this area.
- Green Ridge State Forest (44,000 acres, Western part of state; CHOH is very narrow at this point and acts as a buffer to the State Forest)
- Seneca Creek State Park (7,000 acres, Montgomery County)
- McKee-Beeshers Wildlife Management Area
- Dickerson Conservation Area
- Blockhouse Point Park

GEORGE WASHINGTON MEMORIAL PARKWAY

OVERVIEW

George Washington Memorial Parkway was developed in 1932 as a memorial to George Washington and to protect the scenic view along the Potomac River shoreline and its tributaries in the DC area between Mt. Vernon and Great Falls. The park's 3,198 ha offer opportunities to travel to historical, natural, and recreational areas located within the park. In addition, the park provides refuge for native species in close proximity to a large urban population that can witness the natural relationships and beauty within a short walk. In the parks enabling legislation, the parkway is broadly mandated "…to prevent pollution of Rock Creek, and the Potomac and Anacostia Rivers, to preserve forests and natural scenery in and about Washington." The mandate also mentions the protection of the scenery of the Gorge and Great Falls of the Potomac River. Approximately 700 ha are zoned as natural areas.

Distinct administrative units protect significant natural resources and provide refuge for native species including at least 28 state-listed plant and animal species. Along the steep ravines bordering the Potomac River are possibly the best representations of mature second growth forest in the immediate DC area. Units with significant natural resources include:

> *Arlington House*—managed as a memorial to Robert E. Lee, contains a small mature oak forest that is maintained in pre-Civil War conditions.
>
> *Dyke Marsh*—covers approximately 150 ha of tidal marsh, floodplain, and swamp forest.
>
> *Great Falls*—the 300 ha park is covered by second growth deciduous forest.
>
> *Theodore Roosevelt Island*—35 ha; this natural island is located in the Potomac River and is a tribute to Theodore Roosevelt. It was also mandated to be maintained as a natural area. Hiking trails pass through marsh, swamp, and upland forest communities.
>
> *Turkey Run*—contains over 280 ha of mostly deciduous forest and includes a well-developed floodplain forest that may be up to 180 m wide and extends for nearly 5 km along the Potomac River shore.

Exotic species are a concern in several natural areas including Dyke Marsh where porcelainberry (*Ampelopsis brevipedunculata*), Japanese honeysuckle (*Lanicera japonica*), and Asian bittersweet (*Celastus orbiculatus*) are spreading. Overabundance of white-tailed deer is a potential problem and may have significant impacts on natural vegetation within the parkway as well. Traffic associated with the parkway and development close to the park's boundaries also pose potential threats to the area's wildlife.

SUMMARY OF ENABLING LEGISLATION

The *1994 Resource Management Plan* states, "The George Washington Memorial parkway is part of a large park system serving the Nation's Capital. Its origin can be found in the 1924 Act that established the National Capital Park Commission, Public Law 202. This commission was directed to acquire land in the District of Columbia, Maryland and Virginia suitable for development into a 'National Capital park, parkway and playground system." According to Sect. 1 Ch 270 1947 Chapter 270 "An Act providing for a comprehensive development of the park and playground system of the National Capital." "Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That to preserve the flow of water in Rock Creek, to prevent pollution of Rock Creek and the Potomac and Anacostia Rivers, to preserve forests and natural scenery in and about Washington, and to provide for the comprehensive systematic, and continuous development of the park, parkway, and playground system of the National Capital, there is hereby constituted a commission, to be known as the National Capital Park Commission..."

"In 1930, the Capper-Cramton Act (46 Stat. 482) was passed to acquire and establish the George Washington Memorial Parkway...The Act brought protection of the Great Falls of the Potomac under the jurisdiction of the National Capital Park and Planning Commission. The park's enabling legislation defines four distinct management roles, including, "To preserve the Potomac River shoreline from pollution and commercial development...To provide for the protection and preservation of the natural scenery of the Gorge and Great Falls of the Potomac, and preservation of the historic Patowmack Canal." "The parkway is also guided by the Chesapeake Bay Protection Act, an act establishing guidelines for the protection of the Chesapeake Bay and its tributaries."

PARK RESOURCES AND SPECIES OF CONCERN

Most Valuable Resources

Great Falls of the Potomac and the Potomac Gorge

Dyke Marsh

Numerous Potomac River intakes

More than 15 perennial streams

Swamp forests

Upland forests

Seeps

Theodore Roosevelt Island

Species of concern have been identified and include species that are overabundant/invasive, as well as rare/threatened/endangered. At least 16 birds, 4 mammals, 3 herps, and more than 3 invertebrates have been identified as species of concern in the park. In addition, 38 plant species are listed S1-S3 in the 1999 National Capital Region Status Report. The park has identified 17 exotic species of special concern. Species of concern will be discussed in greater detail by workgroup(s) at a later date.

Threats and Resource Management Issues

Threats —

Contamination of tributary streams and the river.

Sedimentation.

Pipeline operations (sewer lines, etc.).

Exotic invasive species.

Deer overbrowsing (potentially).

Overfishing.

Residential/Commercial/Recreational development.

Vehicles/speed and volume.

Telecommunications towers.

Threat Abatement —

Promote replanting of native vegetation to buffer streams from runoff.

Promote local government adoption of stricter regulations for stormwater management and erosion control.

Construct deer exclosures around sensitive resources

Use best management practices on parklands to reduce the spread of invasive plants.

Promote the use of less toxic road treatment materials, snow melters, etc.

Resource Management Issues — The overall goal of the park is to maintain the natural landscape.

SUMMARY OF EXISTING MONITORING PROGRAMS AND NEEDS

Air — None in the park. Data from nearby stations is available.

Amphibian — Annual surveys conducted using Terrestrial Salamander Monitoring Program. Data will be submitted to the national program.

Birds — Breeding Bird Project conducted at Dyke Marsh since 1970s; annual CBCs cover Fort Hunt and Dyke Marsh; Breeding Bird counts conducted by Fairfax Audubon Society (FAS) at Great Falls since 1995; Duck survey conducted by volunteers at Boundary Channel since 1980s. None of the data has been analyzed; a graduate student is currently analyzing FAS data.

Fire — None.

Fish — Jim Cummins has been monitoring shad restoration efforts in the Potomac. No monitoring in the tributaries. Inventories have been done at CIA Run and are currently being conducted at Dyke Marsh.

Geology — None.

Mammals — Deer Distance Sampling started in FY2001 and is planned twice a year in spring and fall.

Meteorology — None in the park; data is available from DC National Airport.

Pests — USDA surveys Gypsy Moths annually; more work is needed in the park. West Nile Virus is monitored by region.

Pesticides Use — Pesticide logbook on file.

Reptiles — None.

Soils — None.

Sound — None.

Vegetation — Exotics – invasive species are mapped and controlled by the Exotic Plant Management Team. Volunteers and the maintenance division implement additional control measures.

Visitors — None.

Visual Landscape — None.

Water Quality — Surface water monitoring implemented in 2000 along 7 tributaries. Sampling is following standard protocol developed by Fairfax County.

Most Important Monitoring Needs —

Air quality monitoring (including ozone damage to plants)

Forest health monitoring (including Gypsy Moths[limited, already implemented], Dutch Elm disease, exotic species)

Rate of erosion at Dyke Marsh

Current Research Projects and Needs

Existing Research Projects — None.

Research Needs — Analyze erosion of Dyke Marsh by reviewing aerial photos.

Analyze 20 years of duck data and approximately 20 years of Breeding Bird Survey data collected at Dyke Marsh.

PARTNERING AND NEIGHBORING AGENCIES AND INDIVIDUALS

Partnering Agencies/Individuals

- Virginia Heritage
- Fairfax County
- Fairfax Audubon Society
- Friends of Dyke Marsh

Neighboring Land Management Agencies

- Riverbend Park
- Potomac Overlook Park
- Gulf Branch Nature Center

HARPERS FERRY NATIONAL HISTORICAL PARK

OVERVIEW

Harpers Ferry National Historical Park is located at the confluence of the Shenandoah and Potomac Rivers in West Virginia, Virginia, and Maryland. The 926 ha park is within the Blue Ridge physiographic province and contains forested mountains, riparian habitats, and floodplains that surround the park's historic town area.

Natural resource issues for Harpers Ferry NHP include impacts from external developments, adjacent landowners, and private and public land uses within the park. One hundred fifty-five exotic species have been identified in the park, and of these, 34 are considered to be invasive and a concern to the park because of their effects on native plants. The most obvious threats to vegetation have come from diseases or insect infestations on the park's eastern hemlock *(Tsuga canadensis*), butternut (*Juglans cinerea*), American elm (*Ulmus americana*) and oaks (*Quercus* spp.). The status of the native eastern dogwood (*Cornus florida*) is unknown but suspected to be affected by disease.

SUMMARY OF ENABLING LEGISLATION

Resource Management Plan (2000) — "All park lands are included on the National Register of Historic Places denoting their national significance."

PARK RESOURCES AND SPECIES OF CONCERN

Most Valuable Resources

- Eastern deciduous forest
- Riparian habitat (about 10 miles fall within the park)
- Wetlands (about 100 acres fall within the park)
- John Brown Cave (4,000 foot-long cave)
- Exposed shale (predominates on the east side of the park)
- Limestone (predominates on the west side of the park)
- State listed rare plants
- Native species
- Historic Structures
- Agricultural fields (wheat, soybean, corn, and pasture)
- Cultural and natural landscape

Species of concern have been identified and include species that are overabundant/invasive, as well as rare/threatened/endangered species. 15 species of concern for Harpers Ferry National Historic Park were identified in the following taxonomic categories: 6 birds, 1 mammal, 8 and vegetation. This subject will be discussed in greater detail by workgroup(s) at a later date.

Threats and Resource Management Issues

Threats —

- Floods
- Drought
- Gypsy Moths
- White-tailed Deer (may be a threat but needs further documentation)
- Canada Geese (overabundance perceived in the lower town area)
- Invasive exotic plant species (among 158 exotic species, 32 are considered invasive including bamboo, Japanese honeysuckle, Japanese stiltgrass, and kudzu [minor problem)
- Human impacts (railroads, trails, and park services, including restoration of cultural resources and general maintenance)
- Adjacent land development and construction impacts (towers, highways, utility rights of way)
- Exotic forest pests (Gypsy Moths, Hemlock Wooly Adelgid, Dogwood Anthracnose)

Point and non-point source pollution to tributaries of the Potomac and Shenandoah River

Threat Abatement —

Exotic plant management

Resource Management Issues —

Steep slopes must be monitored for rock movement and managed accordingly.

Exotic plants are spreading and need to be controlled and mapped.

Peregrine falcons are being restored through a multi-year release project.

Larger staff is needed to adequately address resource issues.

Gypsy Moth needs to be continually monitored and controlled.

Cultural and natural resource management issues must be balanced continually.

Basic inventories need to be completed, including John Brown Cave.

Boundary identification and marking is not complete.

Consistent soils data are needed among counties.

Sources of pollution to wetlands need to be identified.

Expand herbarium to document all of park flora.

SUMMARY OF EXISTING MONITORING PROGRAMS AND NEEDS

Air — None.

Amphibian — None.

Birds — Raptors were monitored at a temporary banding station during the early 1990s.

Fire — Data collected and maintained by Ranger Division.

Fish — None.

Geology — Building 45 and Jefferson rock monitored for rock movement.

Mammals — The park has set up 99 pellet plots to determine deer abundance. Vegetation plots and exclosures may be added to measure deer impacts.

Meteorology — Data collected and maintained by Ranger Division.

Pests — Hemlock Wooly Adelgid, Dogwood Anthracnose, West Nile Virus and Gypsy Moths (NPS and USDA).

Pesticides Use — None.

Reptiles — None.

Soils — None.

Sound — None.

Vegetation — Rare plants (monitored by Native Plant Society and NPS), Exotics (mapped by NPS and EPMT but more work is needed).

Visitors — None.

Visual Landscape — None.

Water Quality — None.

Most Important Monitoring Needs

Monitoring of adjacent land use and development via photo points or aerial photography

White-tailed Deer abundance and impacts on natural resources (monitoring is already implemented)

Gypsy moth management: annual monitoring (monitoring is already implemented)

Monitoring geologic resources (monitoring is already implemented)

Monitor water quality at selected sites (monitoring is already implemented)

Monitor insect pests, which are a problem to structures, museums, library, and archive

Rare plant monitoring (monitoring is already implemented)

Wetland monitoring

Current Research Projects and Needs

Existing Research Projects — None.

Research Needs —

Evaluate impact of forest pest management operation and external pollution sources on moths, butterflies, damselflies, dragonflies, aquatic insects, and other fauna.

Identify major threats to rare fauna.

PARTNERING AND NEIGHBORING AGENCIES AND INDIVIDUALS

Partnering Agencies/Individuals

- Chesapeake and Ohio Canal National Historical Park
- Appalachian Trail
- FWS and US Customs Agency. HAFE manages 260 acres of the land owned by FWS and US Customs. This land is primarily leased to agriculture.

Neighboring Land Management Agencies

- Harpers Ferry Conservancy develops land easements and files lawsuits on behalf of environmental issues.

MANASSAS NATIONAL BATTLEFIELD

OVERVIEW

Manassas National Battlefield Park was established in 1940 to preserve the scene of two major Civil War battles that took place a few miles north of the prized railroad junction of Manassas, Virginia, in 1861 and 1862. The 2,064 ha park is located approximately 72 km southwest of Washington, DC within the Triassic basin of the northern Virginia Piedmont. The park is characterized by gently rolling hills with a patchwork of open fields and a successional range of oak-hickory forests with riparian vegetation along the streams.

Like other Civil War parks, Manassas NB has the unique challenge of combining the retention and re-creation of a historic landscape with natural resource management. Maintenance of the historical landscape, except in extreme cases, must take precedence due to the park's enabling legislation. However, this leaves flexibility for the management and preservation of the natural resources of the park and for the enjoyment of those resources by the public. Rare plants founds in the park include: Appalachian quillwort *(Isoetes appalachiana)*, marsh hedgenettle *(Stachys pilosa var. arenicola)*, blue-hearts *(Buchnera americana)*, hairy beardtongue *(Penstemon hirsutus)*, and buffalo clover *(Trifolium reflexum)*. In addition, several rare community types are found in the park, including oak-hickory forest, eastern white pine forest, Piedmont/mountain swamp forest, and upland depression swamp.

Natural resource issues for Manassas include suburban sprawl, potential overpopulation of white-tailed deer and beaver (*Castor canadensis*), exotic species, and a shortage of natural resource staff.

SUMMARY OF ENABLING LEGISLATION

The 1985 Statement for Management quotes the order from the Secretary of the Interior which established Manassas National Battlefield Park "Whereas certain lands and structures in Manassas Magisterial District, Prince William County, Virginia, because of their historical importance as the battlefield site of the First and Second battles of Manassas during the war between the States, have been declared by the Advisory Board on National Parks, Historic Sites, Buildings and other monuments to be of national significance...I, Harold L. Ickes, Secretary of the Interior...do hereby designate all those certain tracts or parcels of land, with the structures thereon...to be a national historic site, having the name 'Manassas National Battlefield Park.'"

Influences on Management: (A) Legislative and Administrative Constraints "The park is managed as a historical area under the appropriate provisions of its basic legislative authorization (8/21/35) and as amended (4/17/54)."

PARK RESOURCES AND SPECIES OF CONCERN

Most Valuable Resources

- Shrub/meadow habitat
- Basic oak hickory forest
- Eastern white pine forest
- Piedmont swamp forest
- Upland depression swamp

Species of concern have been identified and include species that are overabundant/invasive, as well as rare/threatened/endangered. 31 species of concern for Manassas National Battlefield were identified in the following taxonomic groups: 9 birds, 2 mammals, 2 herps, 4 invertebrates, 10 vegetation, and 4 vegetation communities. In addition, the park harbors at least 37 exotic species of concern. This subject will be discussed in greater detail by workgroup(s) at a later date.

Threats and Resource Management Issues

Threats —

- Exotic vegetation (especially ailanthus, multiflora rose, Japanese honeysuckle, and Japanese stiltgrass)

- White-tailed deer overabundance. The current population density estimate for fall 2000/spring 2001 =

142.5 deer/sq. mile; 90% CI: 127.50-159.50 deer/sq. mile.

Stream bank erosion along Young's Branch Development

Threat Abatement —

Shrub/meadow restoration of approximately 300 acres

100-acre partially-developed lot being restored, including 15 acres of wetland

Exotic plants are being mapped. Plans are underway to implement control measures of ailanthus and honeysuckle, among others. Eradication of all exotic species will focus on rare communities.

Resource Management Issues —

The overall goal of the park is to maintain the general landscape and viewshed as it was during the Civil War including natural and cultural resources.

Addressing development takes considerable staff time.

GMP is being developed and requires extensive planning.

Integrated pest management

Controlling exotic species. Emphasis placed on most common, including tree of heaven, multiflora rose, Japanese honeysuckle, and Japanese stiltgrass.

SUMMARY OF EXISTING MONITORING PROGRAMS AND NEEDS

Air — None.

Amphibian — None.

Birds — There are various volunteer efforts: (1) Northern Virginia Breeding Bird Study (Contact: Carolyn Williams, Fairfax Audubon Society). Point counts conducted since 1996. (2) CBC count conducted every year. (Contact: Jack Dent). (3) Also, Kestrel and barn owl nest boxes are inventoried by volunteer Mark Causey.

Fire — Chief of Visitor Protection is working on a fire management plan.

Fish — None.

Geology — None.

Mammals — Deer Distance Sampling started in FY2001 and is planned twice a year in spring and fall.

Meteorology — No data collected in the park but NOAA data is available for nearby Dulles Airport.

Pests — West Nile Virus and Gypsy Moths monitored as needed.

Pesticides Use — Pesticide logbook on file.

Reptiles — None.

Soils — None.

Sound — None.

Vegetation — Vegetation Plot Protocols were developed in 1997 for a vegetation monitoring study by CUE staff members to evaluate impacts from white-tailed deer. Data from the vegetation monitoring project is on file and is in a database including GPS locations of all plots. In addition, 30 deer exclosures were set up in 2000 to monitor vegetation types. Exotics have been mapped by Exotic Plant Management Team.

Visitors — Visitor counts made at the Visitor Center.

Visual Landscape — None.

Water Quality —

A wetland restoration project (15 acres) will be monitored through a Smithsonian Institution mitigation effort. MANA is awaiting monitoring protocols.

Audubon Naturalist Society collects macroinvertebrate data along Young's Branch quarterly. Intermittent Hach Kit water chemistry testing completed. Data is on file.

Water Quality data inventory and analysis was completed in 1997. The report described 16 groups of parameters that exceeded the screening criteria within the park. MANA is continuing to monitor the sampling sites as time permits.

Most Important Monitoring Needs

Exotic species and control efforts need to be monitored to identify best management practices

White-tailed deer need to be monitored and data analyzed (already implemented). In addition, there is a need to evaluate deer impacts on potentially sensitive species such as ground nesting birds.

Water quality monitoring is needed. Current work is limited to volunteer efforts by the Audubon Naturalist Society. There is additional concern about runoff from new roads and development.

Species of concern need to be monitored, including birds

Bird and mammal monitoring

Current Research Projects and Needs

Existing Research Projects — Deer exclosures set up to evaluate impacts of deer on native vegetation.

Research Needs — Evaluate impacts of deer on sensitive species.

PARTNERING AND NEIGHBORING AGENCIES AND INDIVIDUALS

Partnering Agencies/Individuals

None.

Neighboring Land Management Agencies

Conway Robinson – Virginia State Forest

MONOCACY NATIONAL BATTLEFIELD

OVERVIEW

Monocacy National Battlefield is located in central Maryland along the Monocacy River and is dominated by active farms with some second generation mixed hardwood forests and field/edge habitat. This park is managed as a cultural resource commemorating the Civil War battle that took place on July 9, 1864. Significant natural resources include three state endangered plants: Short's rockcress (*Arabis shortii*), dwarf larkspur (*Delphinium tricorne*), and harbinger-of-spring (*Erigenia bulbosa*) which have been located in the extreme southern section of the park.

Potential threats to the conservation of the park's natural resources include the release of airborne pollutants from industrial plants located southwest of the park and from heavy traffic on I-270, which bisects the park. Encroaching suburban sprawl makes the park an important preserve for wildlife and the spread of exotic plants has already been documented. An over-abundance of white-tailed deer may be altering the habitat in undesirable ways and needs to be evaluated.

SUMMARY OF ENABLING LEGISLATION

Resource Management Plan (1998) cites the Act to establish a national military park 48 Stat 1198, "Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled. That in order to commemorate the Battle of Monocacy, Maryland, and to preserve for historical purposes the breastworks, earthworks, walls, or other defenses or shelters used by the armies therein, the battlefield at Monocacy, in the State of Maryland, is hereby declared a national military park to be known as the 'Monocacy National Military Park'".

PARK RESOURCES AND SPECIES OF CONCERN

Most Valuable Resources

The overall goal of the park is to maintain the general landscape as it was during the Civil War. Current crops include corn, small grains (wheat, winter wheat, and barley), soybeans, and alfalfa.

Forest habitat (Triangle Woods)

Riparian habitat

Open fields

Some small wetlands

Species of concern have been identified and include species that are overabundant/invasive, as well as rare/threatened/endangered. 18 species of concern for Monocacy National Battlefield were identified in the following taxonomic groups: birds (8), mammals (1), invertebrates (1), and plants (8). This subject will be discussed in greater detail by workgroup(s) at a later date.

Threats and Resource Management Issues

Threats —

Exotic plants (focus on ailanthus, multiflora rose, and honeysuckle)

White-tailed deer. The current population density estimate for fall 2000/spring 2001 = 192.15 deer/sq. mile; 90% CI: 138-265 deer/sq. mile.

Encroaching housing development

Agricultural runoff into the Monocacy River

Water pollution to Monocacy Creek

Eutrophication, especially in Gambril Mill Pond

Sound from highway I-270, which bisects the park

Visitation to the park may grow rapidly in the future given rapid rate of development in surrounding areas.

Threat Abatement —

Easements to maintain agricultural setting

General Management Plan is being developed

Exotic Plants–EPMT has inventoried most of the park for exotics. Control efforts have targeted Brooks Hill. Target species include ailanthus, multiflora rose, and honeysuckle

MONO has a fire suppression plan

Restoration: Best farm planted 20 acres of warm season grasses in September 2001

Resource Management Issues —

Need more funding to get people into the field

Need to maintain the cultural and natural landscape

White-tailed deer overabundance

SUMMARY OF EXISTING MONITORING PROGRAMS AND NEEDS

Air — None.

Amphibian — None.

Birds — None.

Fire — None.

Fish — None.

Geology — None.

Mammals — Deer monitoring has been incorporated into the Antietam National Battlefield Deer Monitoring Program and includes distance sampling. Three deer exclosures have been established and are monitored by Dr. Bob Ford (Frederick Community College).

Meteorology — None.

Pests — USDA monitors Gypsy Moths.

Pesticides Use — Logbook is on file.

Reptiles — None

Soils — None.

Sound — None.

Vegetation — None.

Water Quality — Stream Water – volunteers may be monitoring chemistry at 11 sites within the park covering entrance and exit locations for stream flows.

Current Research Projects and Needs

Existing Research Projects — None.

Research Needs — None.

Most Important Monitoring Needs —

Deer overpopulation (already implemented)

Exotic vegetation (already implemented)

Species of concern, especially monitoring for rare plants in Triangle Woods where deer abundance and poaching are perceived problems

Water quality monitoring was recommended by MD – Heritage Program because of evidence of recent freshwater mussels living in the Monocacy River.

PARTNERING AND NEIGHBORING AGENCIES AND INDIVIDUALS

Partnering Agencies/Individuals:

Bob Ford (Frederick Community College) has collected fecal pellet counts at MONO.

Neighboring Land Management Agencies

None.

NATIONAL CAPITAL PARKS – EAST

OVERVIEW

National Capital Parks-East includes 12 major park areas covering 4,378 ha within the District of Columbia and three nearby counties in Maryland. The park lies entirely within the upper Coastal Plain physiographic region and is managed for a variety of natural, cultural, and recreational resources. Several administrative units provide significant natural resources including:

Anacostia Park – 227 ha river corridor park, with river access, recreational facilities, open space, restored tidal marshlands, and managed meadow habitat.

Fort Circle Parks (eastern section of the Civil War Defenses of Washington)– 409 ha; Forts Chaplin, Carroll, Davis, Dupont, Foote, Mahan, Stanton, and the Shepherd Parkway are managed for both their natural landscape and historical significance. Natural areas include extensive forested ridgelines of deciduous hardwoods, forest seeps, and a 10 ha stand of loblolly pine (*Pinus taeda*).

Fort Washington – 140 ha; remains of several forts built between 1808 and 1902 highlight changing military tactics. Approximately 2/3 of the park consists of high quality deciduous forest.

Frederick Douglass National Historic Site – 3.4 ha; home of the important historical civil rights figure. The property also contains woodlands but is primarily managed for its cultural and historic significance.

Greenbelt Park/Baltimore-Washington Parkway – 475 ha; oak-hickory woodland provides nature study, outdoor recreational activities. The historic limited access scenic parkway passes through deciduous forest, meadows, and maintained lawns.

Harmony Hall – 27 ha; on Broad Creek along the Potomac River and is largely wooded, with significant wetlands, waterfowl usage, as well as significant historic buildings.

Kenilworth Park and Aquatic Gardens – 285 ha; the only National Park Service site devoted to the propagation and display of aquatic plants. Contains remnant tidal wetlands, swamp forest, and restored tidal marsh.

Oxon Cove Park and Oxon Hill Farm – 196 ha; farm representative of the early 20th century and demonstrates historic farming principles and techniques. The land area varies from low flat river shoreline to high river terraces with intermediate rolling hills created by a reclaimed sanitary landfill, which existed on the site until the mid-1970s. Contains significant chestnut oak climax forest, and the meadow/shrub-scrub habitat and ponds of the old landfill have evolved into an important bird and wildlife area.

Oxon Run Parkway – 51 ha; an island sanctuary that is composed of deciduous forest and includes wetlands and floodplain areas. Includes several Magnolia bogs, NACE's rarest wetland community.

Piscataway Park – Stretches 9.7 km from Piscataway Creek to Marshall Hall (665 ha plus 1155 ha in easement); established in 1952 to preserve the river viewshed from Mount Vernon as it was in

George Washington's days and Fort Washington. Extensive high quality forest and significant wetlands, shell-marl ravine communities, etc.

Suitland Parkway – 247 ha; the limited access scenic roadway passes through deciduous forest, meadows, and maintained lawns.

Significant communities in the park include rare upland communities such as the glauconite rich shell-marl ravine forest and the northern (McAteean) magnolia bog. The state rare grass-leaved arrowhead tidal community alliance is also found. At least 60 rare plants have been documented in the parks. Nesting bald eagles are found along the park's 50 km of shoreline.

SUMMARY OF ENABLING LEGISLATION

The acquisition of much of the park lands under the jurisdiction of National Capital Parks East was done through the *Capper-Cramton Act of May 1930*. See George Washington Memorial Parkway. This legislation provided the authority for the acquisition of much of the parkland within the District of Columbia destined to become part of National Capital Parks-East." *1989 Resource Management Plan*

Anacostia — Public Law 60 (1909) 35 Stat. 700 states that the park "Provide[s] for the employment of Special Counsel to determine ownership of the land and riparian rights along the Anacostia River, for the purpose of improvement of the Anacostia flats." Most of the land now known as Anacostia Park was created under the authority of the Anacostia River Flats Act of 1914 (Public Law 63, 38 Stat. 549). The 1929 legislation creating the National Capital Planning Commission (44 Stat. 374) also designated three main purposes of the park including: 1. to prevent pollution of the Anacostia River, 2. to preserve the forest and natural scenery, and 3. to meet park and recreation needs of Washington DC residents.

Baltimore Washington Memorial Parkway — 1988 Resource Management Plan states, "The Act of August 2, 1950 (P.L. 643-81st Congress) provided for the acquisition, construction, development, administration and maintenance of the parkway as a part of the park system of the District of Columbia and its environs by the Secretary of Interior. The stated purpose was 'to provide a protected, safe and suitable approach for passenger-vehicle traffic to the Nation's Capital and for an additional means of access between the several Federal establishments adjacent thereto and the seat of government in the District of Columbia."

Specifically the B-W Parkway Act says (1) it is to be regarded as a part of the park system of the District of Columbia and environs (section 1), and (2) the Act of Aug. 25, 1916 (39 Stat. 535) and amendments and supplements apply (section 1), and (3) lands may be obtained under authority of the Act of May 19, 1930 (46 Stat. 482). Now the park system of D.C. and environs is under the National Park Service and the basic Act that tells the purpose of these parks was approved June 6, 1924, amended in 1926, and 1953, (42 Stat. 463, 44 Stat. 374, Public la2 592). Among other things the purpose of these parks is to prevent pollution of the Potomac and Anacostia Rivers [several streams that cross the parkway including those in Greenbelt Park which is a part of the Parkway are tributary to the Potomac and Anacostia], to preserve forests and natural scenery and resources, and to preserve features of historic and scientific interest and educational value (section 1 of original act and first amendment, section 4b of second amendment)"

Capitol Hill Parks — 1989 Resource Management Plan states, "In 1924, Congress (43 Stat 463), directed the Commissioners to provide 'for a comprehensive development of the park and playground system of the National Capital.'"

Greenbelt — The land making up Greenbelt park was acquired along with that which formed the Baltimore Washington Memorial Parkway. Public Law 643 81st Congress Chapter 525 2D Session H. R. 5990 states that lands acquired for the BW Parkway "shall be regarded as an extension of the park system of the District of Columbia and its environs...and it shall be constructed, developed, administered, and maintained by the Secretary of the Interior, through the National Park Service"

1984 Development Concept Plan states, "The primary intent of the park's enabling legislation is 'to provide overnight camping facilities to meet the needs of individuals, families and groups visiting the Nation's Capital; to serve as a regional park for residents of the National Capital area by providing a program of day-use recreation, picnicking and interpretation, and to preserve the area's remaining natural resources so that visitors may enjoy recreational experiences in a natural and pleasant environment.'"

Piscataway — The *1989 Resource Management Plan* states that "The basic purpose of the park cited in Public Law, 87-362, insures the preservation of scenic and historic values of lands which provide the principal overview of the Mount Vernon estate and Fort Washington, in a manner which will insure the natural beauty of such lands as it existed at the time of the construction and active use of Mount Vernon mansion and Fort Washington."

PARK RESOURCES AND SPECIES OF CONCERN

Most Valuable Resources

Natural landscape including unique habitats in an urban setting

Viewshed

Eastern deciduous forest

Mixed deciduous pine forest

Tidal and non-tidal wetlands including restored wetlands

Seeps

Glauconite rich shell-marl ravine forest and associated plant community.

Sandy beaches – especially at Mockley Point and Fort Foote. Also, gravel shorelines (cobblestone size), which include rare plant communities.

Magnolia bog at Oxon Run

Reptile and amphibian populations in many areas, including inner-city sites

Birds (including ground-nesting species within the city limits)

Species of concern have been identified and include species that are overabundant/invasive, as well as rare/threatened/endangered. 209 species of concern for National Capital Parks East were identified in the following taxonomic groups: 21 birds, 2 fish, 3 mammals, 12 herps, 13 invertebrates, 153 vegetation, and 5 vegetation communities. This subject will be discussed in greater detail by workgroups at a later date.

Threats and Resource Management Issues

Threats —

Exotic plant invasion

Development on adjacent lands; also development pressure on park lands from DC

Abundant white-tailed deer

Feral cats

Visitor impacts including illegal dumping; soil compaction

Sedimentation and urbanization of streams/erosion

Pollution

Threat Abatement —

Public outreach

Increased vigilance of surrounding development and border issues

Exotic Plant Management Team

Land easements (approximately 2/3 of Piscataway is protected through land easements)

Resource Management Issues —

Address NEPA compliance issues

Interpreting of the natural resources (protecting NR requires public understanding; understanding comes from interpretation and education)

Building internal and external support for the natural resources in the parks

Development of general management plans for all park units

Preserving the overall integrity of the natural landscape

SUMMARY OF EXISTING MONITORING PROGRAMS AND NEEDS

Air — None.

Amphibian — Upland chorus frog monitoring protocol being developed by Dr. Robin Jung (USGS).

Birds — Flyovers of nesting Bald Eagles conducted by USGS; bird and other observations made along transect at Kingman Lake by resource manager.

Fire — None.

Fish — None.

Geology — None.

Mammals — Deer Distance Sampling started in FY2001 and is planned twice a year in spring and fall at Greenbelt and Piscataway. Fort Washington may be added.

Meteorology — Available at Reagan National Airport.

Pests — West Nile Virus monitored by region; and Gypsy Moths monitoring coordinated with CUE and USDA.

Pesticides Use — Pesticide logbook on file.

Reptiles — None (except for Kingman Lake transect – see birds above).

Soils — None.

Sound — None.

Visitors — Data on visitor numbers may be available; visitor impacts are not monitored.

Vegetation—

Restoration–vegetation and seedbank plots monitored by USGS at Kingman Lake.

Permanent Plots–set up at Greenbelt Park but are not monitored.

Submerged Aquatic Vegetation–monitored by USGS.

Crops–farmers collect yield data.

Visual Landscape — None.

Water Quality — There has been water quality monitoring at Kingman Lake and Kenilworth by USGS as part of restoration effort. The project is ongoing and annual reports are on file. In addition, there have been several other water quality evaluations in the park. The DC-COG has collected surface water quality at Fort Dupont. This one time evaluation may continue into the future. Also, WSSC has done water quality work in Piscataway in the 1970s. A report is on file. Groundwater was measured by USCE at Oxon Run prior to Metro construction; well sites are still in place but are not monitored. The Potomac and Anacostia Rivers fall under the jurisdiction of Maryland and District of Columbia.

Most Important Monitoring Needs

Exotic Plants and their effect on native species and forest regeneration (already implemented but more effort needed)

Development and boundaries (already implemented but more effort needed)

Deer and their impacts on native species and forest regeneration (already implemented but more effort needed)

Forest regeneration

Monitoring of species of concern

Monitoring of restored wetlands (already implemented but more effort needed)

Shoreline change

Feral cats and their impacts on native wildlife

Monitoring of vegetation types and habitats

Monitor effects of hunting on waterfowl abundance in the park.

CURRENT RESEARCH PROJECTS AND NEEDS

Existing Research Projects:

Effects of Organic and Inorganic Contaminants on Wildlife at Kingman Lake and Kenilworth Marsh--submitted in 1999. The project to evaluate toxic buildup in Barn Swallows has been implemented. A final report will be forthcoming upon completion.

Research Needs — None.

PARTNERING AND NEIGHBORING AGENCIES AND INDIVIDUALS

Partnering Agencies/Individuals

- Anacostia Watershed Restoration Committee
- USGS-BRD [has several Anacostia Projects, including monitoring at Kingman Lake by Dick Hammerschlag]
- USFWS
- DC-COG has several water quality studies
- Anacostia Toxic Alliance (EPA, FWS and others) works on toxicity projects in the Anacostia Watershed
- MD–DNR works on hunting program along Piscataway Park shore
- There are also several watchdog groups (Anacostia Watershed Society, Anacostia River Keeper, Sierra Club, Neighborhood Groups, and Natural Resource Defense Council).

Neighboring Land Management Agencies

- Smallwood State Park

PRINCE WILLIAM FOREST PARK

OVERVIEW

Prior to the 1700s, the area now covered by the 7,518 ha Prince William Forest Park was forested by deciduous trees. By the early part of the 20th century, much of that land had been farmed or mined. In 1936, an Executive Order was issued, establishing the Chopawamsic Recreation Demonstration Area, one of 46 recreation demonstration projects in 25 states. The Civilian Conservation Corps (CCC) constructed five cabin camps, numerous roads and lakes, and miles of trails to provide recreational opportunities.

Management of the recreation area was turned over to The National Park Service in 1940, and, in 1948, its name was changed to Prince William Forest Park. A significant mineral deposit of iron pyrite exists within the park boundary. This is the largest of its kind in Prince William County and one of the largest in the United States. The 30 square mile watershed of the Quantico Creek is almost entirely forested. The headwaters of South Fork Quantico Creek, 9 square miles, lie within Quantico Marine Corps Base, while 4 square miles of watershed are in private ownership. The remaining 17 square miles of the watershed lie within the park. Thus, the park has the unique opportunity to preserve and protect a large portion of this ecosystem. Because the park includes two physiographic provinces (Piedmont and Coastal Plain) and lies in the transition zone between northern and southern climates, it exhibits a wide range of habitat and vegetative communities. It is now the only natural area in the National Park System that contains a significant expanse of Piedmont Forest. The park contains several rare communities, including a seepage swamp and remote stands of eastern hemlock that contain old growth specimens, and two rare plants, the federally threatened small-whorled pogonia (*Isotria medeoloides*) and a state endangered sedge (*Carex vestita*). The star-nosed mole (*Condylura cristata*), although secure in its range, is considered rare in Virginia and is abundant in the park. The first documented observation of a timber rattlesnake (*Crotalus horridus horridus*) in Prince William County was recorded in the park in 1992. Subsequent sightings of the timber rattlesnake indicate that a relict population may exist in the park.

SUMMARY OF ENABLING LEGISLATION

Resource Management Plan (1998) states, "On November 14th, 1936, President Franklin D. Roosevelt issued Executive Order number 7496 transferring such lands in several states to the Secretary of the Interior ... With the passing of Public Law Number 763 on August 13, 1940, the Chopawamsic Recreation Demonstration Area became 'a part of the park system of the National Capital and its environs'. On June 22, 1948, Public Law Number 736 was enacted to provide monies and authority to round out the boundaries of the recreational area and to transfer control of approximately 5,000 acres to the Secretary of the Navy for inclusion into Quantico Marine Corps Base properties contiguous with the park. In addition, the law changed the name of the park to Prince William Forest Park and charged the Department of Navy with guaranteeing 'the potability and the undamaged source of water of the South Branch of Quantico Creek to the lands lying east of Route 619...' The land purchase and transfer portions of the law have not been carried out." This fact is primarily due to the $10,000 limit appropriated for land purchases.

PARK RESOURCES AND SPECIES OF CONCERN

Most Valuable Resources —

- Piedmont forest
- Watershed
- Open space

Species of concern have been identified and include species that are overabundant/invasive, as well as rare/threatened/endangered. 16 species of concern for Prince William Forest Park were identified in the following taxonomic groups: 5 birds, 2 mammals, 4 herps, 2 invertebrates, 1 vegetation, and 2 vegetation communities. This subject will be discussed in greater detail by workgroup(s) at a later date.

Threats and Resource Management Issues

Threats —

Outside development and encroachment

Overuse by park visitors

Sedimentation

Loss of habitat

Soil compaction

Threat Abatement —

Education

Working with partners such as Prince William County and Quantico

Easements

Exotic plant control

Pest control, such as gypsy moth

Boundary patrols by park rangers

Resource Management Issues —

Outside development

Site restoration

Education of the surrounding community through interpretation

Maintaining water quality

Balancing natural resources protection with recreation activities, and park development

Protecting human health and safety

Protecting resources from external development and overuse

SUMMARY OF EXISTING MONITORING PROGRAMS AND NEEDS

Air — None.

Amphibian — Anuran call surveys; visual encounter surveys; larval surveys.

Birds — Breeding Bird Survey conducted by volunteers and data is available online. The park has data from Migratory Bird Counts conducted in 1992, 1993, 1994, 1998, and 1999.

Fire — There is a draft fire management plan. There is a MS Access database with fire data. Fires have been mapped through 1998. There is also a report on the fire history of the park.

Fish — A post-reclamation water quality monitoring study includes fish and benthics data.

The park has the Kelso draft report, which is a survey of fish and habitat.

Geology — None.

Mammals — Deer distance sampling started in FY2001 and is planned twice a year in the spring and fall.

Meteorology — In 1999, an automated fire-weather station was established. It collects a variety of fire weather related data, including relative humidity, fuel moisture, wind speed and direction, precipitation, and temperature. Law enforcement downloads the data. The park also obtains data from the weather station located on Quantico Marine Corps base, which is used in the Water Quality and Amphibian Monitoring programs.

Pests — The park responds to pest complaints such as termites, rodents, wasps, etc.. Gypsy moth egg mass surveys are done annually using 1/40-acre plots. The region monitors mosquitoes for the West Nile Virus.

Pesticides Use — Monitoring of structures is done, and pesticide use is recorded. Logs are turned in every year.

Reptiles — There is an ongoing timber rattlesnake project in the park by a GMU graduate student (Terry Creque). There is no monitoring for reptiles other than noting wildlife through wildlife observation cards, which are used for visitors and staff.

Soils — None.

Sound — There are problems with Quantico and I-95, but no monitoring is done.

Visitors — Visitor counters for cars are used. The visitor center maintains visitor statistics for cabins and campgrounds as well as for visitor contacts.

Vegetation —

Exotics – A binder that contains treatment forms and maps of the locations of exotic vegetation is maintained in the Resource Management office. RM staff worked with the EPMT this past year on numerous exotic vegetation removal projects. Prior to the EPMT, RM staff primarily worked in heavily infested and high use areas, treating approximately 1-5 acres per year. The EPMT is currently looking for and mapping additional locations of exotic species in the park.

Vegetation Plots – John Hadidian set up 50, 20 x 20 m plots throughout the park. The data folders were lost, and PRWI is currently trying to relocate these plots to start monitoring them again.

Rare plants – Annual surveys for *Isotria* are conducted by park staff. Loyal Merhoff conducted surveys for Isotria on potential exchange lands this past year, and Dr. Donna Ware will most likely be conducting surveys in the upcoming year on the lands affected by the construction of the new waterline.

Visual Landscape – The only established photo points in the park are at the Pyrite Mine Site. They were set up before the reclamation project in an effort to document the changes to the area as a result of the work that was performed.

Water Quality —

Macroinvertebrate data is collected at 34 points along Quantico Creek, South Fork and their tributaries. Fecal coliform data is collected from the 4 lakes weekly and from 7 stream sites biweekly. Water chemistry data is collected once a summer from the 4 lakes and the 7 stream sites. The chemical parameters being measured are sulfate, nitrate, nitrite, phosphate, lead, iron, aluminum, manganese, copper, and chlorine. The data collected under the current program goes back to 1995. Water quality data was collected before this point also. Fecal coliform data before 1995 was analyzed at CUE. Macroinvertebrate data was also collected. Resource management staff collects and manages the data. It is all stored in a Microsoft Access database.

PRWI is not currently monitoring groundwater depth. Groundwater water quality has been monitored at the pyrite mine site, the greenwood mine, and the newly acquired Freeman Bradford property.

Most Important Monitoring Needs —

Air quality

Noise pollution

Exotic species (already implemented)

Deer population and health (already implemented)

Post-burn monitoring of wildfires

Gypsy moths (already implemented)

Mosquitoes for West Nile Virus (already implemented)

Cultural – pest management

Threatened and endangered species (small whorled pogonia)

Birds–migratory bird monitoring

Amphibian monitoring (already implemented)

Surface water quality (already implemented)

Ground water quality

Vegetation plots

Monitoring of headwater wells. PRWI needs to have certain wells monitored prior to acquiring lands – as long as they still have legal recourse. Well testing will cost about $30,000. USGS may be able to fund some of the testing.)

Monitoring of Quantico Marine Base

Monitoring to predict fire danger, especially from Quantico

Current Research Projects and Research Needs

Existing Research Projects —

Survey of *Crotalus horridus* Population at Prince William Forest Park. Terry Creque, George Mason University.

Loudoun County Baseline Biological Monitoring Survey. John Galli, Metropolitan Washington Council of Governments.

Determine the Distribution of Mosquito Species Associated with West Nile Encephalitis and Survey Potential Breeding Habitat in NPS Units in the Northeast and National Capital Regions. Dr. Howard Ginsberg, URI.

National Park Service Bird Inventory – National Capital Region. Marcus Koenen, Center for Urban Ecology.

Sediment Survey of Quantico Creek and South Fork Quantico Creek. Michael Komelasky, George Mason University.

Fairfax County Stream Protection Strategy. Matt Handy, Fairfax County, Dept. of Public Works and Environmental Services.

Research Needs —

Map groundwater sinkholes, subsurface Karst resources

How can fire be used to manage exotic species?

Vegetation surveys

PARTNERING AND NEIGHBORING AGENCIES AND INDIVIDUALS

Partnering Agencies/Individuals

- Quantico Marine Base
- The town of Dumfries
- Prince William County

Neighboring Land Management Agencies

- The park is bounded on the South by Quantico Marine Corps Base, Quantico National Cemetery, and Prince.
- William County Park lands. A county park, Locust Shade, is located near the southeastern boundary of the park. There is also a county park, Hellwig, at Independent Hill. A golf course was added to Locust Shade and is located directly to the South of Prince William Forest Park.

ROCK CREEK NATIONAL PARK

OVERVIEW

Rock Creek National Park was set aside by Congress in 1890 for the preservation "of all timber, animals, or curiosities... and their retention in their natural condition, as nearly as possible." Besides being one of the oldest parks in the National Park Service, Rock Creek is also one of the largest forested urban parks in the United States, containing a wide variety of natural, historical, and recreational features in the midst of Washington, DC. The park also administers the Rock Creek and Potomac Parkway that connects this natural area to downtown, a series of historic sites from Civil War earthwork forts to colonial buildings, and landscaped areas in the District of Columbia. These areas total approximately 1,100 ha.

The park surrounds the lower watershed of Rock Creek and its tributaries as the drainage drops from the piedmont plateau to the coastal plain. The largest contiguous section of the park contains 726 ha of natural forests along Rock Creek. The mixed deciduous forests, streams, and sensitive floodplain communities contain a variety of wildlife including 22 state or watch-listed plant species and 2 state-listed birds. The park also contains Washington's only endangered species, the Hay's Spring Amphipod, a crustacean found in selected freshwater springs.

Except for the narrow extension of parkland into Maryland that is under county administration, Rock Creek Park represents a largely isolated natural system surrounded by urban areas, which have impacted the park in significant and fundamental ways. These effects include flooding and pollution in park streams, introductions of invasive non-native species into natural areas, extirpations or reductions of sensitive native species, and the artificial inflation of a few native species' populations adversely that affect other native plants and wildlife.

SUMMARY OF ENABLING LEGISLATION

Public No. 297 Section 7 September 27, 1890 states "That the public park authorized and established by this act shall be under the joint control of the Commissioners of the District of Columbia and the Chief of Engineers of the United States Army...such regulations shall provide for the preservation from injury or spoliation of all timber, animals, or curiosities within said park, and their retention in their natural condition, as nearly as possible."

PARK RESOURCES AND SPECIES OF CONCERN

Most Valuable Resources

Rock Creek and tributaries

Natural springs, vernal pools, and wetlands

Meadow habitat

Riverine flood plain

Upland deciduous forests

Herps

Neotropical Migrants

Species of concern have been identified and include species that are overabundant/invasive, as well as rare/threatened/endangered species. 77 species of concern for Rock Creek National Park were identified in the following taxonomic groups: 12 birds, 5 mammals, 11 herps, 4 invertebrates, 45 vegetation, and 3 vegetation communities. This subject will be discussed in greater detail by workgroups at a later date.

Threats and Resource Management Issues

Threats —

Exotics plant species

White-tailed deer overabundance. The current population density estimate for fall 2000/spring 2001 = 59 deer/sq. mile; 90% CI: 34.25-101.25 deer/sq. mile.

Boundary (dumping, encroachment, development)

Sedimentation (driven by water quality, sewer issues)

Stream bank erosion (driven by water quantity)

Urban runoff, sediment control, water quality, leaky sewers, and combined sewer overflows (CSOs)

Springs and groundwater (water levels and quality)

Traffic (reducing wildlife populations)

Urban influence: illegal collecting, feral animals (e.g., cats), trash, development and loss of groundwater (the park is losing floodplain habitat because of the lowering of groundwater tables)

Tree disease (Dutch elm, dogwood, red oak decline)

Flood damage

Acid deposition

Loss of wildlife habitat

Threat Abatement —

Treatment of exotic plants

Resource Management Issues:

Non-native plants

Management of rare, threatened, and endangered species

Shrinking habitats

Maintaining water quality

Overabundant deer

Traffic

Development along the borders and encroachment

SUMMARY OF EXISTING MONITORING PROGRAMS AND NEEDS

Air — None.

Amphibians — Partners in Parks volunteer program coordinated by Robin Jung—monitoring methods include coverboards and transects on waterways and tributaries. Northern section of park being inventoried. Dr. Jung also performs separate herp surveys that are part of the national Amphibian and Reptile Monitoring Initiative (ARMI).

Birds — Breeding Bird Census–data available since 1948; Christmas Bird Count – conducted annually since 1960s; raptors and waterfowl have been surveyed but monitoring program has not been established.

Fire — Fires are inspected when they occur and evaluated to determine cause. Ken Ferebee writes an incident report. Fire locations since 1997 are in the GIS database.

Fish — The D.C. government monitors the fish populations at three sites on the main stem of Rock Creek. DC also samples egg and larvae at the mouth of Rock Creek once a week during fish migration. The tributaries are monitored every other year to get a population estimate. DC also collects fish tissue samples for toxicity analysis of the Potomac and Anacostia. Three-four sites north of Pierce Mill will be monitored monthly for all species during anadromous fish spawning season.

Geology — None.

Mammals —

Deer distance sampling implemented in 2000 as part of a regional monitoring program; Spotlight deer counts have been for the last six years by park personnel; in 2000, 40 paired deer exclosure plots were set up – 20 exclosures and 20 control plots.

Beaver monitoring protocols were set up in 1980. The population survey is repeated every 8-10 years.

Meteorology — There is a weather station with a thermometer and a rain gauge at the visitor center. Data is usually submitted to NOAA or D.C.

Pests — Gypsy moth egg masses are monitored every year. There are 200 plots (1/40 acre plot) set up on a grid system, including the tributary parks. 57 are read each year in oak forest habitats.

Pesticide Use — Pesticide logbook is on file.

Reptiles — No monitoring of reptiles is being done. A mark and recapture study of box turtles was implemented in 2001.

Soils — None.

Sound — Carter Barron monitors sound emanating from theatre to meet local regulations. There are no other monitoring stations.

Vegetation —

There are 20 plots set up to monitor the invasive non-native plant mitigation program. Ten of these plots are control and ten are treatment. This is follow-up to a 3-year research program initially conducted 1996–1998.

There are 27 long-term vegetation plots set up to monitor trees, soils, herbaceous layer, etc. So far they have been done every 4 years: 1991, 1995, 1999, and one is planned for 2003.

Visitors — Permanent traffic counters are set up; data is compiled by the Washington Support Office in Denver. Also, the interpretation program maintains numbers of visitors using the visitor center, guided talks, horse rides, etc. Visitor impacts are not monitored.

Visual Landscape — No photo points.

Water Quality —

DC has fixed station monitoring (two stations read once a month; metals are measured quarterly). The tributaries are measured for fecal coliform and metals quarterly. A hydro lab measures temperatures, dissolved oxygen, pH, conductivity monthly at the fixed stations and quarterly on the tributaries. Macroinvertebrates are sampled every other year at two spots. Also the Audubon Naturalist Society volunteers program samples macroinvertebrates quarterly on three tributaries.

The U.S. Geological Survey's gauging station at Sherrill Drive is still running to collect flow data.

There is currently intermittent long-term monitoring of periodic flow at West Spring.

Regular annual inspections are performed for stream channels, sanitary sewer stream crossing, trails, and boundaries of the park.

Most Important Monitoring Needs

Deer impact – monitor sensitive plants and vegetative impacts more frequently

Herps–monitor population status and threats annually

Rare plants/animals – monitor status and threats of known listed species (including macroinvertebrates, though they don't know how they can do this)

Springs–monitor flow and water quality testing at multiple sites 2-4 times annually

Exotics – monitor degree of infestation; monitor degree of regrowth in treatment areas; monitor regeneration of native species on treated sites; monitor residual effect of herbicides

Boundaries and encroachment

Monitoring of flow and water quality during dry weather at 275 storm water outfalls and 49 combined sewer outfalls draining into the park.

Urban runoff, sediment control

Anadromous fish – after stream barrier mitigation

Tree disease – monitor status of Dutch elm disease and dogwood anthracnose

Roadkills – more systematic sampling needed

Moths and butterflies – monitor species and numbers in natural area

Flow/water quality – continuous monitoring at fixed station on Rock Creek

Water quality – monitor several water quality parameters on the tributaries

Fish numbers and diversity – monitor Rock Creek and tributaries every 2–3 years

Macroinvertebrate numbers and species diversity – increase monitoring sites on Rock Creek and include 14 tributaries

Trails – monitor erosion rates and repair/stabilize

Picnic areas – monitor soil compaction, erosion, and tree health at 30 sites each 2 years

Property encroachments – monitor forest regeneration at 100+ sites along the park boundary

Air quality – biological monitoring of numbers, locations and health of plant species sensitive to air quality

Long-term meadow monitoring

Ground water levels and quality – rare spring invertebrates

Vegetation impact of deer

CURRENT RESEARCH PROJECTS AND NEEDS

Existing Research Projects — Ongoing project evaluates control measures (glyphosate) for *Ranunculus*.

Research Needs —

Survey for bobcat, coyote, gray fox, flying squirrel, and opossum. Gray fox and opossum may be declining, and flying squirrel may be scarce.

PARTNERING AND NEIGHBORING AGENCIES AND INDIVIDUALS

Partnering Agencies/Individuals

- DC – water quality monitoring/fish monitoring
- Audubon Naturalist Society – Christmas Bird Count, Breeding Bird Census, volunteer stream monitoring
- Volunteers who work on exotic species control
- Maryland Native Plant Society – monitor rare plants
- USGS – monitor flow of Rock Creek
- Partners in Parks – inventory and monitoring of herps.

Neighboring Land Management Agencies

- District of Columbia

WOLF TRAP FARM PARK

OVERVIEW

Wolf Trap Farm Park encompasses 53 ha of rolling hills and woods originally donated to the National Park Service by Catherine Filene Shouse to be used exclusively for the performing arts. It is now the only National Park dedicated to the performing arts, and its largest venue seats over 7,000 people.

Wolf Trap Farm Park lies entirely within the Piedmont Province. Within the boundaries of the park are streams, meadows and heavily wooded areas.

SUMMARY OF ENABLING LEGISLATION

Public Law 89-671 89th Congress, S. 3423 October 15, 1966 reads, "Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That for the purpose of establishing in the National Capital area a park for the performing arts and related educational programs, and for recreation use in connection therewith, the Secretary of the Interior is authorized to establish, develop, improve, operate, and maintain the Wolf Trap Farm Park in Fairfax County, Virginia."

Public Law 97-310 October 14, 1982 Section 8 (b) "The Secretary shall monitor noise pollution which is associated with the Dulles road corridor (including the airport access and toll roads) and shall notify the Federal Aviation Administration, the Commonwealth of Virginia, and the appropriate committees of Congress if, after conferring with the Administrator of the Federal Aviation Administration, the Secretary finds that such noise pollution is exceeding the standards set forth in section 4(e). Within sixty days after any such notification, the Administrator of the Federal Aviation Administration shall take steps to reduce noise pollution so as to conform to such standards. The Secretary or the Foundation may bring an action in the United States District Court for the District of Columbia to in join any violation by the Commonwealth of Virginia of the easement referred to in section 4 (e)."

PARK RESOURCES AND SPECIES OF CONCERN

Most Valuable Resources—

Forest patches in the midst of development

Streams including Court House Branch and Wolf Trap Run.

Riparian forest along Court House Branch and Wolf Trap Run.

Species of concern have been identified and include species that are overabundant/invasive, as well as rare/threatened/endangered species. 6 species of concern for Wolf Trap Farm Park were identified in the following taxonomic groups: birds (2), mammals (1), invertebrates (1), vegetation (1), and vegetation communities (1). The subject will be discussed in greater detail by workgroups at a later date.

Threats and Resource Management Issues

Threats —

Water Quality is a major concern. Fecal coliforms have been measured in Wolf Trap Creek and pose a public health issue. Swimming is no longer allowed in the creek. Also, Old Court House Branch contained zero macroinvertebrates in 2000 surveys (more recent surveys documented some macros, however).

Stream bank erosion has occurred due to increased development around the park. The erosion may threaten the maintenance yard in the future. This has lead to sediment deposition.

Runoff from the Dulles Toll Road may have detrimental effects.

Streams threatened by fertilizer runoff from the park's management are a concern. There may be other related issues, such as parking lot runoff.

Exotic species coming into the park from neighbors is a concern; the park also has planted exotics in the past.

Deer may be causing a browsing problem, but this has not been monitored.

Salt storage in maintenance yard is a concern (runoff to stream).

Encroachment onto the park boundaries is some concern – neighbors dump grass clippings, etc. onto the property and develop informal trails.

Noise from the Dulles Toll Road is a problem.

Threat Abatement —

Resource Management has been communicating with McLean Bible Church about soil erosion and associated sedimentation problems.

Homeowners Association keeps some areas out of development.

Stream bank stabilization has occurred near the east parking lot to prevent further encroachment upon the park's road.

Scenic easements exist on the east side of Trap Road.

Resource Management Issues —

Visitor Impacts–Maintaining grass parking lots is a huge effort. It is difficult due to the nightly parking needs during the summer concert series.

SUMMARY OF EXISTING MONITORING PROGRAMS AND NEEDS

Air — None.

Amphibians — None.

Birds — Eastern bluebird only (volunteer – data is not available).

Fire —None.

Fish — None.

Geology — None.

Mammals —None.

Meteorology — None.

Pests — West Nile Virus, Gypsy Moth

Pesticides Use — None.

Reptiles — None.

Soils — None.

Sound — None.

Vegetation — Exotic plant species are being mapped by EPMT.

Visitors — None.

Visual Landscape — None.

Water Quality — (1) Surface waters monitored by NPS (focus on macroinvertebrates and pesticides). (2) Monitoring also by Northern Va. Soil & Water Conservation District which follows the Izaak Walton League protocol (contact Joanna Arciszewski at Joanna.Arciszewski@co.fairfax.va.us). (3) Audubon Naturalist Society is conducting independent Water Quality monitoring (Contact Cliff Fairweather).

Most Important Monitoring Needs

Water Quality needs continued monitoring

Exotic Plants (limited; already implemented)

Deer browse to monitor deer impact

Current Research Projects and Needs

Existing Research Projects — None.

Research Needs — None.

PARTNERING AND NEIGHBORING AGENCIES AND INDIVIDUALS

Partnering Agencies/Individuals

None.

Neighboring Land Managers

- Homeowners Associations including:
- Cinnamon Woods HA (west)
- Shouse Village HA (north)
- Wolf Trap/Wolf Den HA (north and west)

Appendix E

Rare, Threatened and Endangered Species Prioritization

Urban parks are often overlooked for their biodiversity but many reprsent remnant habitats especially for rare species that may be displaced by the harsh conditions in urban ecosystems (Stalter et al. 1996). This is also true for the National Capital Region Network (NCRN) where the parks were established mainly for their cultural value, yet provide unique habitats for the region's rare species. The Potomac Gorge, for example, stretching along 24 km of the Chesapeake and Ohio Canal National Historical Park (CHOH) and the George Washington Memorial Parkway (GWMP), is considered one of the country's most biologically diverse areas due to its unusual hydrogeology and its more than 400 occurrences of 200 rare plants (Cohn 2004; Wiegand 1999; NPS and TNC 2001). Over 382 rare species and communities have been documented in the NCRN by the heritage programs in the DC metropolitan area (The Nature Conservancy 1999). Additional data review, including literature searches, data queries from the NPS inventory database (NPSpecies), park lists of rare species, and interviews with park superintendents and resource managers, resulted in a list of over 600 species that were considered rare or of special concern.

Given the long list of species with varying ecological needs, the rare, threatened, and endangered species (RTE) workgroup prioritized species based on rarity and viability (Noss 2002). The rare, threatened, and endangered species workgroup developed criteria to prioritize species reflecting legal protection following guidelines DO-77-8 Section 3.1 and 3.2 (NPS 2002) as well as rarity and viability based on heritage ranks (NatureServe 2002). See figure 1 for an outline of the prioritization process.

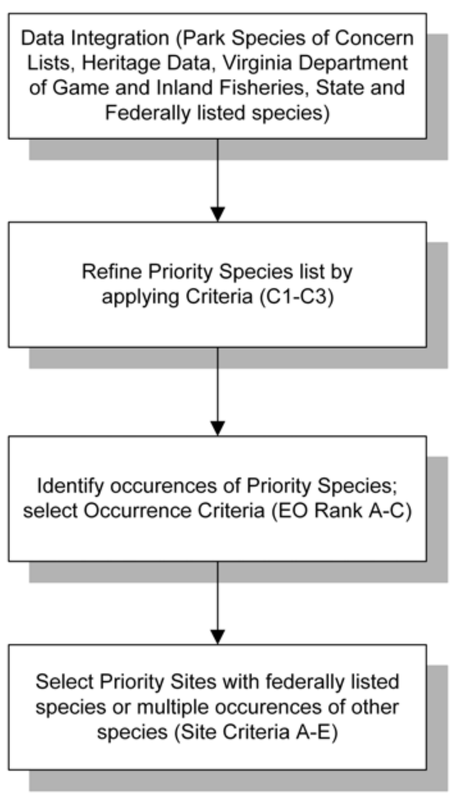

FIGURE 1: STEPS OUTLINING RARE, THREATENED, AND ENDANGERED SPECIES PRIORITIZATION PROCESS

Priority Species Criteria

Legally Protected Species (DO-77-8; Section 3.3);

Criterion 1 (federal): Species listed under the *Endangered Species Act*

Criterion 1 (state): Any species listed as threatened or endangered by Maryland or Virginia (note that West Virginia and the District of Columbia do not maintain state listed species). Species meeting this criteria will be additionally ranked according to G rank where G1 species will have the highest priority and G5 will have the lowest priority.

High Priority Species (DO-77-8, Section 3 for heritage rank definitions):

Criterion 2: G1 and G2 ranked species

Criterion 3: G3 ranked species

Criterion 4 (G4/S1): This criterion was added to provide guidance to parks wishing to prioritize additional monitoring programs once species meeting Criteria 1–3 were being monitored. This criterion would not be used by the NCRN Inventory and Monitoring (I&M) program to set priorities.

Criterion 5: Other species by nomination: Given limited information currently available and the anticipation of new knowledge gained from field research, the workgroup added an additional criterion to weigh in newly acquired information. The Nature Conservancy's Eco-regional Plans may be sources of information on species for nomination. Examples of "other species by nomination" could include:

- A species indicative of a long-term trend that is currently not threatened
- A species of unique/unusual significance to a location
- A non-native species which may threaten other species in the future
- Species of Concern as listed by Partners in Flight

Note that species originally listed as G? in the heritage database were not considered, because not enough information was currently available about their status.

Viability: Preserving viable populations was considered to be a high priority. Although limited information is available, heritage data does rank viability factors based on subject matter experts. Only occurrence with viable populations were considered for monitoring. These occurrences were defined by heritage data EO Ranks A–C (The Nature Conservancy 1999).

These criteria were applied in the following sequence:

Step 1 — Reviewed heritage data for VA, MD, WV, and DC. Queried data by all criteria 1–3 (Fed listed Threatened and Endangered (T&E), State T&E for Maryland and Virginia, and occurrences with EO Ranks = A, B, or C (including CD). All other ranks were removed.

Step 2 — Data provided by parks (including APPA) were added to the list if they met Criteria 1–3. This data included occurrence that may have been recorded in the parks but had not yet been entered into heritage databases. Maryland, for example, has not entered new data during the last 5 years.

Step 3 — Reviewed Virginia Department of Game and Inland Fisheries species database and added species meeting criteria 1–3.

Step 4 — Removed duplicates. For example, species ranked G1G2 may show up under both Criterion 2 and 3 during the queries

By applying the steps above, the original list of over 600 species was whittled down to 341 viable occurrences as follows:

C1 Fed	22 occurrences
C1 (Plants)	210 occurrences (G2 = 6; G3 = 17; G4 = 46; and G5 = 141 occurrences)
C1 (Animals)	29 occurrences
C2	25 occurrences
C3	55 occurrences

See table 1 for a complete list of occurrences. Among them are three C1 animal species that are already being monitored or will soon be monitored by other agencies including the Bald Eagle, Indiana Bat, and American Sturgeon.

Priority Sites Criteria

Many of priority species identified above occurred in close proximity and could potentially be monitored together. The workgroup adopted a site based monitoring approach similar to one developed by the Heritage Programs and The Nature Conservancy (The Nature Conservancy 2000; Poiani et al. 1998). Site based conservation has proven to be more efficient and effective than the species based approaches.

Using heritage ranks to prioritize vegetation communities was considered by the workgroup but there was no data available for the National Capital Region Network. The workgroup, however, was able to prioritize sites based on the number of priority species occurring at a given site.

An important monitoring site was defined by the working group as:

1. An area where one or more priority species is present;
2. The critical area needed by a species for its life history;
3. The area that contains the ecological processes necessary for the species or community to persist.

Sites were prioritized as follows:

A – Any site with at least one federally listed species occurrence.

B – Any site with >1 G1-G3 occurrence.

C – Any site with at least one G1

D – Any site with at least one G2

E – Any site with >2 State listed T&E species.

State listed species were a lower priority because many species that are state listed are still considered common throughout their range and have a G4 or G5 ranks. As a result of this analysis, we have 40 sites for monitoring viable rare, threatened, and endangered species occurrence (see table 2). If protocols are developed for monitoring a site, we will attempt to monitor all species at a site, not just those that were a priority. This might have to be changed, since many at the last rare, threatened, and endangered species meeting said that species-level protocols are necessary. Also I was wondering when reading above about criterion 1 state. It doesn't make sense to include state listed species with a G rank of 3, 4 or 5. If these were eliminated as well as those species meeting criteria 3, there would be a manageable number of species and sites. This may be necessary since species-level monitoring protocols are required. Some may overlap enough to have the same or similar monitoring protocols, but many will not.

TABLE 1: LIST OF RARE, THREATENED, AND ENDANGERED SPECIES MEETING RARE, THREATENED, AND ENDANGERED SPECIES CRITERIA 1–3

Common Name	Criteria	G Rank	S Rank	State Protection Status	Federal Status	Site Name
Alleghany Cave Amphipod						
	C1 State Animal	G4		T		CHOH
	C1 State Animal	G4		T		CATO
Alleghany Plum						
	C1 State	G4	S2	T	No Status	Big Run Glades
Amelanchier nantucketensis						
	C3					CHOH
American Beakgrain						
	C1 State	G4?	S1	E	No Status	Little Pool
	C1 State	G4?	S1	E	No Status	Licking Creek Scour Bar
	C1 State	G4?	S1	E	No Status	Little Pool
	C1 State	G4?	S1	E	No Status	Potomac Gorge
	C1 State	G4?	S1	E	No Status	Sideling Hill Creek Macrosite
	C1 State	G4?	S1	E	No Status	The Neck
American Frog's-Bit						
	C1 State	G4	S1	E		Piscataway/Fort Washington
American Ginseng						
	C3	G3G4	S2			GWMP
	C3	G3G4	S2			CHOH
	C3	G3G4	S2			CATO
	C3	G3G4	S2			NACE
Appalachian Spring Snail						
	C2	G2	S2			CHOH
Bald Eagle						
	C1 Federal	G4	S2S3B,S3N	T	LT,PDL	Prince Georges
	C1 Federal	G4	S2S3B,S3N	T	LT,PDL	Washington
	C1 Federal	G4	S2S3B,S3N	T	LT,PDL	Frederick
	C1 Federal	G4	S2S3B,S3N	T	LT,PDL	ANTI
	C1 Federal	G4	S2S3B,S3N	T	LT,PDL	Prince Georges
	C1 Federal	G4	S2S3B,S3N	T	LT,PDL	HAFE
	C1 Federal	G4	S2S3B,S3N	T	LT,PDL	Prince Georges
	C1 Federal	G4	S2S3B,S3N	T	LT,PDL	CATO
	C1 Federal	G4	S2S3B,S3N	T	LT,PDL	CHOH (Breeding)
	C1 Federal	G4	S2S3B,S3N	T	LT,PDL	Piscataway/Fort Washington
	C1 Federal	G4	S2S3B,S3N	T	LT,PDL	Potomac Gorge
	C1 Federal	G4	S2S3B,S3N	T	LT,PDL	GWMP
	C1 Federal	G4	S2S3B,S3N	T	LT,PDL	PRWI
	C1 Federal	G4	S2S3B,S3N	T	LT,PDL	NACE
	C1 Federal	G4	S2S3B,S3N	T	LT,PDL	ROCR
Big Shellbark Hickory						
	C1 State	G5	S1	E	No Status	Little Pool

Table 1: List of Rare, Threatened, and Endangered Species Meeting Rare, Threatened, and Endangered Species Criteria 1–3 (continued)

Common Name	Criteria	G Rank	S Rank	State Protection Status	Federal Status	Site Name
Bigger's Cave Amphipod						
	C2	G2G4				CHOH
	C2	G2G4				CATO
Black-Fruit Mountain-Ricegrass						
	C1 State	G5	S2	T	No Status	Dargan Bend Woods
	C1 State	G5	S2	T	No Status	Ferry Hill Limestone Cliffs
	C1 State	G5	S2	T	No Status	Dam Number Four Cliffs
	C1 State	G5	S2	T	No Status	Taylors Landing
	C1 State	G5	S2	T	No Status	The Neck
Blackburnian Warbler						
	C1 State Animal	G5	S1	T		ROCR
	C1 State Animal	G5	S1	T		NACE
	C1 State Animal	G5	S1	T		GWMP
Blue Ridge Mountain Amphipod						
	C2	G2	S2			Reservoir Hollow
	C2	G2	S2			Reservoir Hollow
Blue Ridge Spring Amphipod						
	C3	G3	S2S3	qq	No Status	Reservoir Hollow
Blue Ridge Springsnail						
	C1 State Animal	G2G3	S1	E	No Status	Howell Cave
Bluntleaf Spurge						
	C1 State	G5	S1	E	No Status	Bevan Bend Shale Barren
	C1 State	G5	S1	E	No Status	Mccoys Ferry
	C1 State	G5	S1	E	No Status	Piscataway/Fort Washington
Bog Bluegrass						
	C3					APPA
	C3	G3	S2			Richard Thompson Wildlife Management Area
Bog Fern						
	C1 State	G4G5	S2	T	No Status	Suitland Bog
Broad-Glumed Brome						
	C1 State	G5	S1	E	No Status	Graham Tunnel Bend
	C1 State	G5	S1	E	No Status	Ferry Hill Limestone Cliffs
Brook Floater						
	C1 State Animal	G3	S1	E	No Status	Potomac River - Cherry Run
	C1 State Animal	G3	S1	E	No Status	Potomac River - Pearre
	C1 State Animal	G3	S1	E	No Status	Sideling Hill Creek Macrosite
Buttercup Scorpion-Weed						
	C1 State	G2	S1	E	No Status	Clara Barton Area
	C2	G2	S1	qq	No Status	Turkey Run Park Slopes
	C1 State	G2	S1	E	No Status	Potomac Gorge

Table 1: List of Rare, Threatened, and Endangered Species Meeting Rare, Threatened, and Endangered Species Criteria 1–3 (continued)

Common Name	Criteria	G Rank	S Rank	State Protection Status	Federal Status	Site Name
Butternut						
	C3	G3G4	S1			CATO
	C3	G3G4	S1			HAFE
	C3	G3G4	S1			GWMP
	C3	G3G4	S1			NACE
	C3	G3G4	S1			CHOH
	C3	G3G4	S1			MANA
	C3	G3G4	S1			ROCR
	C3	G3G4	S1			ANTI
	C3	G3G4	S1			MONO
	C3	G3G4	S1			PRWI
Canadian Milkvetch						
	C1 State	G5	S1	E	No Status	Potomac Gorge
Carey's Sedge						
	C1 State	G5	S1	E	No Status	Potomac Gorge
Carolina Anglepod						
	C1 State	G4	S1	E	No Status	Piscataway/Fort Washington
Cerulean Warbler						
	C1 Federal				? LE	CHOH
Climbing Dogbane						
	C1 State	G4G5	S1	E	No Status	Potomac Gorge
Climbing Fumitory						
	C1 State	G4	S2	T	No Status	Sideling Hill Creek Macrosite
Climbing Milkweed						
	C1 State	G4?	S1	E	No Status	Potomac Gorge
	C1 State	G4?	S1	E	No Status	West Fairplay
Clingman's Hedge-Nettle						
	C1 State	G2Q	S1	E	No Status	Old Deneen Road Woods
Clustered Beakrush						
	C1 State	G5	S2	T	No Status	Piscataway/Fort Washington
Creeping Cucumber						
	C1 State	G5?	S1	E	No Status	Piscataway/Fort Washington
Crested Dwarf Iris						
	C1 State	G5	S1	E	No Status	Maryland Heights
Crossleaf Milkwort						
	C1 State	G5	S2	T	No Status	Suitland Bog
Dwarf Bulrush						
	C1 State	G4	S1	E	No Status	Potomac Gorge
Earleaf Foxglove						
	C1 State	G3	S1	E	No Status	Nolands Ferry Floodplain
	C1 State	G3	S1	E	No Status	Piscataway/Fort Washington
Eastern Leatherwood						
	C1 State	G4	S2	T	No Status	Ferry Hill Limestone Cliffs

Table 1: List of Rare, Threatened, and Endangered Species Meeting Rare, Threatened, and Endangered Species Criteria 1–3 (continued)

Common Name	Criteria	G Rank	S Rank	State Protection Status	Federal Status	Site Name
	C1 State	G4	S2	T	No Status	Potomac Gorge
	C1 State	G4	S2	T	No Status	Potomac Gorge
	C1 State	G4	S2	T	No Status	Owens Creek Swamp
Elusive Clubtail						
	C3	G3	S1	qq	No Status	Loudoun
Fewflower Tick-Trefoil						
	C1 State	G5	S1	E		Piscataway/Fort Washington
Franz's Cave Amphipod						
	C2	G2G3	S2S3	I	No Status	Williamsport Spring
	C2	G2G3	S2S3	I	No Status	Roundtop Hill
	C2	G2G3	S2S3	I	No Status	Roundtop Hill
Fringe-Top Bottle Gentian						
	C1 State	G5?	S2	T	No Status	Piscataway Park Site
Glade Fern						
	C1 State	G5	S2	T	No Status	Potomac Gorge
	C1 State	G5	S2	T	No Status	Johnson's Gully
	C1 State	G5	S2	T	No Status	Fort Ravine
	C1 State	G5	S2	T	No Status	Limestone Woods
	C1 State	G5	S2	T	No Status	Piscataway/Fort Washington
Glassy Darte						
	C1 State Animal	G4G5	S1S2	E	No Status	Little Patuxent River
Golden-Seal						
	C1 State	G4	S2	T	No Status	Snyders Landing Woods
	C1 State	G4	S2	T	No Status	Snavely's Ford Woods
	C1 State	G4	S2	T	No Status	Lock 29 Floodplain
Green Floater						
	C1 State Animal	G3	S1	E		CHOH
Hairy Wild-Petunia						
	C1 State	G5	S1	E	No Status	The Neck
Halbard-leaved Rose Mallow						
	C3	G3G5	S3			HAFE
	C3	G3G5	S3			CHOH
	C3	G3G5	S3			Weverton Floodplain
	C3	G3G5	S3			GWMP
	C3	G3G5	S3			Nace
Harbinger of Spring						
	C3	G3G4	S2			HAFE
	C3	G3G4	S2			CHOH
	C3	G3G4	S2			GWMP
	C3	G3G4	S2			MONO
	C3	G3G4	S2			MANA
Harperella						
	C1 Federal	G2	S1	E	LE	Potomac Panorama Shoreline

TABLE 1: LIST OF RARE, THREATENED, AND ENDANGERED SPECIES MEETING RARE, THREATENED, AND ENDANGERED SPECIES CRITERIA 1–3 (CONTINUED)

Common Name	Criteria	G Rank	S Rank	State Protection Status	Federal Status	Site Name
Hay's Spring Amphipod						
	C1 Federal	G1G2	S1	qq	LE	West Rapids Spring
	C1 Federal					ROCR
	C1 Federal	G1G2	S1	qq	LE	Ross Drive Spring
Herb-Robert						
	C1 State	G5	S1	E	No Status	Hunting Creek Hollow
Hoffmaster's Cave Planarian						
	C1 State Animal	G2G3	S1	E	No Status	Roundtop Hill
Horse-Tail Paspalum						
	C1 State	G5	S1	E	No Status	Potomac Gorge
	C1 State	G5	S1	E	No Status	Potomac Gorge
Indiana Bat						
	C2	G2			LE	CHOH
John Friend's Cave Isopod (Md)						
	C3	G3	S1	qq	No Status	Roundtop Hill
	C3	G3	S1	qq	No Status	Roundtop Hill
Kate's Mountain Clover						
	C1 State	G3	S2S3	T	No Status	Tunnel Hollow
	C1 State	G3	S2S3	T	No Status	North Sandy Flat Hollow
	C1 State	G3	S2S3	T	No Status	Oldtown Romney Shale Glade
	C1 State	G3	S2S3	T	No Status	Outdoor Club Shale Barrens
	C1 State	G3	S2S3	T	No Status	Long's Hunt Club Shale Glades
	C1 State	G3	S2S3	T	No Status	Long's Hunt Club Shale Glades
Kenk's Amphipod						
	C2					CHOH
	C2					ROCR
KNOW ONLY FROM VA & DC						
	C2	G1	S1	qq	No Status	Pimmit Run Slopes
	C2	G1	S1	qq	No Status	Turkey Run Park Slopes
Lance-Leaf Loosestrife						
	C1 State	G5	S2	T	No Status	Piscataway/Fort Washington
	C1 State	G5	S2	T	No Status	Potomac Gorge
Large-Leaf Water-Leaf						
	C1 State	G5	S2	T	No Status	Cohill Floodplain
	C1 State	G5	S2	T	No Status	Old Deneen Road Woods
	C1 State	G5	S2	T	No Status	Powell Bend
	C1 State	G5	S2	T	No Status	Fort Duncan
	C1 State	G5	S2	T	No Status	Gift Road Woods
	C1 State	G5	S2	T	No Status	Taylors Landing
	C1 State	G5	S2	T	No Status	Dam Number Four Cave
	C1 State	G5	S2	T	No Status	Roundtop Hill

TABLE 1: LIST OF RARE, THREATENED, AND ENDANGERED SPECIES MEETING RARE, THREATENED, AND ENDANGERED SPECIES CRITERIA 1–3 (CONTINUED)

Common Name	Criteria	G Rank	S Rank	State Protection Status	Federal Status	Site Name
Limestone Petunia						
	C1 State	G4G5	S1	E	No Status	Potomac Gorge
	C1 State	G4G5	S1	E		Sandy Hook Floodplain
	C1 State	G4G5	S1	E	No Status	Piscataway/Fort Washington
	C1 State	G4G5	S1	E		Weverton Floodplain
Lobed Spleenwort						
	C1 State	G4	S1	E	No Status	Maryland Heights
	C1 State	G4	S1			Lock 32, HAFE
	C1 State	G4	S1	E	No Status	Manidokan Ravine
Loggerhead Shrike						
	C1 State Animal	G4	S1B,S1N	E	No Status	NACE
	C1 State Animal	G4	S1B,S1N	E	No Status	Mondell Road Site
Long-Bract Green Orchis						
	C1 State	G5	S1	E	No Status	Owens Creek Swamp
	C1 State	G5	S1	E	No Status	Hunting Creek Hollow
Marsh-Speedwell						
	C1 State	G5	S1	E	No Status	Mckee-Beshers West Swamp
	C1 State	G5	S1	E	No Status	Sycamore Landing Riverside
Mcdowell Sunflower						
	C1 State	G5	S1	T	No Status	Potomac Gorge
Michaux's Stitchwort						
	C1 State	G5	S2	T	No Status	Kasecamp Shale Barrens
Mountain Parsley						
	C1 State	G4	S2	T	No Status	Sideling Hill Creek Macrosite
Mourning Warbler						
	C1 State Animal	G5	S1	E		CATO
	C1 State Animal	G5	S1	E		ROCR
	C1 State Animal	G5	S1	E		GWMP
Narrow Melic Grass						
	C1 State	G5	S1	T	No Status	Potomac Gorge
	C1 State	G5	S1	T	No Status	Blockhouse Point
Northern Bedstraw						
	C1 State	G5	S1	E	No Status	Ferry Hill Limestone Cliffs
	C1 State	G5	S1	E	No Status	Snyders Landing Woods
Northern Goshawk						
	C1 State Animal	G5	S1	E		HAFE
	C1 State Animal	G5	S1	E		NACE
Northern Metalmark						
	C1 State Animal	G3G4	S2	T	No Status	Kasecamp Shale Barrens
	C1 State Animal	G3G4	S2	T	No Status	Kasecamp Riparian Forest
	C1 State Animal	G3G4	S2	T	No Status	Roundtop Hill
	C1 State Animal	G3G4	S2	T	No Status	West Fairplay

TABLE 1: LIST OF RARE, THREATENED, AND ENDANGERED SPECIES MEETING RARE, THREATENED, AND ENDANGERED SPECIES CRITERIA 1–3 (CONTINUED)

Common Name	Criteria	G Rank	S Rank	State Protection Status	Federal Status	Site Name
Northern Oak Fern						
	C1 State	G5	S1	E	No Status	Upper Black Rock Creek
Northern Oak Hairstreak						
	C1 State Animal	G4T4	S1S2	E	No Status	High Germany Hill
Northern Pitcher-Plant						
	C1 State	G5	S2	T	No Status	Suitland Bog
Northern Virginia Well Amphipod						
	C2					Possibly At GWMP
Northern White Cedar						
	C1 State	G5	S1	T	No Status	Snyders Landing Woods
	C1 State	G5	S1	T	No Status	Powell Bend
	C1 State	G5	S1	T	No Status	Ferry Hill Limestone Cliffs
	C1 State	G5	S1	T	No Status	Dam Number Four Cliffs
Nottoway Brome						
	C3	G3G4	SH			NACE
	C3	G3G4	SH			CHOH
Nottoway Brome Grass						
	C3	G3G4	SH	X	No Status	Piscataway/Fort Washington
Ozark Milk-Vetch						
	C1 State	G5	S2	T	No Status	Kasecamp Shale Barrens
	C1 State	G5	S2	T	No Status	Outdoor Club Shale Barrens
	C1 State	G5	S2	T	No Status	Outdoor Club Shale Barrens
	C1 State	G5	S2	T	No Status	Outdoor Club Shale Barrens
	C1 State	G5	S2	T	No Status	Bevan Bend Shale Barren
Pizzini's Cave Amphipod						
	C2	G2G4	S1	qq	No Status	Chick Road Springs
	C2	G2G4	S1S2	SC	No Status	Pimmit Run Slopes
	C2	G2G4	S1	qq	No Status	Three Spring Hollow
	C2	G2G4	S1S2	SC	No Status	Turkey Run Park Slopes
	C2	G2G4	S1	qq	No Status	Monocacy Spring
	C2	G2G4	S1	qq	No Status	Chilton Woods Springs
Poa Paludigna						
	C3	G3	S1			Richard Thompson Wma
Potato Dandelion						
	C1 State	G5	S1	E	No Status	Potomac Gorge
	C1 State	G5	S1	E	No Status	Piscataway/Fort Washington
	C1 State	G5	S1	E	No Status	Accokeek Creek
	C1 State	G5	S1	E	No Status	Blockhouse Point
Purple Mecardonia						
	C1 State	G5	S1	E	No Status	Potomac Gorge
Queen-Of-The-Prairie						
	C1 State	G4G5	S1	E	No Status	Foxville Swamp

Table 1: List of Rare, Threatened, and Endangered Species Meeting Rare, Threatened, and Endangered Species Criteria 1–3 (continued)

Common Name	Criteria	G Rank	S Rank	State Protection Status	Federal Status	Site Name
Racemed Milkwort						
	C1 State	G5	S1	T	No Status	Potomac Gorge
Red Milkweed						
	C1 State	G4G5	S1	E	No Status	Suitland Bog
Rock Creek Groundwater Amphipod						
	C2	G1G3	S1	qq	No Status	East Spring
	C2	G1G3	S1	qq	No Status	Sherrill Drive Spring
Rock Grape						
	C3	G3	S1?	qq	No Status	Great Falls
	C3	G3	S1?	qq	No Status	Madeira School
	C3	G3	S1?	qq	No Status	Potomac Wayside
Rock Skullcap						
	C1 State	G3	S1			Hafe, Loudoun Heights
	C1 State	G3	S1	E	No Status	Potomac Gorge
Rough Dropseed						
	C1 State	G5	S1	E	No Status	Potomac Gorge
Running Serviceberry						
	C1 State	G5	S2	T	No Status	Potomac Gorge
Sand Grape						
	C3	G3				Hafe
	C3	G3				Choh
	C3	G3				Appa
Seneca Snakeroot						
	C1 State	G4G5	S2	T	No Status	Roundtop Hill
Shale-Barren Skullcap						
	C1 State	G4T4	S2	T	No Status	Oldtown Romney Shale Glade
	C1 State	G4T4	S2	T	No Status	Long's Hunt Club Shale Glades
Shenandoah Valley Cave Amphipod						
	C1 State Animal	G2G4	S1	E	No Status	Hawkins Zoaves Monument Spring
	C1 State Animal	G2G4	S1	E	No Status	Williamsport Spring
Short's Rock-Cress						
	C1 State	G5	S2	T	No Status	Fort Duncan
	C1 State	G5	S2	T	No Status	Snyders Landing Woods
	C1 State	G5	S2	T	No Status	Potomac Gorge
	C1 State	G5	S2	T	No Status	Monocacy Aqueduct Site
	C1 State	G5	S2	T	No Status	Ferry Hill Limestone Cliffs

TABLE 1: LIST OF RARE, THREATENED, AND ENDANGERED SPECIES MEETING RARE, THREATENED, AND ENDANGERED SPECIES CRITERIA 1–3 (CONTINUED)

Common Name	Criteria	G Rank	S Rank	State Protection Status	Federal Status	Site Name
Shumard Oak						
	C1 State	G5	S2	T	No Status	Nolands Ferry Floodplain
	C1 State	G5	S2	T	No Status	Potomac Gorge
	C1 State	G5	S2	T	No Status	Piscataway/Fort Washington
	C1 State	G5	S2	T	No Status	Williamsport Filtration Plant Site
	C1 State	G5	S2	T	No Status	Lock 43 Floodplain
	C1 State	G5	S2	T	No Status	Sycamore Landing Riverside
	C1 State	G5	S2	T	No Status	Potomac Gorge
	C1 State	G5	S2	T	No Status	Mile Marker 72 Floodplain
	C1 State	G5	S2	T	No Status	Lock 29 Floodplain
	C1 State	G5	S2	T	No Status	Lock 26 Floodplain
	C1 State	G5	S2	T	No Status	Fort Frederick Floodplain
	C1 State	G5	S2	T	No Status	Dargan Bend Woods
	C1 State	G5	S2	T	No Status	The Neck
Small Whorled Pogonia						
	C1 Federal	G2	S2	LE	LT	Little Union Slopes
	C1 Federal	G2	S2	LE	LT	Prince William Forest Park
Small-Footed Bat						
	C3	G3	S1			CHOH
	C3	G3	S1			CATO
Smooth Buttonweed						
	C1 State	G4G5	S1	E	No Status	Potomac Gorge
Smooth Cliff-Brake						
	C1 State	G5	S1	E	No Status	Two Locks
	C1 State	G5	S1	E	No Status	Cedar Grove Cliffs
Snow Trillium						
	C1 State	G4	S1	E	No Status	Falling Waters Bluff
Snowberry						
	C1 State	G5	S1	T	No Status	Roundtop Hill
	C1 State	G5	S1	T	No Status	Kasecamp Shale Barrens
Snowy Campion						
	C1 State	G4?	S1	E	No Status	CHOH
	C1 State	G4?	S1	E	No Status	HAFE
	C1 State	G4?	S1	E	No Status	Dam Number Three Scour Bar
Sourwood						
	C1 State	G5	S1	E		Piscataway/Fort Washington
Spine-Crowned Clubtail						
	C3	G3G4	S2	qq	No Status	Potomac Wayside
Spreading Rockcress						
	C3	G3	S2	qq	No Status	Berkeley
	C3	G3	S2	qq	No Status	National Conservation Training Center

TABLE 1: LIST OF RARE, THREATENED, AND ENDANGERED SPECIES MEETING RARE, THREATENED, AND ENDANGERED SPECIES CRITERIA 1–3 (CONTINUED)

Common Name	Criteria	G Rank	S Rank	State Protection Status	Federal Status	Site Name
Starflower Solomon's-Plume						
	C1 State	G5	S1	E	No Status	Potomac Gorge
	C1 State	G5	S1	E	No Status	Whites Ferry Woods
	C1 State	G5	S1	E	No Status	Sycamore Landing Riverside
	C1 State	G5	S1	E	No Status	Nolands Ferry Floodplain
	C1 State	G5	S1			Weverton Floodplain
	C1 State	G5	S1			Sandy Hook Floodplain
	C1 State	G5	S1	E	No Status	Potomac Gorge
	C1 State	G5	S1	E	No Status	Lock 29 Floodplain
Sticky Goldenrod						
	C1 State	G5	S1	T	No Status	Potomac Gorge
Sundial Lupine						
	C1 State	G5	S2	T	No Status	Piscataway/Fort Washington
	C1 State	G5	S2	T	No Status	Tonoloway Ridge South
Swamp Lousewort						
	C1 State	G5	S1	E		Piscataway/Fort Washington
Swamp Wedgescale						
	C1 State	G4	S1S2	T	No Status	East Piscataway Marsh
Sweet-Scented Indian-Plantain						
	C3	G3	S2	qq	No Status	Lander Slopes
	C1 State	G3	S1	E	No Status	Knott Island
	C3	G3	S2	qq	No Status	Great Falls
	C1 State	G3	S1	E	No Status	Fort Frederick Floodplain
	C1 State	G3	S1	E	No Status	Weverton Cliffs Floodplain
	C3	G3	S2	qq	No Status	Short Hill Mountain
	C3	G3	S2	qq	No Status	River Bend Park
	C1 State	G3	S1	E	No Status	Dam Number Four Cliffs
	C1 State	G3	S1	E	No Status	Brunswick Riverside
	C1 State	G3	S1	E	No Status	Bealls Island
Tall Dock						
	C1 State	G5	S1	E	No Status	Potomac Gorge
	C1 State	G5	S1	E	No Status	Potomac Gorge
Tall Larkspur						
	C1 State	G3	S1	E	No Status	Roundtop Hill
Tall Tickseed						
	C1 State	G5	S1	E	No Status	Potomac Gorge
	C1 State	G5	S1	E	No Status	Potomac Gorge

Table 1: List of Rare, Threatened, and Endangered Species Meeting Rare, Threatened, and Endangered Species Criteria 1–3 (continued)

Common Name	Criteria	G Rank	S Rank	State Protection Status	Federal Status	Site Name
Three-Flower Melic Grass						
	C1 State	G5	S2	T	No Status	Sideling Hill Creek Macrosite
	C1 State	G5	S2	T	No Status	Kasecamp Shale Barrens
	C1 State	G5	S2	T	No Status	Oldtown Romney Shale Glade
	C1 State	G5	S2	T	No Status	High Germany Hill
	C1 State	G5	S2	T	No Status	Outdoor Club Shale Barrens
	C1 State	G5	S2	T	No Status	Kasecamp Shale Barrens
	C1 State	G5	S2	T	No Status	Bevan Bend Shale Barren
Torrey's Mountain Mint						
	C1 State	G2	S1	E		CATO
	C1 State	G2	S1	E	No Status	Hunting Creek Hollow
	C1 State	G2	S1	E		HAFE
Torrey's Rush						
	C1 State	G5	S1	E	No Status	East Piscataway Marsh
Upand Sandpiper						
	C1 State Animal	G5	S1	E		HAFE
Upright Burhead						
	C1 State	G5	S1	E	No Status	Potomac Gorge
Valerian						
	C1 State	G4	S1	E	No Status	Potomac Gorge
	C1 State	G4	S1	E	No Status	Lock 26 Floodplain
Veined Skullcap						
	C1 State	G5	S1	E	No Status	Whites Ferry Woods
	C1 State	G5	S1	E	No Status	Johnson's Gully
	C1 State	G5	S1	E	No Status	Potomac Gorge
	C1 State	G5	S1	E	No Status	Piscataway/Fort Washington
Virginia False-Gromwell						
	C1 State	G4	S1	E	No Status	Potomac Gorge
Virginia Mallow						
	C2	G2	S1			GWMP
	C2	G2	S1			CHOH
White Trout-Lily						
	C1 State	G5	S2	T	No Status	Violets Lock Floodplain
	C1 State	G5	S2	T	No Status	Powell Bend
	C1 State	G5	S2	T	No Status	Williamsport Filtration Plant Site
	C1 State	G5	S2	T	No Status	Catoctin Creek Mouth
	C1 State	G5	S2	T	No Status	Spring Gap Bottomland
	C1 State	G5	S2	T	No Status	Snyders Landing West
	C1 State	G5	S2	T	No Status	Potomac Gorge
	C1 State	G5	S2	T	No Status	Pennyfield Lock Floodplain
	C1 State	G5	S2	T	No Status	North Branch Bottomland
	C1 State	G5	S2	T	No Status	Lock 29 Floodplain
	C1 State	G5	S2	T	No Status	Lock 28 Floodplain

TABLE 1: LIST OF RARE, THREATENED, AND ENDANGERED SPECIES MEETING RARE, THREATENED, AND ENDANGERED SPECIES CRITERIA 1–3 (CONTINUED)

Common Name	Criteria	G Rank	S Rank	State Protection Status	Federal Status	Site Name
	C1 State	G5	S2	T	No Status	Horseshoe Bend Woods
	C1 State	G5	S2	T	No Status	Catoctin Station
	C1 State	G5	S2	T	No Status	Canal Bottomland
	C1 State	G5	S2	T	No Status	Canal Bottomland
	C1 State	G5	S2	T	No Status	Fort Duncan North
Wild False Indigo						
	C1 State	G5	S2	T	No Status	Potomac Gorge
	C1 State	G5	S2	T	No Status	Potomac Gorge
	C1 State	G5	S2	T	No Status	The Neck
Winged-Loosestrife						
	C1 State	G5	S1	E	No Status	Potomac Gorge
Wood Turtle						
	C1 State Animal	G4	S2			4-Mile Run
	C1 State Animal	G4	S2	T	No Status	Short Hill Mountain
Yellow Lampmussel						
	C3	G3G4	S1	X	No Status	Potomac River - Cherry Run
	C3	G3G4	S1	X	No Status	Potomac River - Cherry Run
	C3	G3G4	S1		No Status	CHOH
	C3	G3G4	S1		No Status	NACE
	C3	G3G4	S1		No Status	Piscataway/Fort Washington
Yellow Nailwort						
	C1 State	G4T1Q	S1	E	No Status	Potomac Gorge
	C1 State	G4T1Q	S1	E	No Status	Bevan Bend Shale Barren
Yellow Water-Crowfoot						
	C1 State	G5	S1	E	No Status	Sycamore Landing Riverside
Yellowleaf Tinker's-Weed						
	C1 State	G5	S1	E	No Status	Kasecamp Shale Barrens

TABLE 2: PRIORITY SITES FOR PARKS OF THE NATIONAL CAPITAL REGION

Priority Sites	Criteria		G Rank	S Rank	State Protection Status	Federal Status
Antietam National Battlefield						
D - Hawkins Zoaves Monument	C1 State	Shenandoah Valley Cave	G2G4	S1	E	No Status
Priority species meeting C1-C3 criteria: None						
Appalachian National History Trail						
B - Reservoir Hollow	C2	Blue Ridge Mountain	G2	S2		
	C3	Blue Ridge Spring	G3	S2S3	qq	No Status
E - Weverton Cliffs Floodplain	C1 State	Sweet-Scented Indian-Plantain	G3	S1	E	No Status
E - Weverton Floodplain	C1 State	Limestone Petunia	G4G5	S1	E	
		Starflower Solomon's-Plu	G5	S1		
	C3	Halbard-Leaved Rose Mallow	G3G5	S3		
Priority species meeting C1-C3 criteria: Bog Bluegrass and Sand Grape						
Catoctin Mountain Park						
Priority Sites: None						
Priority species meeting C1-C3 criteria: Small footed Bat, Butternut (numerous locations), American Ginseng (numerous locations), and Torrey's Mountain Mint.						
Chesapeake and Ohio Canal National Historical Park						
B - Potomac Gorge	C1	Bald Eagle	G4	S2S3B,S3N	T	LT,PDL
	C1 State	Wild False Indigo	G5	S2	T	No Status
		Veined Skullcap	G5	S1	E	No Status
		Canadian Milkvetch	G5	S1	E	No Status
		McDowell Sunflower	G5	S1	T	No Status
		Climbing Dogbane	G4G5	S1	E	No Status
		Wild False Indigo	G5	S2	T	No Status
		Carey's Sedge	G5	S1	E	No Status
		Tall Tickseed	G5	S1	E	No Status
		Tall Tickseed	G5	S1	E	No Status
		Tall Dock	G5	S1	E	No Status
		Tall Dock	G5	S1	E	No Status
		Limestone Petunia	G4G5	S1	E	No Status
		Rough Dropseed	G5	S1	E	No Status
		Glade Fern	G5	S2	T	No Status
		Shumard Oak	G5	S2	T	No Status
		Eastern Leatherwood	G4	S2	T	No Status
		Eastern Leatherwood	G4	S2	T	No Status
		Upright Burhead	G5	S1	E	No Status
		Shumard Oak	G5	S2	T	No Status
		American Beakgrain	G4?	S1	E	No Status
		Purple Mecardonia	G5	S1	E	No Status
		Horse-Tail Paspalum	G5	S1	E	No Status
		Horse-Tail Paspalum	G5	S1	E	No Status
		Yellow Nailwort	G4T1Q	S1	E	No Status

TABLE 2: PRIORITY SITES FOR PARKS OF THE NATIONAL CAPITAL REGION (CONTINUED)

Priority Sites	Criteria		G Rank	S Rank	State Protection Status	Federal Status
		Smooth Buttonweed	G4G5	S1	E	No Status
		Virginia False-Gromwel	G4	S1	E	No Status
		Buttercup Scorpion-Weed	G2	S1	E	No Status
		Potato Dandelion	G5	S1	E	No Status
		Racemed Milkwort	G5	S1	E	No Status
		Short's Rock-Cress	G5	S2	T	No Status
		Climbing Milkweed	G4?	S1	E	No Status
		Dwarf Bulrush	G4	S1	E	No Status
		Starflower Solomon's-Plu	G5	S1	E	No Status
		Valerian	G4	S1	E	No Status
		Winged-Looses Trife	G5	S1	E	No Status
		Lance-Leaf Loosestrife	G5	S2	T	No Status
		Rock Skullcap	G3	S1	E	No Status
		Starflower Solomon's-Plu	G5	S1	E	No Status
		Running Serviceberry	G5	S2	T	No Status
		Narrow Melic Grass	G5	S1	T	No Status
		White Trout-Lily	G5	S2	T	No Status
		Sticky Goldenrod	G5	S1	T	No Status
D- Howell Cave	C1 State	Blue Ridge Springsnail	G2G3			
D - Monocacy Spring	C2	Pizzini's Cave Amphipod	G2G4	S1	qq	No Status
D - Old Deneen Road Woods	C1 State	Large-Leaf Water-Leaf	G5	S2	T	No Status
		Clingman's Hedge-Nettle	G2Q	S1	E	No Status
D - Three Spring Hollow	C2	Pizzini's Cave Amphipod	G2G4	S1	qq	No Status
E - Bevan Bend Shale Barren	C1 State	Yellow Nailwort	G4T1Q	S1	E	No Status
		Bluntleaf Spurge	G5	S1	E	No Status
		Three-Flower Melic Grass	G5	S2	T	No Status
		Ozark Milk-Vetch	G5	S2	T	No Status
E - Dam Number Four Cliffs	C1 State	Black-Fruit Mountain-Riceg	G5	S2	T	No Status
		Northern White Cedar	G5	S1	T	No Status
		Sweet-Scented Indian-Plantain	G3	S1	E	No Status
E - Ferry Hill Limestone Cliffs	C1 State	Black-Fruit Mountain-Riceg	G5	S2	T	No Status
		Northern Bedstraw	G5	S1	E	No Status
		Northern White Cedar	G5	S1	T	No Status
		Short's Rock-Cress	G5	S2	T	No Status
		Eastern Leatherwood	G4	S2	T	No Status
		Broad-Glumed Brome	G5	S1	E	No Status

TABLE 2: PRIORITY SITES FOR PARKS OF THE NATIONAL CAPITAL REGION (CONTINUED)

Priority Sites	Criteria		G Rank	S Rank	State Protection Status	Federal Status
E - Kasecamp Shale Barrens	C1 State	Three-Flower Melic Grass	G5	S2	T	No Status
		Yellowleaf Tinker's-Weed	G5	S1	E	No Status
		Ozark Milk-Vetch	G5	S2	T	No Status
		Three-Flower Melic Grass	G5	S2	T	No Status
		Michaux's Stitchwort	G5	S2	T	No Status
		Snowberry	G5	S1	T	No Status
		Northern Metalmark	G3G4	S2	T	No Status
E - Little Pool	C1 State	American Beakgrain	G4?	S1	E	No Status
		Big Shellbark Hickory	G5	S1	E	No Status
		American Beakgrain	G4?	S1	E	No Status
E - Lock 29 Floodplain	C1 State	Shumard Oak	G5	S2	T	No Status
		White Trout-Lily	G5	S2	T	No Status
		Starflower Solomon's-Plu	G5	S1	E	No Status
		Golden-Seal	G4	S2	T	No Status
E - Nolands Ferry Floodplain	C1 State	Starflower Solomon's-Plu	G5	S1	E	No Status
		Earleaf Foxglove	G3	S1	E	No Status
		Shumard Oak	G5	S2	T	No Status
E - Outdoor Club Shale Barrens	C1 State	Ozark Milk-Vetch	G5	S2	T	No Status
		Ozark Milk-Vetch	G5	S2	T	No Status
		Ozark Milk-Vetch	G5	S2	T	No Status
		Three-Flower Melic Grass	G5	S2	T	No Status
		Kate's Mountain	G3	S2S3	T	No Status
E - Powell Bend	C1 State	Northern White Cedar	G5	S1	T	No Status
		Large-Leaf Water-Leaf	G5	S2	T	No Status
		White Trout-Lily	G5	S2	T	No Status
E - Sideling Hill Creek Macrosite	C1 State	Mountain Parsley	G4	S2	T	No Status
		Climbing Fumitory	G4	S2	T	No Status
		American Beakgrain	G4?	S1	E	No Status
		Three-Flower Melic Grass	G5	S2	T	No Status
	C1 State	Brook Floater	G4	S1	E	No Status
E - Snyders Landing Woods	C1 State	Golden-Seal	G4	S2	T	No Status
		Northern Bedstraw	G5	S1	E	No Status
		Northern White Cedar	G5	S1	T	No Status
		Short's Rock-Cress	G5	S2	T	No Status
E - Sycamore Landing Riverside	C1 State	Shumard Oak	G5	S2	T	No Status
		Yellow Water-Crowfo	G5	S1	E	No Status
		Marsh-Speedwell	G5	S1	E	No Status
		Starflower Solomon's-Plu	G5	S1	E	No Status
E - The Neck	C1 State	Black-Fruit Mountain-Riceg	G5	S2	T	No Status
		Wild False Indigo	G5	S2	T	No Status
		Shumard Oak	G5	S2	T	No Status
		Hairy Wild-Petunia	G5	S1	E	No Status
		American Beakgrain	G4?	S1	E	No Status

TABLE 2: PRIORITY SITES FOR PARKS OF THE NATIONAL CAPITAL REGION (CONTINUED)

Priority Sites	Criteria		G Rank	S Rank	State Protection Status	Federal Status
E - Weverton Cliffs Floodplain (See APPA)						
Priority species meeting C1-C3 criteria: Alleghany Cave Amphipod, Green Floater, Virginia Mallow, Kenk's Amphipod, Indiana Bat, Biggers Cave Amphipod, Appalachian Spring Snail, Butternut, Sand Grape, Yellow Lampmussel, American Ginseng, Nottoway Brome, Small-footed Bat, Amelanchier Nantucket.						
George Washington Memorial Parkway						
B - Great Falls	C3	Rock Grape	G3	S1?	qq	No Status
		Sweet-Scented Indian-Plantain	G3	S2	qq	No Status
B - Pimmit Run Slopes	C2	Pizzini's Cave Amphipod	G2G4	S1S2	SC	No Status
		Unnamed species (known only from VA and DC)	G1	S1	qq	No Status
B - Potomac Gorge (See CHOH)						
B - Turkey Run Park Slopes	C2	Buttercup Scorpion-Weed	G2	S1	qq	No Status
		Unnamed species (known only from VA and DC)	G1	S1	qq	No Status
		Pizzini's Cave Amphipod	G2G4	S1S2	SC	No Status
Priority species meeting C1-C3 criteria: Virginia Mallow, Butternut, Northern Virginia Amphipod, and American Ginseng.						
Harpers Ferry National Historical Park						
Priority Sites: None						
Priority species meeting C1-C3 criteria: Butternut.						
Manassas National Battlefield						
Priority Sites: Stuart's Hill (for multiple Butternut trees)	C3		G3G4	S1		No Status
Priority species meeting C1-C3 criteria: Butternut.						
Monocacy National Battlefield						
Priority Sites: None						
Priority species meeting C1-C3 criteria: Butternut.						
National Capital Parks - Central						
Priority Sites: None						
Priority species meeting C1-C3 criteria: None						
National Capital Parks - East						
NACE Buffer						
C - Suitland Bog	C1 State	Northern Pitcher-Plant	G5	S2	T	No Status
		Bog Fern	G4G5	S2	T	No Status
		Red Milkweed	G4G5	S1	E	No Status
		Crossleaf Milkwort	G5	S2	T	No Status
Priority species meeting C1-C3 criteria: American Ginseng, Butternut, Sourwood, Glade Fern, Sundial Lupine, Lance Leaf Lo., Shumard Oak, Clustered Bea., Veined Skullcap, Limestone pet., Fewflower Ti., Potato Dandelion, Carolina Ang., Swamp Louse., American Fro., Earleaf Foxglove, Yellow Lampmussel, Nottoway Brome.						
Prince William Forest Park						
A - Little Union Slopes	C1	Small Whorled Pogonia	G2	S2	LE	LT
A - Prince William Forest Park	C1	Small Whorled Pogonia	G2	S2	LE	LT
Priority species meeting C1-C3 criteria: None						

TABLE 2: PRIORITY SITES FOR PARKS OF THE NATIONAL CAPITAL REGION (CONTINUED)

Priority Sites	Criteria		G Rank	S Rank	State Protection Status	Federal Status
Rock Creek Park						
A - Ross Drive Spring	C1	Hay's Spring Amphipod	G1G2	S1	qq	LE
A - West Rapids Spring	C1	Hay's Spring Amphipod	G1G2	S1	qq	LE
D - East Spring	C2	Rock Creek Groundwater	G1G3	S1	qq	No Status
D - Sherrill Drive Spring	C2	Rock Creek Groundwater	G1G3	S1	qq	No Status
Priority species meeting C1-C3 criteria: Hay's Spring Amphipod. Blackburnian Warbler, Mourning Warbler, Kenk's Amphipod, Butternut.						

Appendix F

Draft Comprehensive Conceptual Models

These draft models were developed by the Science Advisory Committee (SAC) and Monitoring Workshop through brainstorming in order to identify the all of the region's resource components, stresses, sources, ecological effects, and potential vital signs. The draft models are presented in table format and were developed by workgroups (air, geology, landscape, vegetation, water, and wildlife resources).

TABLE 1: DRAFT CONCEPTUAL MODEL OF AIR RESOURCES IN THE NATIONAL CAPITAL REGION NETWORK

Resource Component	Stressor	Sources	Ecological Effects
Particulates	Nitrogen, sulfur, metals (i.e., mercury), Ozone, PM (10) and PM (2.5), greenhouse gasses, hydrogen ion deposition, air toxics	*Natural* – wind blown geological crust, volcanoes, aerosols, fire *Anthropogenic* – fossil fuels, fertilizers, industrial processes	• Reduced visibility • Terrestrial and aquatic eutrophication • Terrestrial and aquatic acidification • Toxicity affects; bioaccumulation (especially mercury) • Biotic changes • Climate change • Human health
Visibility	Particulates, aerosols	*Natural* – wind blown geological crust, volcanoes, aerosols, fire, humidity *Anthropogenic* – fossil fuels, small sources such as dry cleaners, rock quarries	• Human perception • Health of terrestrial living beings
Climate	Urban Heat Island	Development	• Change in weather patterns • Warming urban environment • Change in biotic communities
Particulates		*Natural* – wind blown geological crust, volcanoes, aerosols, fire *Anthropogenic* – stationary (smokestack) utilities and industries, mobile (planes, trains, and automobiles), area (i.e., rock quarries)	• Biodiversity (terrestrial and aquatic)

TABLE 2: DRAFT CONCEPTUAL MODEL OF GEOLOGICAL RESOURCES IN THE NATIONAL CAPITAL REGION NETWORK

Resource Component	Stressor	Sources	Ecological Effects
Soil	Pesticide loading	Agricultural, residential, and commercial use	Accumulation of pesticides that adhere to soil particles, causing changes to or the elimination of nontarget soil fauna populations
Soil/bedrock	Nutrient loading	Agricultural, residential, and commercial use	Acidification of the soil, reduction of soil organic matter, change in soil fertility status
Soil/bedrock	Change in pH, loss of buffering capacity	Acid rain, atmospheric deposition	Change in vegetation types, mycorrhiza and other soil flora and fauna
Soil	Temperature change	Climate change	Changes in soil micro-climate
Soil/surficial factors	Clearing of land	Soil surface exposure, development, agriculture, zoning laws (local and county governments)	Loss of soil surface cover, increased soil surface and groundwater temperatures
Soil	Erosion	Development, land clearing, increasing impervious surface	Increased siltation, reduced productivity/health/abundance of soil, plants, and aquatic organisms
Soil/surficial factors	Erosion	Development	Change in “normal” sedimentation sequence and composition
Soil	Change in vegetation/ exotics	Development, nursery use of exotics	Change in soil organic matter composition, changes in soil flora and fauna, pH, nitrification rates
Soil, creation of new soils	Fill dirt: complete changes in soil physical and chemical composition resulting from filling in land areas with soil from another location (esp. DC)	Landfills, abandoned mines, land engineering	Changed, destroyed, or new soil profile, change in chemical composition of soil, introduction of toxics, introduction of impervious structures into soil profile, compaction, resultant changes to biodiversity and vegetation communities, changes to hydrologic cycle
Soil	Compaction	Visitor use	Changes in vegetation survival, changes in soil physical properties, creation of soil crusts (an impervious surface).
Soil	Impervious surfaces	Paving, walls, armored banks	Scouring, cutting/changing shoreline, flooding
Unique soils: calcareous and serpentine soils	Lack of information for these soils and soil in general	Lack of information for these soils and soil in general	Potential for damage to unknown/unmapped resource
Groundwater	Consumption of groundwater in excess of replenishment	Human, agricultural, residential, commercial use and domestic animal use	Reduced groundwater quantity and quality, loss of springs and seeps, wetland loss, change of soil saturation zones, change in drinking water quality and quantity
Groundwater	Introduction of toxics, acid drainage (natural and mining)	Landfills, abandoned mines, land engineering, bedrock	Reduced groundwater quality
Groundwater	Physical failure	Landfills, abandoned mines, land engineering	Change in subsurface water flow patterns, change in subsurface temperatures, introduction of contaminants
Groundwater	Water bypasses the soil profile	Old/abandoned wells (farms)	Increased groundwater contamination with nutrients, pesticides and other chemicals
Groundwater	Impervious surfaces	Roads, buildings, infrastructure	Reduced water infiltration leading to reduced groundwater recharge, movement of water between watersheds

TABLE 2: DRAFT CONCEPTUAL MODEL OF GEOLOGICAL RESOURCES IN THE NATIONAL CAPITAL REGION NETWORK (CONTINUED)

Resource Component	Stressor	Sources	Ecological Effects
Exposed rock	Cutting the toe of slopes, over-steepened slopes, dipslopes	Development, roads, structures, trails, flooding, vegetation death (hemlock, etc.), logging	Reduced slope stability
Karst	Toxics: pesticides, dumping, spills	Agriculture, septic systems, sewage, dumping, industry, spills	Rapid movement of contaminants to groundwater, change in groundwater chemistry and resulting in change in biology
Karst	Nutrient loading	Agriculture, septic systems, sewage, dumping, industry, spills	Rapid movement of nutrients to groundwater resulting in change to groundwater quality and change in biology
Karst	Structural collapse, sinkholes	Inappropriate construction practices, dissolution in karst areas	Change in biology due to changes in air flow and temperature, volume and flow of water increased in areas, dissolution of bedrock
Surface water	Impervious surfaces	Infrastructure, development, residential and agricultural use, rip rap, armoring, etc.	Increased storm water flow, increased erosion, changes in sedimentation, changes in stream morphology, increased exposure to nutrients/pesticides, change in hydrologic cycle effecting floodplains, and floodplain/riparian buffer capacity, change in base flow
Surface water	Pesticide loading	Agricultural, residential, and commercial use	Reduced water quality, fishery health, and aquatic invertebrate communities and populations
Surface water	Nutrient loading	Agricultural, residential and commercial use	Reduced water quality, fishery health, and aquatic invertebrate communities and populations; algal blooms, eutrophication
Coastal areas	Impervious surfaces	Rip rap, armoring, coastal walls, dredging	Changes in water flow rates, unnatural erosion and deposition, changes in natural shoreline, changes in sedimentation, wetland flooding, changes in wetland extent.
Lakes, ponds, seeps, vernal pools	Nutrient loading	Agriculture, residential lawn care, vegetation change	Eutrophication, change in fauna (esp. herps), effect upon T&E species
Lakes, ponds, seeps, vernal pools	Pesticide loading	Agriculture, residential, and commercial use	Addition of herbicides and pesticides to surface water, change in fauna, effect upon T&E species
Riparian areas, wetlands	Change in soil surface elevation and horizontal dimensions	Land engineering resulting in changes to deposition and erosion, dredging, dumping, creation of impoundments and dams	Disruption to the wetland/riparian ecosystems, change in storm water flow rates, vegetation change, wildlife change, change in stream bed characteristics

TABLE 3: DRAFT CONCEPTUAL MODEL OF LANDSCAPE RESOURCES WITHIN THE LOWER CHESAPEAKE BAY WATERSHED

Resource Component	Stressor	Sources	Ecological Effects
Corridors	Land use practices	Any development	Habitat fragmentation, increase in exotics, increase in edge
Forest interior habitat	Habitat fragmentation /amount of edge	Any development	Loss of habitat and species through habitat degradation
Habitat structure (contagion and configuration)	Habitat fragmentation /amount of edge	Altered disturbance regime	Habitat degradation, loss of species and ecosystem functions
Habitat structure (type, shape, and configuration)	Exotics; natural succession	Altered disturbance regime	Habitat degradation, loss of species and ecosystem functions
Habitat structure (type, shape, and configuration)	Species over-abundance; natural succession	Altered disturbance regime	Habitat degradation, loss of species and ecosystem functions
Habitat transition zones (edge)	Land use practices	Any development	Loss of habitat and species
Landscape matrix (greater landscape)	Fragmentation of decision making	Legislation; land ownership; demographics	Altered ecosystem structure and function
Species-specific natural habitats	Land use practices	Land use	Change of habitat availability, change in species composition
Total forest habitat	Land use practices	Land use	Deforestation, altered rates of nutrient export
Viewshed	Land use practices	Land use	Physical alteration of habitat components and topography

TABLE 4: DRAFT CONCEPTUAL MODEL OF VEGETATION RESOURCES IN THE NATIONAL CAPITAL REGION NETWORK

Resource Component	Stressor	Sources	Ecological Effects
Aging hardwoods (e.g., oak, hickory), lichens, conifers	Air pollution (including ozone and acid deposition); increase CO_2 and N (human-caused)	Power plant and car emissions	Increased incidence of decline of some species; disease (multiple stress effect), increased vegetation growth (CO_2 and N)
Plant Species Composition	Climate change	Power plant and car emissions, agriculture	Increasing: Sweetgum, loblolly, S. Red Oak, Blackjack Oak, Post Oak, Winged Elm. Decreasing: Sugar Maple, Beech, White Ash, N. Red Oak
Upland communities - fire; riparian, 1st and 2nd terrace communities–flood	Changes to natural disturbance regimes (fire, flood) human caused	Land use changes inside and outside parks–fire and flood, weather events drives all	Changes in natural species composition/cover, successional changes may (flood) or may not (fire) be disturbance driven
All vegetation communities	Catastrophic disturbance (natural)	Hurricane, tornado, river flooding, ice storm, strong wind, landslides, fire	Soil saturation, biomass loss (limb breakage, defoliation, removal of above-ground portion), soil loss around roots, increased light (from canopy), decreased light (heavy layer of dead and down wood), canopy loss, understory loss, gap creation, increase seed distribution, loss of seed bank, erosion, change in species diversity, change in species composition, increase in nonnative species, increase forage for wildlife, loss of wildlife habitat
Riparian and aquatic vegetation	Erosion (stream bank)	Increased impervious surfaces within the watershed, flooding, boat wake (larger rivers), deforestation, agriculture, construction, recreation (vehicles, horseback riding, hikers)	Destruction of stream bank, incising/lowering of stream, addition of sediment
Riparian and aquatic vegetation	Erosion (stream channel)	Construction, deforestation	Uprooting of aquatic vegetation, sediment addition in wetland areas downstream; change in flooding regime
Upland vegetation	Erosion (land surface)	Culverts	Removal of substrate and vegetation and deposition of silt downstream
All vegetation communities	Cultural resources	Overlapping and conflicting legislation	Fragmentation, habitat changes, introduction of chemicals, increase in exotics, change in natural species composition
All vegetation communities, especially rare or sensitive species	Overuse and concentrated use, poaching, littering	Visitors	Soil compaction, trampling of plants, population decline of rare plants, increase in nonnatives
All contiguous vegetation cover types	Fragmentation	Changes in land use inside and outside parks, park legislation and management	Increased amount of edge, increased nonnative plants through corridors, decrease in population size viability
All vegetation communities, soil, water quality	Development – external (non-NPS, outside boundaries)	Commercial, residential, utilities	Wildlife habitat fragmentation, changes in hydrology (vernal pools, ephemeral ponds, wetlands), increase in nonnative species, erosion, loss of vegetation and change in species composition
All vegetation communities, soil, water quality	Development – internal (NPS and others, inside park boundaries)	New facilities, concessions, politics, utilities, maintenance	Wildlife habitat fragmentation, changes in hydrology, increase in nonnative species, erosion, wetland drainage, loss of vegetation and change in species composition
Native wetlands	Wetland mitigation (creation of new wetlands)	Installation of new facilities, utilities, infrastructure, concessions, maintenance	Hydrology, changes in species composition, displacement of native plants, habitat loss

TABLE 4: DRAFT CONCEPTUAL MODEL OF VEGETATION RESOURCES IN THE NATIONAL CAPITAL REGION NETWORK (CONTINUED)

Resource Component	Stressor	Sources	Ecological Effects
Potentially all vegetation types, especially successional areas, grasslands and shrub habitat (seen as politically more expendable than forest)	Politics, greed, homo-centricism, self promotion	Congress, NPS hierarchy, survival instinct	Loss of habitat, fragmentation
All types, forests, wetlands, meadows, scrub / shrub	Nonnative plants	Accidental and deliberate introduction, horticulture, land use disturbances, dumping, animals	Displacement of native plants, changes in hydrology, changes in soil chemistry, wildlife habitat loss
Insect pollinated plant species, especially species specific to certain pollinators	Loss of native pollinators	Loss of habitat	Decline in native species abundance, change in species composition, loss of habitat
Forest understory	White-tailed deer	Lack of predators, and increase in mature forest and edge habitat	Changes in natural species composition/cover, impedes/alters successional changes
Marshes	Nonnative animals: nutria	Accidental and deliberate introduction	Trampling, grazing, changes in natural plant population sizes
Meadows, forest	Nonnative animals: feral cats, dogs, rabbits	Accidental and deliberate introduction	Trampling, grazing, changes in natural plant population sizes, nutrient loading
American beech	Beech bark disease	Accidental introduction	Change in natural species composition, mortality of species, loss of habitat, change in viewshed, increase in exotics
American chestnut	Chestnut blight	Accidental introduction	Change in natural species composition, mortality of species, loss of habitat, change in viewshed, increase in exotics
American elm, other elms?	Dutch elm disease	Accidental introduction	Change in natural species composition, mortality of species, loss of habitat, change in viewshed, increase in exotics
Butternut	Butternut canker	Accidental introduction	Change in natural species composition, mortality of species, loss of habitat, change in viewshed, increase in exotics
Flowering dogwood	Dogwood anthracnose	Accidental introduction	Change in natural species composition, mortality of species, loss of habitat, change in viewshed, increase in exotics
Hemlock	Hemlock wooly adelgid	Accidental and deliberate introduction	Defoliation, mortality, changes in species composition, loss of habitat, increase in exotics
Maple, elm	Asian longhorn beetle	Accidental and deliberate introduction	Defoliation, mortality, changes in species composition, loss of habitat, increase in exotics
Oaks, pine, other trees	Gypsy moth	Accidental and deliberate introduction	Defoliation, mortality, changes in species composition, loss of habitat, increase in exotics
Vegetation communities along road edges and beyond	Localized pollutants (salts, spills, mowing, herbicide)	Road management	Damage; change in species composition

Table 5: Draft Conceptual Model of Threats and Ecological Effects to Aquatic Resource Components within the National Capital Region Network

Stressor	Threat Priority	Source	Ecological Effects
Fish (Resource Component)			
Flow regime (low/high)	1	Impervious surfaces, stormwater runoff/CSO, deforestation, water withdrawal (low), impoundments, climate change	↓ Biodiversity, Generalists: Specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Less desirable spp, Fish kills (low), ↓ Reproductive success, Change in migration patterns/ spawning time/location, Disease/mutation rate ↑, Stenothermal: Eurythermal changes (low), Population ↓
Sediments	2	Development/new construction, impervious surfaces, stormwater runoff/CSO, agriculture, silviculture, deforestation, erosion, recreation	↓ Biodiversity, Generalists: Specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Less desirable spp, Fish kills, ↓ Reproductive success, Change in migration patterns/ spawning time/location, Disease/mutation rate ↑, Population ↓
Deforestation	3	Atmospheric deposition, ozone, development/new construction, agriculture, silviculture, introduced biota, climate change, forest pests/diseases	↓ Biodiversity, Generalists: Specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Fish kills, ↓ Reproductive success, Stenothermal: Eurythermal changes, Population ↓
Habitat alteration	4	Development/new construction, impervious surfaces, stormwater runoff/CSO, commercial/industrial dumping, agriculture, silviculture, land mgt, deforestation, erosion, recreation	↓ Biodiversity, Generalists: Specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Fish kills, ↓ Reproductive success, Change in migration patterns/ pawning time/location, Stenothermal: Eurythermal changes, Population ↓, Sedimentation, habitat loss or change
Nutrients	5	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, silviculture, deforestation, erosion, nonnative spp	↓ Biodiversity, Generalists: Specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Less desirable spp, Fish kills, ↓ Reproductive success, Disease/mutation rate ↑, Population ↓
Water temperature	6	Development/new construction, impervious surfaces, stormwater runoff/CSO, commercial/industrial dumping, agriculture, silviculture, impoundments, climate change	↓ Biodiversity, Generalists: Specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Fish kills, ↓ Reproductive success, Change in migration patterns/spawning time/location, Disease/ mutation rate ↑, Stenothermal: Eurythermal changes, Population ↓
Nonnative spp	7	Development/new construction, park visitors and personnel, agriculture, land mgt, recreation, climate change, migratory wildlife, astorms, ballast water	↓ Biodiversity, Generalists: Specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Hybridization, ↓ Reproductive success, Disease/ mutation rate ↑, Population ↓, Habitat loss, ↓ reproduction, ↑ competition and predation
Toxics	8	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, legacy toxics, underground storage tanks	↓ Biodiversity, Generalists: Specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Less desirable spp, Fish kills, ↓ Reproductive success, Disease/mutation rate ↑, Population ↓
Over harvesting	10	Park visitors and personnel, land mgt	Population decrease, loss of diversity and viability (genetic)
Wildlife behavior disruption	11	Development/new construction, park visitors and personnel, land mgt, deforestation, recreation	Fish kills, Hybridization, ↓ Reproductive success, Change in migration patterns/spawning time/location, Disease/mutation rate ↑, Population ↓
Bacteria and other disease	12	Park visitors and personnel, stormwater runoff/Combined Sewer Overflow, lack/failure of septic system, commercial/industrial/homeowner dumping, agriculture, domestic animals, recreation, wildlife	↓ Biodiversity, Generalists: Specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, Fish kills, ↓ Reproductive success, Disease/mutation rate ↑, Population ↓, loss of population viability

TABLE 5: DRAFT CONCEPTUAL MODEL OF THREATS AND ECOLOGICAL EFFECTS TO AQUATIC RESOURCE COMPONENTS WITHIN THE NATIONAL CAPITAL REGION NETWORK (CONTINUED)

Stressor	Threat Priority	Source	Ecological Effects
Hybridization	13	Nonnative spp	↓ Biodiversity, ↑ Nonnative and less desirable spp, Hybridization, ↓ Reproductive success, Change in migration patterns/spawning time/location, Mutation rate ↑
Drugs/ hormones	14	Stormwater runoff/CSO, commercial/industrial/homeowner dumping, agriculture, domestic animals	↓ Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, Fish kills, ↓ Reproductive success, Change in migration patterns/ spawning time/location, Disease/mutation rate ↑, Population ↓
Acid deposition (pH)	n/a	Atmospheric deposition, stormwater runoff/CSO, commercial/ industrial/ homeowner dumping, fertilizer, underground storage tanks, agriculture	↓ Biodiversity, Generalists: Specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Less desirable spp, Fish kills, ↓ Reproductive success, Change in migration patterns/ spawning time/location, Disease/mutation rate ↑, Population ↓
Herps (Resource Component)			
Flow regime (low/high)	1	Impervious surfaces, stormwater runoff/CSO, deforestation, water withdrawal (low), impoundments, climate change	↓ Biodiversity, Generalists: Specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Less desirable spp, ↑ Disease/mutation rates, Change in migration pattern/breeding time/location, Population ↓, Reproductive success ↓, Mortality/ Loss of habitat
Sediments	2	LANDuse and landscape changes, Development/new construction, impervious surfaces, stormwater runoff/CSO, agriculture, silviculture, deforestation, erosion, recreation	↓ Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Change in migration pattern/breeding time/location, Population ↓, Reproductive success ↓, Mortality/Loss of habitat, ↓ availability and quality of habitat
Deforestation	3	Development/new construction, park visitors and personnel, agriculture, land mgt, recreation, climate change, wildlife	↓ Biodiversity, Generalists: Specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, ↑ Disease/mutation rates, Population ↓, Reproductive success ↓, Mortality/Loss of habitat, Loss/change of habitat
Habitat alteration	4	Atmospheric deposition, ozone, development/new construction, agriculture, silviculture, introduced biota, climate change, forest pests/diseases	↓ Biodiversity, Generalists: Specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Change in migration pattern/breeding location, Population ↓, Reproductive success ↓, Mortality/Loss of habitat, Loss/change of habitat
Nutrients	5	Atmospheric deposition, stormwater runoff/CSO, commercial/ industrial/ homeowner dumping, fertilizer, silviculture, deforestation, erosion, nonnative spp	↓ Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ ↑ Disease/mutation rates, Population ↓, Reproductive success ↓, Mortality/ Loss of habitat
Water temperature	6	Development/new construction, impervious surfaces, stormwater runoff/CSO, commercial/industrial dumping, agriculture, silviculture, impoundments, climate change	↓ Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, ↑ Disease/mutation rates, Population, Mortality
Nonnative spp	7	Development/new construction, park visitors and personnel, agriculture, silviculture, land mgt, deforestation, domestic animals, recreation, migratory wildlife, storms, ballast water	↓ Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, ↑ Disease/mutation rates, Population ↓, Reproductive success ↓, Mortality, Loss of habitat, ↑ competition and predation
Toxics	8	Atmospheric deposition, stormwater runoff/CSO, commercial/ industrial/ homeowner dumping, fertilizer, legacy toxics, underground storage tanks	↓ Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, ↑ Disease/mutation rates, Population ↓, Reproductive success ↓, Mortality/Loss of habitat

TABLE 5: DRAFT CONCEPTUAL MODEL OF THREATS AND ECOLOGICAL EFFECTS TO AQUATIC RESOURCE COMPONENTS WITHIN THE NATIONAL CAPITAL REGION NETWORK (CONTINUED)

Stressor	Threat Priority	Source	Ecological Effects
Trampling/ compaction	9	Development/new construction, park visitors and personnel, land mgt, deforestation, domestic animals, recreation, wildlife	↓ Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Less desirable spp, Population ↓, Reproductive success ↓, Mortality, Loss of habitat
Over harvesting	10	Park visitors and personnel, land mgt	↓ Biodiversity, Population ↓, Reproductive success ↓,
Wildlife behavior disruption	11	Development/new construction, park visitors and personnel, land mgt, deforestation, domestic animals, recreation, wildlife	↓ Biodiversity, Generalists: Specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Disease/ mutation rates, Change in migration pattern/breeding time/location, Population ↓, Reproductive success ↓, Mortality, Loss of habitat
Acid deposition (pH)	n/a	Atmospheric deposition, stormwater runoff/CSO, commercial/ industrial/ homeowner dumping, fertilizer, underground storage tanks, agriculture	↓ Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Less desirable spp, ↑ Disease/mutation rates, Population ↓, Reproductive success ↓, Mortality
Physical abnormality	n/a	Park visitors and personnel, stormwater runoff/CSO, lack/failure of septic system, commercial/ industrial/ homeowner dumping, agriculture, domestic animals, recreation, wildlife	↓ Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Less desirable spp, ↑ Disease/mutation rates, Change in migration pattern/breeding time/location, Population ↓, Reproductive success ↓, Mortality
Macroinvertebrates (Resource Component)			
Flow regime (low/high)	1	Impervious surfaces, stormwater runoff/CSO, deforestation, water withdrawal (low), impoundments, climate change	Biodiversity ↓, Generalists: specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Less desirable spp, Population ↓, Change in community structure, ↓ Reproductive success
Sediments	2	Development/new construction, impervious surfaces, stormwater runoff/CSO, agriculture, silviculture, deforestation, erosion, recreation	Biodiversity ↓, Generalists: specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative spp, ↑ Less desirable spp, Population ↓, Change in community structure
Deforestation	3	Development/new construction, park visitors and personnel, agriculture, land mgt, recreation, climate change, wildlife	Biodiversity ↓, Generalists: specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Population ↓, Change in community structure, ↓ Reproductive success
Habitat alteration	4	Atmospheric deposition, ozone, development/new construction, agriculture, silviculture, introduced biota, climate change, forest pests/diseases	Biodiversity ↓, Generalists: specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Population ↓, Change in community structure, ↓ Reproductive success
Nutrients	5	Atmospheric deposition, stormwater runoff/CSO, commercial/ industrial/ homeowner dumping, fertilizer, silviculture, deforestation, erosion, nonnative spp	Biodiversity ↓, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Population ↓, Change in community structure
Water temperature	6	Development/new construction, impervious surfaces, stormwater runoff/CSO, commercial/industrial dumping, agriculture, silviculture, impoundments, climate change	Biodiversity ↓, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Population ↓, Change in community structure ↓ Reproductive success
Nonnative spp	7	Development/new construction, park visitors and personnel, agriculture, silviculture, land mgt, deforestation, domestic animals, recreation, migratory wildlife, storms, ballast water	Biodiversity ↓, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Population ↓, Change in community structure, ↓ Reproductive success, ↑ competition and predation

TABLE 5: DRAFT CONCEPTUAL MODEL OF THREATS AND ECOLOGICAL EFFECTS TO AQUATIC RESOURCE COMPONENTS WITHIN THE NATIONAL CAPITAL REGION NETWORK (CONTINUED)

Stressor	Threat Priority	Source	Ecological Effects
Toxics	8	Atmospheric deposition, stormwater runoff/CSO, commercial/ industrial/ homeowner dumping, fertilizer, legacy toxics, underground storage tanks	Biodiversity ↓, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Population ↓, Change in community structure, ↓ Reproductive success
Trampling/ compaction	9	Development/new construction, park visitors and personnel, agriculture, land mgt, deforestation, domestic animals, recreation, wildlife	Biodiversity ↓, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Less desirable spp, Population ↓, Change in community structure, ↓ Reproductive success
Over harvesting	10	Park visitors and personnel, land mgt	Biodiversity ↓, Population ↓, Change in community structure
Wildlife behavior disruption	11	Development/new construction, park visitors and personnel, agriculture, silviculture, land mgt, deforestation, domestic animals, recreation, wildlife	Biodiversity ↓, Generalists: specialists changes, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Population ↓, Change in community structure, ↓ Reproductive success
Drugs/ hormones	14	Stormwater runoff/CSO, commercial/industrial/homeowner dumping, agriculture, domestic animals	Biodiversity ↓, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Population ↓, Change in community structure
Acid deposition (pH)	n/a	Atmospheric deposition, stormwater runoff/CSO, commercial/ industrial/ homeowner dumping, fertilizer, underground storage tanks, agriculture	Biodiversity ↓, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Population ↓, Change in community structure
Plankton (Resource Component)			
Flow regime (slow/fast)	1	Impervious surfaces, stormwater runoff/CSO, deforestation, water withdrawal (slow), impoundments (slow), climate change	↑ Undesirable and nonnative spp, Disruption in population cycle and size, Change in biodiversity
Sediments	2	Development/new construction, impervious surfaces, stormwater runoff/CSO, agriculture, silviculture, deforestation, erosion, recreation	↑ Undesirable and nonnative spp, Disruption in population cycle and size, Change in biodiversity
Deforestation	3	Development/new construction, impervious surfaces, stormwater runoff/CSO, commercial/industrial dumping, agriculture, silviculture, impoundments, climate change	↑ Undesirable and nonnative spp, Disruption in population cycle and size, Change in biodiversity
Habitat alteration	4	Development/new construction, impervious surfaces, stormwater runoff/CSO, commercial/industrial dumping, agriculture, silviculture, impoundments, climate change	↑ Undesirable and nonnative spp, Disruption in population cycle and size, Change in biodiversity
Nutrients	5	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, silviculture, deforestation, erosion, nonnative spp	↑ Undesirable and nonnative spp, Disruption in population cycle and size, Change in biodiversity
Water temperature	6	Development/new construction, impervious surfaces, stormwater runoff/CSO, commercial/industrial dumping, agriculture, silviculture, impoundments, climate change	↑ Undesirable and nonnative spp, Disruption in population cycle and size, Change in biodiversity

TABLE 5: DRAFT CONCEPTUAL MODEL OF THREATS AND ECOLOGICAL EFFECTS TO AQUATIC RESOURCE COMPONENTS WITHIN THE NATIONAL CAPITAL REGION NETWORK (CONTINUED)

Stressor	Threat Priority	Source	Ecological Effects
Nonnative spp	7	Development/new construction, impervious surfaces, stormwater runoff/CSO, commercial/industrial dumping, agriculture, silviculture, impoundments, climate change	↑ Undesirable and nonnative spp, Disruption in population cycle and size, Change in biodiversity, Hybridization, ↑ competition and predation
Toxics	8	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, legacy toxics, underground storage tanks	↑ Undesirable and nonnative spp, Disruption in population cycle and size, Change in biodiversity
Wildlife behavior disruption	11	Development/new construction, impervious surfaces, stormwater runoff/CSO, commercial/industrial dumping, agriculture, silviculture, impoundments, climate change	↑ Undesirable and nonnative spp, Disruption in population cycle and size, Change in biodiversity
Bacteria	12	Park visitors and personnel, stormwater runoff/CSO, lack/failure of septic system, commercial/industrial/homeowner dumping, agriculture, domestic animals, recreation, wildlife, nonnative spp	↑ Undesirable and nonnative spp, Disruption in population cycle and size, Change in biodiversity, Competition
Acid deposition (pH)	n/a	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, underground storage tanks, agriculture	↑ Undesirable and nonnative spp, Disruption in population cycle and size, Change in biodiversity
Vegetation (Resource Component)			
Flow regime (low/high)	1	Impervious surfaces, stormwater runoff/CSO, deforestation, water withdrawal, impoundments(low), climate change	↓Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Change in community structure,↑ Disease/pest (low), ↓ Regeneration
Sediments	2	Development/new construction, impervious surfaces, stormwater runoff/CSO, agriculture, silviculture, deforestation, erosion, recreation	↓Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Change in community structure, ↑ Disease/pest, ↓ Regeneration, Symptom of erosion of stream bank, incising of stream, uprooting of aquatic vegetation, sediment addition in wetland areas downstream, change in flooding regime
Deforestation	3	Development/new construction, park visitors and personnel, agriculture, land mgt, recreation, climate change, wildlife	↓Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Change in community structure, ↑ Disease/pest, ↓ Regeneration, Fragmentation leading to: ↑ amount of edge, ↑ nonnative plants through corridors, decrease in population size viability
Habitat alteration	4	Atmospheric deposition, ozone, development/new construction, agriculture, silviculture, introduced biota, climate change, forest pests/diseases	↓Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, Change in community structure,↑ Disease/pest, ↓ Regeneration , Fragmentation leading to: ↑ amount of edge, ↑ nonnative plants through corridors, decrease in population size and viability
Nutrients	5	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, silviculture, deforestation, erosion, nonnative spp	↓Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Change in community structure,↑ Disease/pest, ↓ Regeneration
Water temperature	6	Development/new construction, impervious surfaces, stormwater runoff/CSO, commercial/industrial dumping, agriculture, silviculture, impoundments, climate change	↓Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Less desirable spp, Change in community structure, ↑ Disease/pest, ↓ Regeneration

TABLE 5: DRAFT CONCEPTUAL MODEL OF THREATS AND ECOLOGICAL EFFECTS TO AQUATIC RESOURCE COMPONENTS WITHIN THE NATIONAL CAPITAL REGION NETWORK (CONTINUED)

Stressor	Threat Priority	Source	Ecological Effects
Nonnative spp	7	Development/new construction, park visitors and personnel, agriculture, silviculture, land mgt, deforestation, domestic animals, recreation, migratory wildlife, storms, ballast water	↓Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Change in community structure, ↑ Disease/pest, ↓ Regeneration, grazing, changes in natural plant population sizes, ↑ competition and predation, loss of habitat, hybridization, alteration of fire regime, disruption of insect-native plant associations
Toxics	8	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, legacy toxics, underground storage tanks	↓Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Less desirable spp, Change in community structure, ↑ Disease/pest, ↓ Regeneration
Trampling/ compaction	9	Development/new construction, park visitors and personnel, agriculture, land management, deforestation, domestic animals, recreation, wildlife	↓Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, Change in community structure, ↑ Disease/pest, ↓ Regeneration, Disruption to the wetland/riparian ecosystems, change in storm water flow rates, wildlife change, change in stream bed characteristics
Over harvesting	10	Park visitors and personnel, land mgt	↓Biodiversity, Change in community structure, ↓ Regeneration, Soil compaction, trampling of plants, population decline of rare plants
Wildlife behavior disruption	11	Development/new construction, park visitors and personnel, agriculture, silviculture, land management, deforestation, domestic animals, recreation, wildlife	↓Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Change in community structure, ↑ Disease/pest, ↓ Regeneration
Bacteria	12	Park visitors and personnel, stormwater runoff/CSO, lack/failure of septic system, commercial/industrial/homeowner dumping, agriculture, domestic animals, recreation, wildlife, nonnative spp	↓Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Less desirable spp, Change in community structure, ↑ Disease/pest, ↓ Regeneration
Hybridization	13	Nonnative spp	↓Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Change in community structure, ↑ Disease/pest, ↓ Regeneration
Drugs/ hormones	14	stormwater runoff/CSO, commercial/ industrial/homeowner dumping, agriculture, domestic animals	↓Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Less desirable spp, Change in community structure, ↑ Disease/pest, ↓ Regeneration
Acid deposition (pH)	n/a	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, underground storage tanks, agriculture	↓Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Less desirable spp, Change in community structure, ↑ Disease/pest, ↓ Regeneration
Riparian Zone / Floodplain (Resource Component)			
Flow regime (high/low)	1	Impervious surfaces, stormwater runoff/CSO, deforestation, water withdrawal, impoundments, climate change	↑ Impairment of water quality, water supply, and physical habitat, including alteration of range and frequency of disturbance, ↓ Buffer / filter capacity, Change in vegetation community due to altered flooding regime
Sediments	2	Development/new construction, impervious surfaces, stormwater runoff/CSO, agriculture, silviculture, deforestation, erosion, recreation	↑ Impairment of water quality, water supply, and physical habitat, Alteration of range and frequency of disturbance, ↓ Buffer / filter capacity, Change in vegetation community, Symptom of erosion of stream bank, incising of stream, uprooting of aquatic vegetation, sediment addition in wetland areas downstream, change in flooding regime

TABLE 5: DRAFT CONCEPTUAL MODEL OF THREATS AND ECOLOGICAL EFFECTS TO AQUATIC RESOURCE COMPONENTS WITHIN THE NATIONAL CAPITAL REGION NETWORK (CONTINUED)

Stressor	Threat Priority	Source	Ecological Effects
Deforestation	3	Development/new construction, park visitors and personnel, agriculture, silviculture, land mgt, deforestation, domestic animals, recreation, wildlife	↑ Impairment of water quality, water supply, and physical habitat, Alteration of range and frequency of disturbance, ↓ Buffer / filter capacity, ↑ amount of edge, Change in vegetation community due to altered flooding regime , Wildlife habitat fragmentation, changes in hydrology (vernal pools, ephemeral ponds, wetlands), ↑ nonnative spp, erosion
Habitat alteration	4	Development/new construction, park visitors and personnel, agriculture, silviculture, land mgt, deforestation, domestic animals, recreation, wildlife	↑ Impairment of water quality, water supply, and physical habitat, Alteration of range and frequency of disturbance, ↓ Buffer / filter capacity, amount of edge, Change in vegetation community, Wildlife habitat fragmentation, changes in hydrology (vernal pools, ephemeral ponds, wetlands), ↑ nonnative spp, erosion, wildlife change, change in stream bed characteristics, Fragmentation
Nutrients	5	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, silviculture, deforestation, erosion, nonnative spp	↑ Impairment of water quality, water supply, and physical habitat (i.e., vegetation), Alteration of range and frequency of disturbance, ↓ Buffer / filter capacity
Nonnative spp	7	Development/new construction, park visitors and personnel, agriculture, silviculture, land mgt, deforestation, domestic animals, recreation, migratory wildlife, storms, ballast water	↑ Impairment of water quality, water supply, and physical habitat, alteration of range and frequency of disturbance, ↓ Buffer / filter capacity, Change in vegetation community due to altered flooding regime, grazing, changes in natural plant population sizes, disruption of ecological processes
Toxics	8	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, legacy toxics, underground storage tanks	↑ Impairment of water quality, water supply, and physical habitat (i.e., vegetation), alteration of range and frequency of disturbance, ↓ Buffer / filter capacity
Trampling/ compaction	9	Development/new construction, park visitors and personnel, agriculture, land mgt, deforestation, domestic animals, recreation, wildlife	↑ Impairment of water quality, water supply, and physical habitat, alteration of range and frequency of disturbance, Change in vegetation community due to altered flooding regime, ↑ nonnatives, Disruption to the wetland/riparian ecosystems, change in storm water flow rates, wildlife change, change in stream bed characteristics
Wildlife behavior disruption	11	Development/new construction, park visitors and personnel, agriculture, silviculture, land mgt, deforestation, domestic animals, recreation, wildlife	Alteration of range and frequency of disturbance, Change in vegetation community structure
Acid deposition (pH)	n/a	Atmospheric deposition, ozone, development/ new construction, agriculture, silviculture, introduced biota, climate change, forest pests/ diseases	↑ Impairment of water quality, water supply, and physical habitat (i.e., algal blooms), including alteration of range and frequency of disturbance, ↓ Buffer / filter capacity, Change in vegetation community
Groundwater (Resource Component)			
Flow regime (low/high)	1	Impervious surfaces, stormwater runoff/ CSO, deforestation, water withdrawal (low), impoundments, climate change	↑ Impairment of water quality, water supply, and physical habitat (i.e., algal blooms), Alteration of range and frequency of disturbance, ↓ Buffer / filter capacity (high), ↓ Infiltration (low), Altered biological communities, Altered behavior of wildlife
Sediments	2	Development/new construction, impervious surfaces, stormwater runoff/CSO, agriculture, silviculture, deforestation, erosion, recreation	↑ Impairment of water quality, water supply, and physical habitat, alteration of range and frequency of disturbance, ↓ Buffer / filter capacity, ↓ Infiltration, Altered biological communities, Altered behavior of wildlife

TABLE 5: DRAFT CONCEPTUAL MODEL OF THREATS AND ECOLOGICAL EFFECTS TO AQUATIC RESOURCE COMPONENTS WITHIN THE NATIONAL CAPITAL REGION NETWORK (CONTINUED)

Stressor	Threat Priority	Source	Ecological Effects
Deforestation	3	Development/new construction, park visitors and personnel, agriculture, land mgt, recreation, climate change, wildlife	↑ Impairment of water quality, water supply, and physical habitat, Alteration of range and frequency of disturbance, ↓ Buffer / filter capacity, ↓ Infiltration, Altered biological communities, Altered behavior of wildlife
Habitat alteration	4	Atmospheric deposition, ozone, development/new construction, agriculture, silviculture, introduced biota, climate change, forest pests/diseases, Structural collapse, sinkholes	↑ Impairment of water quality, water supply, and physical habitat, alteration of range and frequency of disturbance, ↓ Buffer / filter capacity, ↓ Infiltration, Altered biological communities, Altered behavior of wildlife , Change in biology due to changes in air flow and temperature, volume and flow of water ↑ in areas, dissolution of bedrock
Nutrients	5	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, silviculture, deforestation, erosion, nonnative spp, agriculture, septic systems, sewage, dumping, industry, spills	↑ Impairment of water quality, water supply, and physical habitat (i.e., algal blooms), ↓ Buffer / filter capacity, ↓ Infiltration, Altered biological communities, In Karst: Rapid movement of nutrients to ground water resulting in change to ground water quality and change in biology
Water Temperature	6	Development/new construction, impervious surfaces, stormwater runoff/ CSO, commercial/industrial dumping, agriculture, silviculture, impoundments, climate change	↑ Impairment of water quality, Alteration of range and frequency of disturbance, Altered biological communities, Altered behavior of wildlife
Nonnative spp	7	Development/new construction, park visitors and personnel, agriculture, silviculture, land management, deforestation, domestic animals, recreation, migratory wildlife, streams, ballast water	↑ Impairment of water quality, water supply, and physical habitat (i.e., algal blooms), alteration of range and frequency of disturbance, ↓ Buffer / filter capacity, ↓ Infiltration, ↓ Recreational opportunities (swimming, fishing, etc), and aesthetics, Altered biological communities, Disruption of ecological processes
Toxics	8	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, legacy toxics, underground storage tanks, LANDfills, abandoned mines, land engineering, bedrock, agriculture, septic systems, industry, spills	↑ Impairment of water quality,↓ Buffer / filter capacity, Altered biological communities, Altered behavior of wildlife, In Karst: Rapid movement of contaminants to ground water
Trampling/ compaction	9	Development/new construction, park visitors and personnel, agriculture, silviculture, land management, deforestation, domestic animals, recreation, wildlife	↑ Impairment of water quality, water supply, and physical habitat alteration of range and frequency of disturbance, ↓ Buffer / filter capacity, ↓ Infiltration, Altered biological communities, Altered behavior of wildlife
Over harvesting	10	Human, agricultural, residential, commercial use and domestic animal use	↑ Impairment of water quality, water supply, and physical habitat (i.e., algal blooms), increased contaminants, alteration of range and frequency of disturbance, ↓ Buffer / filter capacity, ↓ Infiltration, Altered biological communities, Altered behavior of wildlife, Loss of springs and seeps, wetland loss, change of soil saturation zones, changes in plant productivity
Wildlife behavior disruption	11	Development/new construction, agriculture, silviculture, introduced biota, climate change, forest pests/ diseases, Structural collapse, sinkholes	↑ Impairment of water quality, water supply, and physical habitat (i.e., algal blooms), alteration of range and frequency of disturbance, ↓ Buffer / filter capacity, ↓ Infiltration, Altered biological communities, Altered behavior of wildlife

TABLE 5: DRAFT CONCEPTUAL MODEL OF THREATS AND ECOLOGICAL EFFECTS TO AQUATIC RESOURCE COMPONENTS WITHIN THE NATIONAL CAPITAL REGION NETWORK (CONTINUED)

Stressor	Threat Priority	Source	Ecological Effects
Bacteria	12	Park visitors and personnel, stormwater runoff/CSO, lack/failure of septic system, commercial/ industrial/ homeowner dumping, agriculture, domestic animals, recreation, wildlife, nonnative spp.	↑ Impairment of water quality, Altered biological communities, Altered behavior of wildlife
Drugs/ hormones	14	Stormwater runoff/CSO, commercial/ industrial/homeowner dumping, agriculture, domestic animals	↑ Impairment of water quality, Altered biological communities, Altered behavior of wildlife
Acid deposition (pH)	n/a	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, underground storage tanks, agriculture	↑ Impairment of water quality, water supply, and physical habitat, ↓ Buffer / filter capacity, Altered biological communities, Altered behavior of wildlife, Decreased Acid Neutralizing Capacity (ANC)
Vernal / Ephemeral Pools (Resource Component)			
Low flow regime	1	Impervious surfaces, stormwater runoff/CSO, deforestation, water withdrawal, impoundments, climate change	Change in number, timing, and presence of pools, ↓ Herp reproductive success, ↓ Biodiversity, Tolerant spp , ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Disease/pest ↑, ↓ Regeneration
Sediments	2	Development/new construction, impervious surfaces, stormwater runoff/CSO, agriculture, silviculture, deforestation, erosion, recreation	Change in number, timing, and presence of pools, ↓ Herp reproductive success, ↓ Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, ↓ Regeneration
Deforestation	3	Development/new construction, park visitors and personnel, agriculture, land mgt, recreation, climate change, wildlife	Change in number, timing, and presence of pools, ↓ Herp reproductive success, ↓ Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Less desirable spp, ↓ Regeneration
Habitat alteration	4	Atmospheric deposition, ozone, development/ new construction, agriculture, silviculture, introduced biota, climate change, forest pests/ diseases	Change in number, timing, and presence of pools, ↓ Herp reproductive success, ↓ Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, ↓ Regeneration
Nutrients	5	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, silviculture, deforestation, erosion, nonnative spp	↓ Herp reproductive success, ↓ Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Disease/ pest ↑
Water temperature	6	Development/new construction, impervious surfaces, stormwater runoff/ CSO, dumping, agriculture, silviculture, impoundments, climate change	↓ Herp reproductive success, ↓ Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Disease/pest ↑
Nonnative spp	7	Development/new construction, park visitors and personnel, agriculture, silviculture, land mgt, deforestation, domestic animals, recreation, migratory wildlife, storms	Change in number, timing, and presence of pools, ↓ Herp reproductive success, ↓ Biodiversity, ↑ Tolerant spp , ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Change in community structure, Diseased/pest increase, ↓ Regeneration, disruption of ecological processes
Toxics	8	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, legacy toxics, underground storage tanks	↓ Herp reproductive success, ↓ Biodiversity, ↑ Tolerant spp ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Disease /pest ↑

TABLE 5: DRAFT CONCEPTUAL MODEL OF THREATS AND ECOLOGICAL EFFECTS TO AQUATIC RESOURCE COMPONENTS WITHIN THE NATIONAL CAPITAL REGION NETWORK (CONTINUED)

Stressor	Threat Priority	Source	Ecological Effects
Trampling/ compaction	9	Development/new construction, park visitors and personnel, agriculture, land mgt, deforestation, domestic animals, recreation, wildlife	Change in number, timing, and presence of pools, ↓ Herp reproductive success, ↓ Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, ↓ Regeneration
Wildlife behavior disruption	11	Development/new construction, park visitors and personnel, agriculture, silviculture, land mgt, deforestation, domestic animals, recreation, wildlife	Change in number, timing, and presence of pools, ↓ Herp reproductive success, ↓ Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Diseased/pest increase
Bacteria	12	Park visitors and personnel, stormwater runoff/CSO, lack/failure of septic system, commercial/ industrial/ homeowner dumping, agriculture, domestic animals, recreation, wildlife, nonnative spp.	↓ Herp reproductive success, ↓ Biodiversity, ↑ Tolerant spp ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Disease/ pest increase, ↓ Regeneration
Drugs/ hormones	14	stormwater runoff/CSO, commercial/ industrial/homeowner dumping, agriculture, domestic animals	↓ Herp reproductive success, ↓ Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Disease/ pest ↑
Acid deposition (pH)	n/a	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, underground storage tanks, agriculture	↓ Herp reproductive success, ↓ Biodiversity, ↑ Tolerant spp, ↓ Intolerant spp, ↑ Nonnative and less desirable spp, Disease/ pest ↑, ↓ ANC
Physical Habitat (Resource Component)			
Flow regime (high/low)	1	Impervious surfaces, stormwater runoff/ CSO, deforestation, impoundments, climate change	Sedimentation (high), Altered stream morphology (high), Scouring (high), Bank instability/mass wasting (high), Altered temperature regime (low)
Sediments	2	Development/new construction, impervious surfaces, stormwater runoff/CSO, agriculture, silviculture, deforestation, erosion, recreation	↑ siltation, reduced productivity/health/abundance of soil, plants, and aquatic organisms, Change in “normal” sedimentation sequence and composition, filling of channels, elevation of streambed, flooding of previously dry areas, creation of wetlands, loss of wildlife habitat
Deforestation	3	Development/new construction, park visitors and personnel, agriculture, land mgt, recreation, climate change, wildlife	Loss of soil surface cover, ↑ soil surface and groundwater temperatures, Wildlife habitat fragmentation, changes in hydrology (vernal pools, ephemeral ponds, wetlands), increase in nonnative spp, erosion, loss of vegetation and change in spp composition
Habitat alteration	4	Atmospheric deposition, ozone, development/ new construction, agriculture, silviculture, introduced biota, climate change, forest pests/ diseases	Wildlife habitat fragmentation, changes in hydrology (vernal pools, ephemeral ponds, wetlands), increase in nonnative spp, erosion, loss of vegetation and change in spp composition
Nonnative spp	7	Development/new construction, park visitors and personnel, agriculture, silviculture, land mgt, deforestation, domestic animals, recreation, migratory wildlife, storms, ballast water	Loss of species, degradation of natural landscapes, alteration of natural fire regimes, disruption of natural processes
Trampling/ compaction	9	Development/new construction, park visitors and personnel, agriculture, land mgt, deforestation, domestic animals, recreation, wildlife	Changes in vegetation survival, changes in soil physical properties, creation of soil crusts (an impervious surface).

TABLE 5: DRAFT CONCEPTUAL MODEL OF THREATS AND ECOLOGICAL EFFECTS TO AQUATIC RESOURCE COMPONENTS WITHIN THE NATIONAL CAPITAL REGION NETWORK (CONTINUED)

Stressor	Threat Priority	Source	Ecological Effects
Wildlife behavior disruption	11	Development/new construction, park visitors and personnel, agriculture, land mgt, deforestation, domestic animals, recreation, wildlife	Changes in vegetation survival, disruption of natural processes
Watershed (Resource Component)			
Flow regime (low/high)	1	Impervious surfaces, stormwater runoff/ CSO, deforestation, water withdrawal (low), impoundments, climate change	Some area may dry up, others have lowered flow regime (low); areas flooded that were not normally (high)
Sediments	2	Development/new construction, impervious surfaces, stormwater runoff/ CSO, commercial/ industrial dumping, homeowner dumping, agriculture, silviculture, deforestation, erosion, recreation	Filling of channels, elevation of streambed, flooding of previously dry areas, creation of wetlands, loss of wildlife habitat
Deforestation	3	Development/new construction, park visitors and personnel, agriculture, land mgt, recreation, climate change, wildlife	Loss of some populations and/or spp, Wildlife habitat fragmentation, changes in hydrology, increase in nonnative spp, erosion, loss of vegetation and change in spp composition
Habitat alteration	4	Atmospheric deposition, ozone, development/ new construction, agriculture, silviculture, introduced biota, climate change, forest pests/ diseases	Loss of some populations and/or spp, Wildlife habitat fragmentation, changes in hydrology, increase in nonnative spp, erosion, loss of vegetation and change in spp composition
Nutrients	5	Atmospheric deposition, stormwater runoff/ CSO, commercial/industrial/ homeowner dumping, fertilizer, silviculture, deforestation, erosion, nonnative spp	Reduced water quality, fishery health, and aquatic invertebrate communities and populations. Algal blooms, eutrophication, Eutrophication, change in fauna (esp. herps), effect upon T&E spp
Water temperature	6	Development/new construction, impervious surfaces, stormwater runoff/ CSO, commercial/ industrial dumping, agriculture, silviculture, impoundments, climate change	Loss of some populations and/or spp
Nonnative spp	7	Development/new construction, park visitors and personnel, agriculture, silviculture, land management, deforestation, domestic animals, recreation, migratory wildlife, storms, ballast water	Change in spp and population distributions, degradation of natural landscapes, alteration of natural fire regimes, disruption of natural processes
Toxics	8	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, legacy toxics, underground storage tanks	Loss of some populations and/or spp, Reduced water quality, fishery health, and aquatic invertebrate communities and populations, Addition of herbicides and pesticides to surface water, change in fauna, effect upon T&E spp
Wildlife behavior disruption	11	Development/new construction, park visitors and personnel, agriculture, silviculture, land management, deforestation, domestic animals, recreation	Change in spp and population distributions, disruption of natural processes

TABLE 5: DRAFT CONCEPTUAL MODEL OF THREATS AND ECOLOGICAL EFFECTS TO AQUATIC RESOURCE COMPONENTS WITHIN THE NATIONAL CAPITAL REGION NETWORK (CONTINUED)

Stressor	Threat Priority	Source	Ecological Effects
Bacteria	12	Park visitors and personnel, stormwater runoff/CSO, lack/failure of septic system, commercial/industrial/ homeowner dumping, agriculture, domestic animals, recreation, wildlife, nonnative spp.	Loss of some populations and/or spp
Drugs/ hormones	14	stormwater runoff/CSO, commercial/ industrial/ homeowner dumping, agriculture, domestic animals	Loss of some populations and/or spp
Acid deposition (pH)	n/a	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, underground storage tanks, agriculture	Loss of buffering ability at downstream locations due to concentration
Water Quality (Resource Component)			
Flow regime (low/high)	1	Impervious surfaces, stormwater runoff/CSO, deforestation, water withdrawal (low), impoundments, climate change	Concentration of solutes and particulates, increase temperature (low); Dilution of solutes and particulates, water chemistry changes, ↓ DO, habitat loss
Sediments	2	Development/new construction, impervious surfaces, stormwater runoff/ CSO, agriculture, silviculture, deforestation, erosion, recreation	Decrease in water quality, habitat loss
Deforestation	3	Development/new construction, park visitors and personnel, agriculture, land mgt, recreation, climate change, wildlife	Decrease in water quality, Increases temperature and solute and particulate inputs
Habitat alteration	4	Atmospheric deposition, ozone, development/ new construction, agriculture, silviculture, introduced biota, climate change, forest pests/ diseases	Decrease in water quality
Nutrients	5	Atmospheric deposition, stormwater runoff/ CSO, commercial/industrial/ homeowner dumping, fertilizer, silviculture, deforestation, erosion, nonnative spp	↓ in water quality, water chemistry changes, eutrophication and ↓ DO, habitat loss
Nonnative spp	7	Development/new construction, park visitors and personnel, agriculture, silviculture, land mgt, deforestation, domestic animals, recreation, wildlife	Disruption of natural processes, loss of water inputs, increased water loss, Add disease or allelopathic compounds, decrease available nutrients and oxygen
Toxics	8	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, legacy toxics, underground storage tanks	↓ in water quality, water chemistry changes, habitat loss
Wildlife behavior disruption	11	Development/new construction, park visitors and personnel, agriculture, silviculture, land mgt, deforestation, domestic animals, recreation	Disruption of natural processes, Add disease or allelopathic compounds, decrease available nutrients and oxygen

TABLE 5: DRAFT CONCEPTUAL MODEL OF THREATS AND ECOLOGICAL EFFECTS TO AQUATIC RESOURCE COMPONENTS WITHIN THE NATIONAL CAPITAL REGION NETWORK (CONTINUED)

Stressor	Threat Priority	Source	Ecological Effects
Bacteria	12	Park visitors and personnel, stormwater runoff/CSO, lack/failure of septic system, commercial/industrial/ homeowner dumping, agriculture, domestic animals, recreation, wildlife, nonnative spp	Decrease in water quality
Drugs/ hormones	14	stormwater runoff/CSO, commercial/ industrial/homeowner dumping, agriculture, domestic animals	Decrease in water quality
Acid deposition (pH)	n/a	Atmospheric deposition, stormwater runoff/CSO, commercial/industrial/ homeowner dumping, fertilizer, underground storage tanks, agriculture	Decrease in water quality, water chemistry changes, ↓ dissolved oxygen (DO), habitat loss, decrease in acid neutralizing capacity (ANC)
Water Quantity (Resource Component)			
Flow regime (low/high)	1	Impervious surfaces, stormwater runoff/CSO, deforestation, water withdrawal (low), impoundments, climate change	Decrease (low), Increase (high)
Sediments	2	Development/new construction, impervious surfaces, stormwater runoff/ CSO, agriculture, silviculture, deforestation, erosion, recreation	Increase or decrease
Deforestation	3	Development/new construction, park visitors and personnel, agriculture, land mgt, recreation, climate change, wildlife	Increase or decrease
Nonnative spp	7	Development/new construction, park visitors and personnel, agriculture, silviculture, land mgt, deforestation, domestic animals, recreation, migratory wildlife, storms, ballast water	Increase or decrease, loss of water inputs, increased water loss
Trampling/ compaction	9	Development/new construction, park visitors and personnel, agriculture, land mgt, deforestation, domestic animals, recreation, wildlife	Decreases infiltration to subsurface and groundwater flow, increases overland flow
Over harvesting	10	Park visitors and personnel, land mgt	Of groundwater, decreases surface flow

Table 6: Summary of Stressors and Sources to National Capital Region Network Aquatic Resources

			SOURCES												
			Atmospheric Deposition	Ozone	Development / New Construction	Impervious Surfaces	Park Visitors and Personnel	Stormwater Runoff/CSO	Lack/Failure of Septic System	Legacy Toxics	Commercial/industrial Dumping	Homeowner Dumping	Underground Storage Tanks	Pesticide Use	Fertilizer
STRESSORS	Flow Regime	Low (base)				X		X							
		High (storm)				X		X							
	Water Quality	Nutrients	X					X			X	X			X
		Toxics	X					X		X	X	X	X	X	X
		Sediment			X	X		X			X	X			
		Acid deposition (pH)	X					X			X	X	X		
		Bacteria					X	X	X		X	X			
		Drugs/Hormones/Pharm.						X			X	X			
	Physical Habitat	Habitat alteration			X	X		X			X				
		Temperature			X	X		X			X				
		Deforestation	X	X	X										
		Introduced Species			X		X								
		Trampling/Compaction			X		X								
		Wildlife Behavior Disruption													
		Overfishing/Harvesting/Collecting					X								
		Hybridization					X								

TABLE 6: SUMMARY OF STRESSORS AND SOURCES TO NATIONAL CAPITAL REGION NETWORK AQUATIC RESOURCES (CONTINUED)

			SOURCES													
			Vehicles	Agriculture	Silviculture	Land Management	Deforestation	Domestic Animals	Water Withdrawal	Erosion	Impoundments	Introduced Biota	Recreation	Climate Change	Forest pests/disease	Wildlife
STRESSORS	Flow Regime	Low (base)					X		X		X			X		
		High (storm)					X				X			X		
	Water Quality	Nutrients		X		X			X		X					
		Toxics														
		Sediment	X	X		X			X			X				
		Acid deposition (pH)	X													
		Bacteria	X				X					X			X	
		Drugs/Hormones/Pharm.	X				X									
	Physical Habitat	Habitat alteration	X	X	X				X			X				
		Temperature	X	X						X			X			
		Deforestation	X		X	X							X		X	X
		Introduced Species			X		X							X	X	X
		Trampling/Compaction			X	X	X	X	X					X		X
		Wildlife Behavior Disruption									X					
		Overfishing/Harvesting/Collecting					X									
		Hybridization											X			

TABLE 7: DRAFT CONCEPTUAL MODEL OF WILDLIFE RESOURCES IN THE NATIONAL CAPITAL REGION NETWORK

Resource Component	Stressor	Sources	Ecological Effects
Birds: FIDS	Deer	Development and landscape changes	Decreased diversity, change or loss of habitat
Birds: FIDS and grassland birds	Development (cell towers, housing development, roads)	Land use and landscape changes	Habitat loss, fragmentation, increased mortality
Birds: FIDS, grassland birds, and waterfowl	Avian diseases	Exotics and population overcrowding	Mortality, decreased diversity
Birds: FIDS, grassland birds, colonial waterbirds, and waterfowl	Predators	Human introduction and landscape changes	Mortality, decreased diversity
Birds: FIDS, grassland birds, raptors	Habitat fragmentation and habitat loss	Development; management practices; natural processes	Habitat loss
Birds: FIDS, grassland birds, raptors	Succession	Natural processes	Habitat variation, change in food supply
Birds: FIDS, grassland birds, raptors, colonial waterbirds, and waterfowl	Contaminants	Residential pesticides, roads (salts and petro. Spills), industrial air pollution, water management practices	Increased mortality, decreased diversity, decreased reproductive rates, malformations
Birds: FIDS, grassland birds, raptors, colonial waterbirds, and waterfowl	Climatic variation	Global warming, El Niño / La Niña	Habitat variation, change in food supply,
Birds: FIDS, grassland birds, raptors, colonial waterbirds, and waterfowl	Exotic and invasive species	Urbanization; transportation mechanisms (human, bird, air, water)	Habitat loss, decreased diversity, increased mortality, increased competition
Fish	Chemical contaminants	Industry / human development	Water chemistry changes, decreased DO, habitat loss, increased disease, decreased reproduction, loss of diversity
Fish	Habitat degradation	Industry / human development	Sedimentation, habitat loss or change, loss of diversity, population changes
Fish	Increased disease levels	Contaminants	Population decrease, loss of diversity, loss of population viability
Fish	Exotic introduction	Commercial and non-commercial	Habitat loss, decreased reproduction, loss of diversity
Fish	Competitor introduction	Humans, habitat changes	Habitat loss, decreased reproduction, loss of diversity
Fish	Change in levels of fishing	Humans	Population decrease, loss of diversity and viability (genetic)
Fish	Fisheries management policies	Humans	Population changes, loss of diversity, over-fishing the resource
Frogs/salamanders/ aquatic turtles	UV radiation	CFC	Mutations / defects
Frogs/salamanders/ aquatic turtles	Contaminants	Agriculture/ Industrial/ Residential	Mutations/defects/ disease
Frogs/salamanders/ aquatic turtles	Droughts	Climate	Mortality, loss of habitat
Frogs/salamanders/ aquatic turtles	Fragmentation (metapopulations)	Natural (fires/storms), land use changes (development)	Loss or change of habitat

TABLE 7: DRAFT CONCEPTUAL MODEL OF WILDLIFE RESOURCES IN THE NATIONAL CAPITAL REGION NETWORK (CONTINUED)

Resource Component	Stressor	Sources	Ecological Effects
Frogs/salamanders/ aquatic turtles	Road mortality	Roads and land use changes	Mortality/population decrease
Frogs/salamanders/ aquatic turtles	Disease	Unknown	Mortality/population decrease
Frogs/salamanders/ aquatic turtles	Competition	Introduction of exotics such as bullfrogs, fish sp.	Mortality/competitive exclusion
Frogs/salamanders/ aquatic turtles	Siltation	Land use and landscape changes	Decreased availability and quality of habitat
Frogs/salamanders/ aquatic turtles	Global warming	Anthropogenic	Water levels change, climate changes, UV, etc.
Land turtles/snakes/ lizards	Fragmentation (metapopulations)	Natural (fires/storms), land use changes (development)	Loss or change of habitat
Land turtles/snakes/ lizards	Road mortality	Roads and landuse changes	Mortality/population decrease
Land turtles/ snakes/lizards	Collecting	Pets/Market Trade	Population decline
Land turtles/ snakes/lizards	Global warming	Anthropogenic	Water levels change, climate changes, UV, etc.
Land turtles/ snakes/lizards	Disease	Unknown	Mortality/population decrease
Small mammals (mice, rats, voles, shrews, weasels, moles, squirrels)	Fragmentation (metapopulations)	Natural (fires/storms), land use changes (development)	Diversity decreases
Carnivores (fox, weasels, coyote, raccoon, bobcats, otter, skunk, possum, mink, bear)	Fragmentation (metapopulations)	Natural (fires/storms), land use changes (development)	Population decreases
Herbivores (deer, beaver, e. cottontails, woodchucks)	Fragmentation (metapopulations)	Natural (fires/storms), land use changes (development)	Population increase
Bats	Fragmentation (metapopulations)	Natural (fires/storms), land use changes (development)	Population decreases
Small mammals (mice, rats, voles, shrews, weasels, moles, squirrels)	Predation	Feral animals (cats, dogs, bullfrogs)	Mortality
Herbivores (deer, beaver, e. cottontails, woodchucks)	Predation	Feral animals (cats, dogs, bullfrogs)	Mortality
Bats	Predation	Feral animals (cats, dogs, bullfrogs)	Mortality
Small mammals (mice, rats, voles, shrews, weasels, moles, squirrels)	Contaminants	Agriculture/ Industrial/ Residential	Mortality and disease
Carnivores (otter and mink only)	Contaminants	Agriculture/ Industrial/ Residential	Mortality and disease
Herbivores (deer, beaver, e. cottontails, woodchucks)	Contaminants	Agriculture/ Industrial/ Residential	Mortality and disease
Bats	Contaminants	Agriculture/ industrial/ residential	Mortality and disease

TABLE 7: DRAFT CONCEPTUAL MODEL OF WILDLIFE RESOURCES IN THE NATIONAL CAPITAL REGION NETWORK (CONTINUED)

Resource Component	Stressor	Sources	Ecological Effects
Small mammals (mice, rats, voles, shrews, weasels, moles, squirrels)	Change in habitat	Exotic species introduction/succession	Loss of habitat and decrease in habitat quality
Carnivores (fox, weasels, coyote, raccoon, bobcats, otter, skunk, possum, mink, bear)	Change in habitat	Exotic species introduction/ succession	Loss of habitat and decrease in habitat quality
Herbivores (deer, beaver, e. cottontails, woodchucks)	Change in habitat	Exotic species introduction/ succession	Loss of habitat and decrease in habitat quality
Bats	Change in habitat	Exotic species introduction/ succession	Loss of habitat and decrease in habitat quality
Mammals (all)	Global warming	Anthropogenic	Water levels change, climate changes, UV, change in habitat
Small mammals (mice, rats, voles, shrews, weasels, moles, squirrels)	Development	Land use change	Change or loss of habitat
Carnivores (fox, weasels, coyote, raccoon, bobcats, otter, skunk, possum, mink, bear)	Development	Land use change	Change or loss of habitat
Herbivores (deer, beaver, e. cottontails, woodchucks)	Development	Land use change	Change or loss of habitat
Bats	Development	Land use change	Change or loss of habitat
Carnivores (fox, weasels, coyote, raccoon, bobcats, otter, skunk, possum, mink, bear)	Road mortality	Roads and land use changes	Mortality
Herbivores (deer, beaver, e. cottontails, woodchucks)	Road mortality	Roads and land use changes	Mortality
Carnivores (fox, weasels, coyote, raccoon, bobcats, otter, skunk, possum, mink, bear)	Poaching	People	Mortality
Herbivores (deer, beaver, e. cottontails, woodchucks)	Poaching	People	Mortality
Herbivores (deer, fur-bearers)	Legal hunting	People	Mortality
Carnivores (fox, weasels, coyote, raccoon, bobcats, otter, skunk, possum, mink, bear)	Disease	NA	Mortality
Herbivores (deer, beaver, e. cottontails, woodchucks)	Disease	NA	Mortality
Bats	Disease	NA	Mortality

Appendix G

Air Quality Monitoring Considerations for the National Capital Region Network

INTRODUCTION

The NPS Air Resources Division (ARD) has contracted with the University of Denver (DU) to produce GIS-based maps that estimate baseline values (with confidence limits) for a set of air quality parameters for all Inventory and Monitoring parks in the U.S. This information will be available in early FY 2002. ARD used preliminary DU products to help develop an implementation strategy for expanding NPS air quality monitoring under the Natural Resources Challenge. Based on the implementation strategy, ARD may fund installation of a wet deposition monitor at Catoctin Mountain Park in FY 2003. The air monitoring implementation strategy will be revisited in FY 2004 if additional funding becomes available. The National Capital Network can use the final DU products (which will be sent to you when available), along with on-site and/or nearby off-site ambient monitoring and natural resource data discussed in this report, to help assess air quality-related conditions and monitoring needs in Network parks.

WET DEPOSITION

None of the NPS units in the National Capital Network have a National Atmospheric Deposition Program/National Trends Network (NADP/NTN) wet deposition monitor on-site, but all units have a monitor within 100 km (60 miles). NADP/NTN collects data on both pollutant deposition (in kilograms per hectare per year) and pollutant concentration (in microequivalents per liter). Deposition varies with the amount of annual on-site precipitation, and is useful because it gives an indication of the total annual pollutant loading at the site. Concentration is independent of precipitation amount, therefore it provides a better indication of whether ambient pollutant levels are increasing or decreasing over the years. In 2000, wet deposition and concentration of sulfate, and wet deposition of nitrate were high in the northeast U.S., including the National Capital Network, relative to the rest of the United States. Wet concentration of nitrate was high in the northeast U.S. Wet ammonium concentration was relatively low in the northeast U.S., whereas wet ammonium deposition was moderate in the northeast (see U.S. wet deposition isopleth maps at http://nadp.sws.uiuc.edu). Data from the NADP/NTN sites in the National Capital Region are summarized below.

Finksburg, MD

The Finksburg, Maryland, NADP/NTN site (site #MD03 [White Rock]) has been in operation since 1984. The site data show a decrease in concentration and deposition of wet sulfate since 1984, a decrease in concentration of wet nitrate, and no apparent trend in deposition of wet nitrate, deposition of wet ammonium, or concentration of wet ammonium.

Wye, MD

The NADP/NTN site was installed at Wye, Maryland, (site #MD13) in 1983. The trends are the same as at the Finksburg site.

Arendtsville, PA

An NADP/NTN site was installed at Arendtsville, Pennsylvania, (site #PA00) in 1999. Sufficient data are not yet available to characterize pollutant trends at the site.

Shenandoah NP

The NADP/NTN site at Shenandoah NP (site #VA28) has been operating since 1981. A review of site data shows concentration and deposition of wet sulfate have decreased, as has deposition of wet nitrate. There has been no apparent trend in concentration of wet nitrate, concentration of wet ammonium, or deposition of wet ammonium.

Parsons, WV

The Parsons, West Virginia, NADP/NTN site (site #WV18) has been in operation since 1978. There has been a decrease in wet sulfate concentration, wet sulfate deposition, wet nitrate deposition, and wet ammonium concentration. There has been no apparent trend in wet nitrate concentration or wet ammonium deposition.

Data from all National Capital Network region NADP/NTN sites show a decrease in wet sulfate concentration and deposition, which is consistent with a nationwide reduction in sulfur dioxide emissions. While trends in wet deposition and concentration of nitrate and ammonium are not consistent among sites, in all cases they are either stable or decreasing.

Based solely on spatial distribution, it appears existing NADP/NTN sites provide adequate coverage for the National Capital Network. ARD will evaluate the adequacy of existing data before making a final decision about installing a wet deposition monitor at Catoctin Mountain Park. Cost information is provided in case the network is interested in installing a site. A NADP/NTN wet deposition site costs $5,000 to $8,000 for equipment purchase and installation, and operating costs (including site operation, chemical analysis, and reporting) are about $7,000 per year.

Dry Deposition. None of the units in the National Capital Network have a Clean Air Status and Trends Network (CASTNet) dry deposition monitor on-site, but all units have a monitor within 100 km. CASTNet uses different monitoring and reporting techniques than NADP/NTN, so the dry deposition amounts are reported here as nitrogen and sulfur, rather than nitrate, ammonium, and sulfate. In addition, because CASTNet calculates dry deposition based on measured ambient concentrations and estimated deposition velocities, there is greater uncertainty in the reported values. Due to the small number of CASTNet sites nationwide, use of dry deposition isopleth maps is not advised at this time. CASTNet data collected at the sites in the National Capital Network region are summarized below.

Beltsville, MD

The Beltsville, Maryland, CASTNet site (site #BEL116) has been operating since 1989. A review of the site data shows a decrease in dry sulfur deposition, but no apparent trend in dry nitrogen deposition since 1989. Based on a comparison of CASTNet and Finksburg, Maryland, NADP/NTN data, CASTNet estimates total sulfur deposition at Beltsville consists of 61 percent wet deposition and 39 percent dry deposition, while total nitrogen deposition is 63 percent wet and 37 percent dry.

Arendtsville, PA

Arendtsville, Pennsylvania, has had a CASTNet site (site #ARE128) since 1988. A review of site data shows a decrease in dry sulfur deposition but no apparent trend in dry nitrogen deposition. According to CASTNet, total sulfur deposition at the site consists of 54 percent wet and 46 percent dry deposition, while total nitrogen deposition is 64 percent wet and 36 percent dry.

Shenandoah NP

The CASTNet site at Shenandoah NP (site #SHN418) has been operating since 1988. The site data show a decrease in dry sulfur deposition but no apparent trend in dry nitrogen deposition. Based on a comparison of CASTNet and on-site NADP/NTN data, CASTNet estimates total sulfur deposition at Shenandoah NP is 60 percent wet and 40 percent dry, while total nitrogen deposition is 56 percent wet and 44 percent dry.

Parsons, WV

The Parsons, West Virginia, CASTNet site (site #PAR107) has been operating since 1988. The site data show a decrease in dry sulfur deposition but no apparent trend in dry nitrogen deposition. Based on a comparison of CASTNet and on-site NADP/NTN data, CASTNet estimates total sulfur deposition is 61 percent wet deposition and 36 percent dry deposition, while total nitrogen deposition is 74 percent wet and 26 percent dry.

Again, the decreasing trend in dry sulfur deposition at the CASTNet sites in the National Capital Network region reflects a decrease in sulfur dioxide emissions. Based solely on spatial distribution, it appears existing CASTNet sites provide adequate coverage for the Network. For future reference, installation and annual operating costs for a CASTNet site are about $50,000 and $15,000, respectively.

Surface Water Chemistry. The Water Resources Division's (WRD) Baseline Water Quality Data Inventory and Analysis reports were reviewed for all of the NPS units in the National Capital Network. Acid-sensitive surface waters typically have a pH below 6.0 and an acid neutralizing capacity (ANC) below 100 microequivalents per liter (μeq/l). Data from the Baseline Water Quality Data Inventory and Analysis reports for National Capital Network parks are summarized below.

Antietam NB

A review of the 1995 Baseline Water Quality Data Inventory and Analysis report for Antietam National Battlefield (NB) indicated many water chemistry data have been collected in the park. Samples collected at various locations along Antietam and Sharpsburg Creeks between 1963 and 1994 had a mean pH of 7.9 and average ANC values of 90-1544 μeq/l. These data indicate surface waters in Antietam NB are not sensitive to acid deposition.

Cactoctin Mountain Park

A review of the 1995 *Baseline Water Quality Data Inventory and Analysis* report for Catoctin Mountain Park indicated few water quality data have been collected in the park and none have been collected since 1985. Many pH values were 7.0 or higher, but some were in the range of 5.4 to 5.7. No ANC data were available. It is possible that the underlying bedrock of certain streams causes those streams to be more acidic. Regardless, the limited data indicate streams and springs in the park are susceptible to acidification from atmospheric deposition. A systematic monitoring program that includes pH, ANC, and other water chemistry parameters would provide better information on the current condition, and sensitivity, of surface waters in the park.

Chesapeake and Ohio Canal NHP

A review of the *Baseline Water Quality Data Inventory and Analysis* report for the Chesapeake and Ohio Canal National Historic Park (NHP) indicated park surface waters consist of the canal, the Potomac, Shenandoah and Monocacy Rivers, and some small tributaries. Typically, large rivers are not sensitive to acidification from atmospheric deposition. Samples collected in the Potomac River had an average pH of about 7.6 and an average ANC of about 500 μeq/l. Samples collected in the canal in 1973 had an average pH of about 7.2. Samples collected from Conococheague Creek between 1980 and 1994 had an average pH of 8.3 and an average ANC of 1160 μeq/l. These data indicate surface waters in the Chesapeake and Ohio Canal NHP are not sensitive to acidification from atmospheric deposition.

George Washington Memorial Parkway

A review of the 1996 *Baseline Water Quality Data Inventory and Analysis* report for the George Washington Memorial Parkway indicated water quality data were collected in the Potomac River and its tributaries between 1972 and 1994. Average pH values were 7.2 to 8.0 and average ANC values were 280-672 μeq/l. A low pH value of 1.0 was reported in 1978, but this was most likely a monitoring or reporting error. In general, the data indicate the river is not susceptible to acidification from atmospheric deposition. Eutrophication, however, is of concern, and many of the samples did have high nitrate and nitrite levels. Given the parkway's metropolitan location, and the Potomac River's exposure to industrial and sewage effluents and runoff, it may be difficult to separate the influence of atmospherically deposited nitrogen from other sources. If eutrophication is a concern, the network may want to consult with ARD and WRD staff, as well as with other subject matter experts, to determine the best way to monitor water quality and potential nitrogen sources.

Harpers Ferry NHP

A review of the 1997 *Baseline Water Quality Data Inventory and Analysis* report for Harpers Ferry National Historic Park (NHP) indicated all water quality data collected in the park were obtained from the Shenandoah River. These data, collected between 1946 and 1995, had an average pH of about 8.1 and an average ANC of about 936 μeq/l. If streams and springs are an important resource at Harpers Ferry NHP, network staff may want to perform a synoptic water quality survey to assess the sensitivity of these water resources to acidification from atmospheric deposition.

Manassas NBP

A review of the 1997 *Baseline Water Quality Data Inventory and Analysis* report for Manassas National Battlefield Park (NBP) indicated many water quality data are available for the park. Data collected between 1973 and 1994 had an average pH of about 7.2 and an average ANC that ranged from 352–

1680 μeq/l. These data indicate surface waters in the park are not sensitive to acidification from atmospheric deposition.

Monocacy NB

A review of the 2000 *Baseline Water Quality Data Inventory and Analysis* report for Monocacy National Battlefield (NB) indicated few pH and ANC data are available for the park. Data collected on Bush Creek and the Monocacy River in 1972–73 and 1996 had an average pH of 7.5, and an average ANC of 1152 μeq/l. If creeks, lakes, ponds, and springs are important resources at Monocacy NB, network staff may want to perform a synoptic water quality survey to assess the sensitivity of these water resources to acidification from atmospheric deposition.

National Capital Parks-East

A review of the 1999 *Baseline Water Quality Data Inventory and Analysis* report for National Capital Parks-East indicated the parks contain a diverse array of water resources including rivers, marshes, wetlands, creeks, and lakes. Data collected on the Potomac River show the river is not sensitive to acidification from atmospheric deposition. Water samples collected on Upland Creek between 1979 and 1984 had an average pH of 6.6 and an average ANC of 160 μeq/l, indicating the creek is not sensitive to acidification. Extremely low pH and ANC events were reported at various locations, e.g., a pH of 1.2 was reported at Watts Branch. It is difficult to determine if this was a sampling or reporting error or a true reading. Given the urban setting, park surface waters are likely exposed to a variety of air- and waterborne pollutants. If the network has a particular concern about the impacts of atmospheric deposition on National Capital Parks-East surface waters, we recommend network staff meet with ARD to discuss how best to address those concerns.

Prince William Forest Park

A review of the 1994 *Baseline Water Quality Data Inventory and Analysis* report for Prince William Forest Park indicated limited pH and ANC data are available for creeks, no creek data are available since 1985, and no water quality data are available for ponds. Data collected on Quantico Creek between 1951 and 1985 had an average pH of about 6.7 and an average ANC of about 100 μeq/l. Network staff may want to consider collecting some new creek and pond water chemistry data to assess surface water sensitivity to atmospheric deposition.

Rock Creek Park

A review of the 1994 *Baseline Water Quality Data Inventory and Analysis* report for Rock Creek Park indicated water quality data were collected between 1973 and 1989. The average pH was about 7.3 and the average ANC ranged from 144 to 592 μeq/l. These data indicate the creek is not sensitive to acidification from atmospheric deposition. Some samples had high concentrations of nitrates and nitrites, so eutrophication may be a concern. However, it may be difficult to distinguish atmospherically deposited nitrogen from other sources, i.e., industrial and sewage effluents and runoff. If eutrophication is a concern, the network may want to consult with ARD and WRD staff, as well as with other subject matter experts, to determine the best way to monitor water quality and potential nitrogen sources.

Wolf Trap Farm Park for the Performing Arts

A review of the 1996 *Baseline Water Quality Data Inventory and Analysis* report for the Wolf Trap Farm Park for the Performing Arts indicated no water quality data have been collected in the park. Limited data have been collected outside the park. Data collected at the Route 193 Bridge between 1979 and 1996 had an average pH of 6.9 and an average ANC of 208 μeq/l. Data collected at the Route 674 Bridge between 1980 and 1996 had an average pH of 7.4 and an average ANC of 176 μeq/l. These data indicate nearby streams are not susceptible to acidification from atmospheric deposition. However, it is not clear if these data are representative of surface water conditions within the park.

Visibility. Visibility-impairing particles and certain gases are monitored in natural areas through the Interagency Monitoring of Protected Visual Environments (IMPROVE) program. Because of the mandates of the Clean Air Act, the IMPROVE program has focused monitoring efforts in Class I air quality areas. Regardless, IMPROVE monitoring provides a regional analysis of visibility; therefore, the data indicate conditions in nearby Class II air quality areas. IMPROVE program staff recently identified an error in past data calculations, and are in the process of re-calculating the data.

Therefore, trend data are not currently available for IMPROVE sites. None of the units in the National Capital Network have an IMPROVE monitor on-site, but all units have a monitor within 100 km. The four monitors in the National Capital region are located on the National Mall in Washington, D.C. (site #WASH1), in Arendtsville, Pennsylvania (site #AREN1), in Shenandoah NP (site #SHEN1), and in Davis, West Virginia, near the Dolly Sods and Otter Creek Wilderness Areas (site #DOSO1). Based solely on spatial distribution, it appears existing IMPROVE sites provide adequate coverage for the National Capital Network. Installation and annual operating costs of an IMPROVE site are about $15,000 and $30,000, respectively.

Ozone. None of the units in the National Capital Network have an ozone monitor on-site, but all units have a monitor within 25 km (15 miles) of some portion of the park. Based solely on spatial distribution of ozone monitors, it appears the portion of the Chesapeake and Ohio Canal NHP between Hagerstown and Cumberland, Maryland, may not be well-represented by existing monitors. In addition, it is not clear if monitors in Frederick and Hagerstown, Maryland, adequately represent ozone conditions in Catoctin Mountain Park. Final products from the DU analysis will help clarify these issues. Installation and annual operating costs for an ozone monitoring site are about $90,000 and $14,000, respectively.

Vegetation. For vegetation, the focus is on ozone sensitivity because 1) ozone is a regional pollutant and is, therefore, more likely to affect park resources than either sulfur dioxide or nitrogen oxide which quickly convert to other compounds, and 2) the literature on ozone sensitivity is more recent and more reliable than that for other pollutants. Park vascular plant lists contained in a May 2001 version of NPSpecies were compared to the general ozone-sensitive plant species lists contained in the NPS Synthesis information management system (see attached Synthesis species lists). The Synthesis lists were developed by an expert in the field of ozone effects on vegetation. Note that the Synthesis lists are a general guide to ozone sensitivity. Differences in plant genetics, weather conditions, water availability, and ozone concentrations will affect whether or not a species exhibits injury in a particular park. Ozone sensitive species of natural vegetation were identified for ten of the 11 units in the National Capital Network; NPSpecies did not contain a list for Wolf Trap Farm Park (see table 1). Note that some crops and other cultivated plants are also sensitive to ozone. In order to determine if any cultivated species grown in National Capital Network parks would be good indicators of ozone injury, it would be necessary for the network to identify specific cultivars at each site.

It is generally agreed that plant foliar injury occurs after a cumulative exposure to ozone. One ozone statistic that is used to evaluate the risk of plant injury is the SUM06. SUM06 is the sum of all hourly average ozone concentrations greater than or equal to 0.06 parts per million (ppm). In 1997, a group of ozone effects experts recommended 3-month, 8:00 a.m. to 8:00 p.m., SUM06 effects endpoints for natural vegetation, i.e., 8 to 12 ppm-hrs for foliar injury to natural ecosystems and 10 to 15 ppm-hrs for growth effects on tree seedlings in natural forest stands. The DU products will give some indication of the ozone risk to sensitive vegetation in National Capital Network parks. If ozone concentrations indicate potential foliar injury of vegetation, network staff may want to conduct foliar injury surveys on a handful of sensitive species.

Conclusions

All of the NPS units in the National Capital Network have a NADP/NTN wet deposition monitor within 100 km.

All of the NPS units in the National Capital Network have a CASTNet dry deposition monitor within 100 km.

Data indicate surface waters in three Network parks—Antietam NB, Chesapeake and Ohio Canal NHP, and Manassas NB are not susceptible to acidification from atmospheric deposition. Eutrophication from atmospherically deposited nitrogen, along with industrial and sewage effluent, and runoff, is a potential concern at George Washington Memorial Parkway and Rock Creek Park. Additional water chemistry data collection may be desirable at other network parks to clarify surface water sensitivity to atmospheric deposition.

All of the NPS units in the National Capital Network have an IMPROVE visibility monitor within 100 km.

All of the NPS units in the National Capital Network have an ozone monitor within 25 km. It may be desirable to install an ozone monitor in the western portion of the Chesapeake and Ohio Canal NHP or in Catoctin Mountain Park.

Ozone sensitive species have been identified for ten of the 11 NPS units in the National Capital Network. Ozone concentrations may be high enough to warrant foliar injury surveys in some parks.

Relevant Websites

NADP - http://nadp.sws.uiuc.edu/

CASTNet - http://www.epa.gov/castnet/

Ozone - http://www.epa.gov/airsdata/sources.htm

IMPROVE - http://vista.cira.colostate.edu/improve/

Pollution sources and air quality data - http://www.epa.gov/air/data/index.html

Ozone-specific sources and data - http://www.epa.gov/ttn/rto/areas/

Pollution source and air quality graphics - http://www.epa.gov/agweb/

TABLE 1: PLANT SPECIES VERY SENSITIVE TO OZONE

These species would be expected to produce distinctive foliar injury when exposed to "normal" levels of ambient ozone. This list was developed for the AQUIMS Project and is considered a work in progress. Future updates and changes to this list will be posted to AQUIMS. This version is dated September 20, 1999.

Code	Scientific Name	Common Name	Family
AIAL	Ailanthus altissima	Tree-of-heaven	Simaroubaceae
AMAL2	Amelanchier alnifolia	Saskatoon serviceberry	Rosaceae
APAN2	Apocynum androsaemifolium	Spreading dogbane	Apocynaceae
ARDO3	Artemisia douglasiana	Mugwort	Asteraceae
ASAC6	Aster acuminatus	Whorled aster	Asteraceae
ASEN2	Aster engelmannii	Engelmann's aster	Asteraceae
ASEX	Asclepias exaltata	Tall milkweed	Asclepiadaceae
ASMA2	Aster macrophyllus	Big-leaf aster	Asteraceae
ASPU5	Aster puniceus	Purple-stemmed aster	Asteraceae
ASQU	Asclepias quadrifolia	Four-leaved milkweed	Asclepiadaceae
ASSY	Asclepias syriaca	Common milkweed	Asclepiadaceae
ASUM	Aster umbellatus	Flat-toppped aster	Asteraceae
FRAM2	Fraxinus americana	White ash	Oleaceae
FRPE	Fraxinus pennsylvanica	Green ash	Oleaceae
GEAM4	Gentiana amarella	Northern gentian	Gentianaceae
LIST2	Liquidambar styraciflua	Sweetgum	Hamamelidaceae
LITU	Liriodendron tulipifera	Yellow-poplar	Magnoliaceae
OEEL	Oenothera elata	Evening primrose	Onagraceae
PAQU2	Parthenocissus quinquefolia	Virginia creeper	Vitaceae
PHCA11	Physocarpus capitatus	Ninebark	Rosaceae
PHCO7	Philadelphus coronarius	Sweet mock-orange	Hydrangeaceae
PIJE	Pinus jeffreyi	Jeffrey pine	Pinaceae
PIPO	Pinus ponderosa	Ponderosa pine	Pinaceae
PIPU5	Pinus pungens	Table mountain pine	Pinaceae
PITA	Pinus taeda	Loblolly pine	Pinaceae
PLOC	Platanus occidentalis	American sycamore	Platanaceae
POTR5	Populus tremuloides	Quaking aspen	Salicaceae
PRPE2	Prunus pensylvanica	Pin cherry	Rosaceae
PRSE2	Prunus serotina	Black cherry	Rosaceae
RHCO13	Rhus copallina	Flameleaf sumac	Anacardiaceae
RUAL	Rubus allegheniensis	Allegheny blackberry	Rosaceae

TABLE 1: PLANT SPECIES VERY SENSITIVE TO OZONE (CONTINUED)

Code	Scientific Name	Common Name	Family
RUHI2	Rudbeckia hirta	Black-eyed susan	Asteraceae
RULA3	Rudbeckia laciniata	Cut-leaf coneflower	Asteraceae
SAAL5	Sassafras albidum	Sassafras	Lauraceae
SACA12	Sambucus canadensis	American elder	Caprifoliaceae
SAME5	Sambucus mexicana	Blue elderberry	Caprifoliaceae
SARA2	Sambucus racemosa	Red elderberry	Caprifoliaceae
SESE2	Senecio serra	Tall butterweed	Asteraceae
VAME	Vaccinium membranaceum	Thin-leaved blueberry	Ericaceae
VILA8	Vitis labrusca	Northern fox grape	Vitaceae

Source: National Park Service, Air Resources Division and Penn State University, Department of Plant Pathology, June 1999.

Appendix H

Summary of Ambient Air Quality Data Collected in and near National Park Service Units in the National Capital Region Network

Park	National Atmospheric Deposition Program/ National Trends Network		Clean Air Status and Trends Network		Interagency Monitoring of Protected Visual Environments		Ozone	
	Location	Site #	Location	Site #	Location	Site #	Location	Site #
ANTI[a]	Arendtsville, PA 55 km NE	PA00	Arendtsville, PA 55 km NE	ARE128	Arendtsville, PA 55 km NE	AREN1	Hagerstown, MD 15 km N	240430009
	Finksburg, MD 70 km E	MD03	Beltsville, MD 80 km SE	BEL116	National Mall 85 km SE	WASH1	Martinsburg, WV 20 km W	540030003
							Frederick, MD 25 km E	240210037
CATO[b]	Arendtsville, PA 30 km NE	PA00	Arendtsville, PA 30 km NE	ARE128	Arendtsville, PA 30 km NE	AREN1	Hagerstown, MD 20 km W	240430009
	Finksburg, MD 50 km SE	MD03	Beltsville, MD 75 km SE	BEL116	National Mall 80 km SE	WASH1	Frederick, MD 20 km S	240210037
CHOH[c]	Arendtsville, PA N, NE	PA00	Arendtsville, PA N, NE	ARE128	Arendtsville, PA N, NE	AREN1	D.C. and surrounding MD and VA suburbs	Many
	Finksburg, MD N, E, NE	MD03	Beltsville, MD E, SE, NE	BEL116	National Mall S, SE, E	WASH1	Hagerstown, MD E, N	240430009
	Parsons, WV W, S, SW	WV18	Parsons, WV W, S, SW	PAR107	Dolly Sods/Otter Creek, WA W, S, SW	DOSO1	Martinsburg, WV W, S	540030003
							Frederick, MD E, N	240210037
							Johnstown, PA N	420210011
GWMP[d]	Finksburg, MD N	MD03	Beltsville, MD NE	BEL116	National Mall E	WASH1	D.C. and surrounding MD and VA suburbs	Many
	Wye, MD E	MD13						

Park	National Atmospheric Deposition Program/ National Trends Network		Clean Air Status and Trends Network		Interagency Monitoring of Protected Visual Environments		Ozone	
	Location	Site #	Location	Site #	Location	Site #	Location	Site #
HAFE[e]	Arendtsville, PA 70 km NE	PA00	Arendtsville, PA 70 km NE	ARE128	Arendtsville, PA 70 km NE	AREN1	Martinsburg, WV 25 km NW	540030003
	Finksburg, MD 70 km NE	MD03	Beltsville, MD 70 km SE	BEL116	National Mall 70 km SE	WASH1	Frederick, MD 30 km NE	240210037
							Hagerstown, MD 35 km N	240430009
MANA[f]	SHEN 85 km SW	VA28	SHEN 85 km SW	SHN418	National Mall 45 km NE	WASH1	D.C. and surrounding MD and VA suburbs	Many
	Finksburg MD 105 km NE	MD03	Beltsville, MD 65 km NE	BEL116	SHEN 85 km SW	SHEN1		
	Wye, MD 125 km E	MD13						
MONO[g]	Finksburg, MD 45 km NE	MD03	Arendtsville, PA 50 km N	ARE128	Arendtsville, PA 50 km N	AREN1	Frederick, MD Within 5 km	240210037
	Arendtsville PA 50 km N	PA00	Beltsville, MD 60 km SE	BEL116	National Mall 60 km SE	WASH1		
NACE[h]	Finksburg, MD N	MD03	Beltsville, MD N, NE	BEL116	National Mall	WASH1	D.C. and surrounding MD and VA suburbs	Many
	Wye MD E	MD13						
PRWI[i]	SHEN 90 km W	VA28	Beltsville, MD 65 km NE	BEL116	National Mall 45 km NE	WASH1	Prince William County	511530009
	Finksburg, MD 110 km NE	MD03	SHEN 90 km W	SHN418	SHEN 90 km W	SHEN1	Stafford County	511790001
	Wye, MD 120 km NE	MD13						
ROCR[i]	Finksburg, MD NE	MD03	Beltsville, MD E, SE	BEL116	National Mall E, SE, S	WASH1	D.C. and surrounding MD and VA suburbs	Many
	Wye, MD E, SE	MD13						

Park	National Atmospheric Deposition Program/ National Trends Network		Clean Air Status and Trends Network		Interagency Monitoring of Protected Visual Environments		Ozone	
	Location	Site #	Location	Site #	Location	Site #	Location	Site #
WOTR[k]	Finksburg, MD 70 km NE	MD03	Beltsville, MD 40 km NE	BEL116	National Mall 20 km E	WASH1	D.C. and surrounding MD and VA suburbs	Many
	Wye, MD 100 km E	MD13						
	SHEN 105 km SW	VA28						

a. ANTI = Antietam National Battlefield

b. CATO = Catoctin Mountain Park

c. CHOH = Chesapeake and Ohio Canal NHP

d. GWMP = George Washington Memorial Parkway

e. HAFE = Harpers Ferry National Historical Park

f. MANA = Manassas National Battlefield Park

g. MONO = Monocacy National Battlefield

h. NACE = National Capital Parks-East

i. PRWI = Prince William Forest Park

j. ROCR = Rock Creek Park

k. WOTR = Wolf Trap Farm Park

Appendix I

Summary of Existing Monitoring Programs in the National Capital Region Network

(LAST UPDATE: 4/30/02)

AMPHIBIANS

U.S. FISH AND WILDLIFE SERVICE (USFWS) – NATIONAL WILDLIFE REFUGES

In 2000, the USFWS launched a nationwide survey of malformed amphibians on wildlife refuges (http://contaminants.fws.gov/Issues/Amphibians.cfm). If malformed amphibians are found, the USFWS will then seek to identify the causes and provide concrete management guidelines to correct the problem.

U.S. GEOLOGICAL SURVEY (USGS)

1. Amphibian Research and Monitoring Initiative (ARMI). ARMI is being coordinated by Dr. Robin Jung at the USGS-Patuxent. ARMI focuses on monitoring population trends and the identification of threats to amphibian populations on federal lands. Malformations are documented with pictures that are sent to the North American Center for Amphibian Malformations. Rock Creek Park is currently one of the focus sites along with Acadia, Shenandoah, and two other National Parks. At Rock Creek Park, the work is implemented in cooperation with Partners in Parks.

2. Frogwatch. Patuxent coordinates this volunteer effort to monitor population trends of frogs. Data is entered online and results can be viewed: http://www.mp2-pwrc.usgs.gov/frogwatch. Data has been collected locally at Riverbend Park, Fairfax County, and Holmes Run II Stream Valley Park. In Maryland at Cabin John Creek, Montgomery County; Flinstone, Allegany County; more than five sites in Anne Arundel County; Greenbelt, Prince Georges County; two sites in Washington County; there are no sites in Frederick County. Only 1999 data is available online.

3. North American Amphibian Monitoring Program (NAAMP). NAAMP is coordinated centrally by Patuxent but implemented locally. Local contacts include: Mary-Keith Garret of the Virginia Department of Game and Inland Fisheries; Wayne Hildebrand (301-898-7025) in Maryland; and Tom Pauley in West Virginia. Linda Weir, USGS, is the National Coordinator. Calling counts are done along roadside transects approximately 15 miles long with 10 stops. One is being conducted at Catoctin Mountain Park and starts at the ranger station. Additional routes are on several local National Wildlife Refuges including Patuxent and Potomac River National Wildlife Complex (Mason Neck, Featherstone, Occaquan Bay).

BIRDS

AUDUBON SOCIETY

1. Christmas Bird Counts (CBC). There are several CBCs in the region. This is part of an annual winter bird survey coordinated by the Audubon Society since 1901. Several counts cover the parks including Fort Belvoir (covers parts of George Washington Memorial Parkway), Frederick (covers parts of Catoctin Mountain Park), Bull Run (covers parts of Manassas National Battlefield Park), and DC (covers parts of Rock Creek Park). Data for the count circles is available online at Cornell University (www.birdsource.org). Park specific data has been provided to the National Park Service (NPS) Inventory and Monitoring (I&M) Program.

2. Mid-Winter Count. Contact: Mike Milton (mikemilton@attglobal.net). A mid-winter count has been implemented by the DC Audubon Society since 1998. This annual count covers the entire length of the C&O Canal. Data is summarized each year and has been submitted to the NPS I&M Program but that data has not yet been analyzed.

3. Northern Virginia Bird Survey. Breeding birds are monitored through point counts at a variety of sites throughout the region. Sites include Manassas National Battlefield, Woodbridge NWF (Formerly Harry Diamond Labs.), Mason Neck National Wildlife Refuge and State Park, Ellanor C. Lawrence Park, Oak Marr Park, Riverbend Park, Fraser Preserve (The Nature Conservancy), Huntley Meadows, Scott's Run Nature Preserve, Difficult Run, Hemlock Overlook and Bull Run Marina, Regional Park at Clarks' Run, and Bull Neck Run. The program is coordinated by the Fairfax Audubon Society. Key contact is Carolyn Williams (703-256-6895). In 2001, graduate student Tom Fagan at George Mason University (tfagan@co.loudoun.va.us) started to analyze the population trend data.

DEPARTMENT OF DEFENSE (DOD)

1. USAG Fort Belvoir. Contact: Dorothy Keough (703) 806-0049; keoughd@belvoir.army.mil. Land bird survey (breeding bird, migratory bird and wintering bird surveys), waterfowl and shorebird surveys have been done since 1998. The protocols for these surveys were developed in coordination with Dr. Richard Fischer of U.S. Army Research and Development Center (formerly Waterways Experiment Station). Turkey surveys (winter and spring) have been done since 2000. Chimney swift survey began in 2001. Bluebird nest box production surveys have been done since 1996. In 2001, the bluebird monitoring was turned over to the Northern Virginia Bluebird Society. Monitoring Avian Productivity Stations (MAPS) monitoring has been done since 1995. Christmas Bird Count has been done since the 1940s by the Fairfax Audubon Society.

2. Quantico Marine Base. Contact: Bruce Frizzel (703) 784-4030; frizzellb@nt.quantico.usmc.mil. The Marine Base conducts Monitoring Avian Productivity Stations (see below for MAPS) and annual turkey gobbler counts. Occasional research projects have been conducted on wood thrushes and other songbirds.

INSTITUTE FOR BIRD POPULATION STUDIES (IBPS) - MONITORING AVIAN PRODUCTIVITY AND SURVIVORSHIP (MAPS)

The nationwide constant effort mist-netting projects are designed to look at long-term trends of breeding bird populations. They are coordinated by the Institute for Bird Population Studies (IBPS; David Desante, Point Reyes, CA). Local MAPS are organized by Fort Belvoir (see DOD above), Quantico Marine Base, Jug Bay, Adventure Banding Station (run by Jenna Radco in Potomac Maryland: Gradko@aspensys.com since 1999) and Shenandoah National Park. IBPS gathers and manages the data.

MARYLAND DEPARTMENT OF NATURAL RESOURCES

Contact: Glen Therres of MD DNR for information (410) 260-8572; gtherres@dnr.state.md.us. The MD DNR conducts annual Bald Eagle counts during the winter. Flights are made over potential nest sites including those on NPS lands. Data is maintained by DNR.

MIGRATION BANDING STATIONS

Margaret and Donald Stokes have run a banding station during the migration period in Northern Virginia for about 20 years. Data have not been analyzed for trends. An additional migration banding station is run out of Jug Bay in Anne Arundel County; a fall migration banding station is run out of Patuxent Wildlife Research Center.

MIGRATION COUNTS

Annual migration counts are conducted on a county basis by volunteers. Jim Stasz is the volunteer coordinator and collects datasheets from the national effort (Jlstasz@aol.com). Data are available for some years covering Rock Creek Park and Prince William Forest Park. Most data, however, are not easily retrievable.

SMITHSONIAN ENVIRONMENTAL RESEARCH CENTER (SERC)

Peter Marra (443-482-2224; marra@serc.si.gov) is coordinating Neighborhood Nestwatch program in this region. This is a habitat suitability study but may be ongoing and long-term. It focuses on residential areas in the DC Area. National parks are not included.

US FISH AND WILDLIFE SERVICE (USFWS)

1. Patuxent National Wildlife Refuge. Contact: Brad Knudsen, Refuge Manager (301) 497-5580; Holliday Obrecht, Biologist, Holliday_Obrecht@fws.gov. The refuge manages about 12,800 acres and lies adjacent to the Baltimore parkway. A variety of surveys are conducted at the refuge:

- Waterbird surveys to track populations since 1988 (USFWS surveys along Potomac also); also tracks waterfowl harvest
- Woodcock surveys are conducted during their spring migration period and summer breeding period
- Whip-poor-will counts are conducted at the end of May
- Turkey call surveys
- CBC and BBS surveys are conducted in cooperation with volunteers (see CBC and BBS above for details)

US FISH AND WILDLIFE SERVICE (USFWS) (CONTINUED)

2. Potomac River National Wildlife Refuge Complex - Mason Neck, Occoquan Bay, Featherstone. Contact Joe Witt, Biologist; 703-490-4979; joe_witt@fws.gov). The three refuges are managed together; a fourth may be added in the near future. Monitoring projects include:

- Songbirds surveys (conducted by volunteer: Jim Wagoner; no standard protocol)
- Bluebirds (nest box volunteer program) at Occoquan Bay and Mason Neck
- CBC - the refuge is part of Fort Belvoir CBC (volunteers)
- Northern Virginia Bird Survey (volunteer effort: Carolyn Williams and Fairfax Audubon; see below for details)
- Bald Eagle Surveys (spring, fall, and winter shoreline surveys—done by Joe with volunteers; roosting survey—year round by volunteers)
- Upland Bird Point Count (winter bird point count surveys, spring bird point count surveys, evening bird point count surveys, territorial mapping surveys [intensive point count grid])
- Monitoring Avian Productivity and Survivorship (MAPS) – the refuge participates in the Fort Belvoir study (see DOD above) with 2 sites at Mason Neck
- Winter Heron Nest Census/Productivity Survey
- Spring migrant bird banding (data feeds into Patuxent Bird Banding Lab data)
- Osprey surveys in spring
- Duck surveys and banding

3. Mid-Winter Waterfowl Survey. Contact: Jim Goldsberry of USFWS for information (301) 497-5880; James_R_Goldsberry@fws.gov. USFWS does a mid-winter waterfowl inventory along lower Potomac which does not include DC.

USGS - BREEDING BIRD SURVEY (BBS)

A modified BBS was initiated at Prince William Forest Park in 1991. Data has been collected sporadically by volunteers. Data is available through USGS Patuxent (http://www.pwrc.usgs.gov/).

VIRGINIA DEPARTMENT OF GAME AND INLAND FISHERIES

The state is monitoring Bald Eagles during the nesting stage. The work is coordinated with The College of William and Mary. The survey covers the eastern 1/3 of Virginia. Contact: Jeff Cooper (540-899-4169). In addition, Virginia Department of Game and Inland Fisheries is working with NPS (Shenandoah, Harpers Ferry), Dominion Power, and William and Mary to release and monitor peregrine falcons. Several falcons were released at Harpers Ferry National Historical Park in 2001 and 2002.

FISH (see also "Water Quality" for fish monitoring)

DC – DEPARTMENT OF ENVIRONMENTAL QUALITY	Contact is Jim Collier (202-535-1656). The department analyzes fish tissue for contaminants every 4 years.
INTERSTATE COMMISSION FOR THE POTOMAC RIVER BASIN	Jim Cummins is monitoring fish along the Potomac River. He is primarily looking at shad survivorship. Shad and herring restoration is ongoing at Anacostia River and Rock Creek. This is being monitored in two ways: first monitor natural reproduction in mid-July. Monitoring transects are established from Chain Bridge to Wilson Bridge using a push net on a Jon-boat. In spring, they monitor for adults at Great Falls and Mather Gorge using gill nets. Cummins identified monitoring needs in the region's tributaries such as Rock Creek, Watts Branch, Greenbelt, and Kenilworth Aquatic Gardens.
MARYLAND DEPARTMENT OF NATURAL RESOURCES (DNR) – MARYLAND BIOLOGICAL STREAM SURVEY (MBSS) RESULTS	Contact: Paul Kazyak (410-260-8607). MBSS came out with a State of the Stream Report 1995–1997 that includes statewide sampling in streams. The probabilistic survey design was established to evaluate water quality. In addition, the MBSS sampled aquatic animals (fish populations, benthic macroinvertebrates, amphibians and reptiles, freshwater mussels), aquatic vegetation, physical habitat, and water chemistry at each site. They developed Indices of Biological Integrity for fish and benthic macro-invertebrates (Fish IBI, Benthic IBI, Hilsenhoff Biotic Index) to tell us the overall ecological health of the stream system. MBSS also looked at acidification and physical habitats, nutrients, watershed land use. Some of the sample sites may include NPS lands. Given the study design, results can be extrapolated to cover the parks. Other potential contacts include Bob Lundsford (410-260-8321). His focus is game fisheries with DNR.
US FISH AND WILDLIFE SERVICE – PATUXENT NATIONAL WILDLIFE REFUGE	Contact: Brad Knudsen - Refuge Manager (301-497-5580); Holliday Obrecht – Biologist (mail to: Holliday_Obrecht@fws.gov). The refuge collects creel data on fish taken out of impoundments.

INVERTEBRATES (see also "Water Quality" for Aquatic Invertebrate Monitoring)

DOD - USAG Fort Belvoir

Contact: Dorothy Keough (703) 806-0049; keoughd@belvoir.army.mil.

Cankerworm surveys. Gypsy moth surveys. Mosquito surveys.

North American Butterfly Association (NABA)

The North American Butterfly Association coordinates a number of activities including the 4th of July Butterfly Count. This volunteer effort is also coordinated locally through the Washington Area Butterfly Club (http://users.sitestar.net/butterfly). There are about 10 counts in the DC/Northern Virginia region. The counts are styled after the Christmas Bird Count 15-mile radius counts and often use the same count circle. Counts occur in July when the greatest diversity of butterflies is present, including spring and fall species. A number of our parks are covered including Manassas and Great Falls. Nearby refuges covered by the survey include Patuxent and Potomac River National Wildlife Complex. The DC area contact is Pat Durkin (202-483-7965, plusultra@aol.com). The North American Butterfly Association has 20 years of data and maintains the data on their web page (www.naba.org). They are using the count data to compile a butterfly Atlas of Virginia by County.

US Department of Agriculture

Contact is Jil Swearingen (NPS) – 202-342-1443 ext. 218; jil_swearingen@nps.gov. Gypsy Moths are monitored in coordination with USGS at all parks except Antietam which has no sizable forest. There are two main ways to monitor: (1) Parks are encouraged to keep their eyes open and implement egg mass walking surveys for any Gypsy Moth infestation. This would happen in late summer/early fall. (2) USDA Forest Service – Rod Whiteman, (304-285-1555) conducts aerial surveys to look for evidence of gypsy moth defoliation and will record observations on maps during flights in early summer. Areas of infestation are roughly sketched out on maps. Heavily infested areas are surveyed on foot along transects and randomly placed circular plots. If heavy infestations occur, proposals must be written to implement spraying activities. This effort is coordinated by the National Capital Region IPM program. In addition, the Forest Service surveys for other pests, including Hemlock Wooly Adelgid, Eastern Tent Caterpillar, Canker Worms. This work is also coordinated with the regional IPM Coordinator.

Various Agencies

In 2001, a cooperative monitoring program was implemented to identify the threat of West Nile Virus. Cooperating agencies included: NPS, DOD, USDA, DC Department of Health, NPS, and County agencies. In 2001, NPS hired 3 biotechnicians to survey in all parks of the National Capital Region. The monitoring may continue in 2002.

MAMMALS

ANN ARUNDEL COUNTY

Contact Phil Normen at Howard County: (410) 313-1675. Conducts Infrared Helicopter Counts for white-tailed deer through Howard County.

DEPARTMENT OF DEFENSE

1. USAG Fort Belvoir. Contact: Dorothy Keough (703) 806-0049; keoughd@belvoir.army.mil. Fort Belvoir collects harvest data (annually) and VA Dep. Of Game and Inland Fisheries (DGIF) perform herd health checks every 3–5 years. The Fort has about 60–80 deer per square mile despite the bow hunting that removes about 20% to 25% of the doe each season. In 2001, began developing bat monitoring protocols with Dr. Chester Martin of U.S. Army Engineer Research and Development Center (formerly Waterways Experiment Station) to develop survey protocol.

2. Quantico Marine Base. Contact Bruce Frizzel (703-784-4030; frizzellb@nt.quantico.usmc.mil) or Wildlife Biologist Tim Stamps (703-784-5383). Deer Hunts are conducted on the base. Biologists conduct spotlight counts coordinated with the Virginia Department of Game and Inland Fisheries.

US FISH AND WILDLIFE SERVICE

1. Patuxent National Wildlife Refuge. Contact: Brad Knudsen - Refuge Manager: 301-497-5580; Holliday Obrecht – Biologist - Holliday_Obrecht@fws.gov)

Mammal monitoring includes:

- Conduct deer spotlight surveys. Hunting program keeps deer at capacity. Also conduct surgical harvests in sensitive areas. The refuge collects harvest data, including dressed weight, age, sex, and location.
- Squirrel harvests are recorded.

2. Potomac River National Wildlife Refuge Complex (Mason Neck, Occoquan Bay, Featherstone). Contact Joe Witt (Biologist; 703-490-4979; joe_witt@fws.gov). Mammal monitoring includes:

- Small mammal surveys (conducted by Northern Virginia Community College professor Larry Underwood)
- Conduct deer spotlight surveys. The refuge has 10 years of data; density at Occoquan Bay is 99 deer/sq mile; hunting is limited to 4 days a year at Mason Neck

HOWARD COUNTY

Contact Phil Normen (410) 313-1675. Conducts Infrared Helicopter Counts for deer.

MARYLAND DNR

Contact is Jim McCann – Zoologist (410-827-8612; Jmccann@dnr.state.md.us). Deer are tracked statewide through hunting permits and number of deer shot in the region.

VIRGINIA DEPARTMENT OF GAME AND INLAND FISHERIES

Occasionally conducts coordinated spotlight counts with county agencies and on state lands or federal lands. See DOD Fort Belvoir and DOD – Quantico, above.

REPTILES

DOD – USAG Fort Belvoir

Contact: Dorothy Keough (703) 806-0049; keoughd@belvoir.army.mil. Developing a monitoring program with Dr. Joe Mitchell. Wood turtle monitoring was initiated in 2002.

T & E SPECIES (& SPECIES OF CONCERN)

DOD - Quantico Marine Base

Contact Wildlife Biologist Tim Stamps (703-784-5383). Monitor about 12 clusters of Small-whorled Pogonia following Natural Heritage methodology.

Maryland Department of Natural Resources - Wildlife and Heritage Division

Contact Jim McCann, Maryland DNR, Wildlife and Heritage State Zoologist (410-827-8612; Jmccann@dnr.state.md.us). For plants contact Richard Wiegand, Ecologist (301-845-8997). The state program tracking and ranking rare species (G1-G3) in addition to sate listed species. Some rare species surveys are done annually, some are done less frequently, depending on need. The department covers public lands in Maryland, but also has some contracts with private lands. Examples of monitoring projects include tiger beetles, mussels, state rare birds (bald eagle, colonial waterbirds), small mammals such as the smoky and pygmy shrews, and great blue heron colonies. Monitoring data typically includes presence/absence information and some measure of relative abundance.

Maryland Chapter of The Nature Conservancy (MD TNC)

TNC monitors about 5–6 Harperella sites near Sideling Hill Creek in Alleghany County. The creek flows into the Potomac.

Virginia Heritage

Contacts: Chris Hobson (bats etc., 804-786-7951); Steve Roble (insects, 804-786-8633); Ann Chazal (mammals). The program has surveyed rare species throughout the National Capital Region parks and will likely continue when funds are available. Monitoring data typically includes presence absence information and some measure of relative abundance.

VEGETATION

MARYLAND NATIVE PLANT SOCIETY

http://www.geocities.com/rainforest/vines/2996. The society is conducting inventories of native plants at Fort Circle Parks in DC. Data is being submitted to National Capital Parks-East.

USDA FOREST SERVICE – FOREST INVENTORY AND ANALYSIS (FIA)

In the past, FIA completed inventories once every 10 years in each state (MD, VA, WV) in order to get landscape level information about forestry resources on both private and public lands. The data is used by a wide variety of research groups, natural resource agencies, conservation associations, state and regional economic development groups, individual landowners, the forest products industry, and others who are interested in the extent, condition, and use of forest resources. Recently, the data collection protocols have changed. Now, between 10% and 20% of all forest inventory and analysis sample plots will be measured each year in every state. A compilation of all the data collected will be made available annually to the public. Every five years a report will be prepared, published, and made available to the public (with the cooperation of the State foresters) detailing the results of the previous inventories, and an analysis of the forest health conditions and trends over the previous two decades. National standards and definitions will be implemented to ensure uniform and consistent data collection by the various forest inventory and analysis units located throughout the country.

The inventories include estimates of trends in forest area, species composition, growth, mortality, and harvesting levels. Other data include the patterns, trends, and numbers of private forest-land owners; estimates of the amount of timber removed from the forest and converted into wood products; other ecological parameters such as extent of wildlife habitat, forest biomass, soil conditions, forest fragmentation, and damage due to insects, disease, and other factors. Also, tree crown conditions, lichen community composition, understory vegetation, down woody debris, and soil attributes are collected. Soil samples are sent to a laboratory for chemical analysis. Finally, an associated sample scheme exists to detect cases of ozone damage occurring to adjacent forest vegetation. Detailed sampling manuals are available online (fia.fs.fed.us – link to library). Sub-plots are set up on some private and some federal lands. The data collection includes full floristic survey on sub-plots (1 ha plots). All plots are permanent. Location information of all plots is exempt from FOIA and not available to the public. Contact Chip Scott (Program Manager in Philadelphia; 610-557-4020).

US FISH AND WILDLIFE SERVICE – PATUXENT NATIONAL WILDLIFE REFUGE

Contact: Brad Knudsen (Refuge Manager; 301-497-5580; Holliday Obrecht – Biologist - Holliday_Obrecht@fws.gov). The refuge collects a variety of vegetation data including:

- Vegetation is monitored to measure effects of drawdowns in ponds
- Rare and endangered plants being monitored annually
- Monitor scrub/shrub habitat along powerline right of ways. Species diversity of vegetation is measured along transects every 7 years

ABIOTIC RESOURCES

AIR QUALITY

CLEAN AIR STATUS AND TRENDS NETWORK (CASTNET)

None of the units in the National Capital Network have a Clean Air Status and Trends Network (CASTNet) dry deposition monitor on-site, but all units have a monitor within 100 km. CASTNet uses different monitoring and reporting techniques than NADP/NTN, so the dry deposition amounts are reported here as nitrogen and sulfur, rather than nitrate, ammonium, and sulfate.

EPA – MID-ATLANTIC INTEGRATED ASSESSMENT

The web page reports about regional air quality (http://www.epa.gov/maia).

INTERAGENCY MONITORING OF PROTECTED VISUAL ENVIRONMENTS (IMPROVE)

All parks in the National Capital Region are within 100 miles of an Interagency Monitoring of Protected Visual Environments (IMPROVE) station. Ozone: None of the units in the National Capital Network have an ozone monitor on-site, but all units have a monitor within 25 km (15 miles) of some portion of the park. Based solely on spatial distribution of ozone monitors, it appears the portion of the Chesapeake and Ohio Canal NHP between Hagerstown and Cumberland, Maryland, may not be well-represented by existing monitors. In addition, it is not clear if monitors in Frederick and Hagerstown, Maryland, adequately represent ozone conditions in Catoctin Mountain Park.

METROPOLITAN WASHINGTON COUNCIL OF GOVERNMENTS (WWW.MWCOG.ORG).

The Council of Governments is the entity certified by the mayor of the District of Columbia and the governors of Maryland and Virginia to prepare an air quality plan for the DC-Maryland-Virginia Metropolitan Statistical Area under Section 174 of the federal *Clean Air Act* Amendments of 1990. Data are collected by agencies in Virginia, Maryland, DC, and by the health department in Alexandria and Fairfax County. Fairfax County, for example, monitors Ozone (O3), Carbon Monoxide, Nitrogen Dioxide, Sulfur Dioxide, Lead, and Particular Matter. Also monitor total suspended particulates (TSP), Nitric Oxide, and meteorological components such as wind speed, wind direction, temperature, and rainfall. There are several air quality monitoring stations in the area. Data is available from 1973 to the present.

"Air Quality Trends in the Washington Metropolitan Region: 1985–1996" states that levels for 6 of 7 pollutants for which EPA has set standards. Only ground level ozone is increasing. There is a State Implementation Plan, which discusses that even with local reductions in ozone, the area may still be above standards because of upwind pollution. Under the *Clean Air Act*, EPA can compel upwind area to take action to reduce the transported air. EPA has issued a NOX State Implementation Plan call to compel action from states upwind of DC and other non-attainment areas. Those require reduction beginning in 2003 with effects noticeable by 2005. Currently, the EPA action is being challenged in court by states and industries.

NATIONAL ATMOSPHERIC DEPOSITION PROGRAM

None of the NPS units in the National Capital Network have a National Atmospheric Deposition Program/National Trends Network (NADP/NTN) wet deposition monitor on-site, but all units have a monitor within 100 km (60 miles). NADP/NTN collects data on both pollutant deposition (in kilograms per hectare per year) and pollutant concentration (in microequivalents per liter).

VIRGINIA – DEPARTMENT OF ENVIRONMENTAL QUALITY (DEQ)

The Department administers the requirements of the federal *Clean Air Act*, and enforces state laws and regulations to improve Virginia's air quality. The DEQ is required to conduct air quality monitoring by both federal and state regulations. The air sampling program is a combined effort of the Air Quality Assessment Office, Air Monitoring, seven regional offices, the Fairfax County Air Pollution Control Bureau, and the Alexandria Health Department. The EPA has specific requirements for a minimum number of monitoring sites, called NAMS - National Air Monitoring Sites, and Virginia has augmented these with additional sites, called SLAMS - State & Local Air Monitoring Sites to provide additional air quality data for DEQ needs.

ENVIRONMENTAL CONTAMINANTS

Fish and Wildlife Service

Environmental Contaminants are monitored through Ecological Services. A variety of contaminants are of interest including pesticide use and oil spills. Mary Henry is the national contact for this program (703-358-2148). She can provide us a list of studies that are conducted every year. For more information: Contaminants.fws.gov. They maintain a database of contamination events. Maryland ES – Annapolis Field Office: 410-573-4501; Virginia ES – White Marsh: – 804-693-6690.

FIRE EFFECTS MONITORING

National Park Service – Fire Effects

The Program goals are: Record basic information for all fires; Document immediate post-fire effects of prescribed burns; Share information between land managers; Follow trends in plant communities where fire research has been conducted, and identify future research needs. (See http://www.fire.nps.gov/fmh/ and http://www.nps.gov/fire/). The U.S. National Park Service has developed the Fire Monitoring Handbook, which contains a standardized protocol for monitoring and documenting prescribed fire behavior and effects. The handbook provides a system to document burning conditions and fire behavior, insure fires remain within certain conditions, verify completion of burn objectives, and follow long-term trends. This information can help managers in burn prescription refinement when objectives are not met or long-term undesirable trends occur, and to identify research needs. In support of the implementation of the handbook, data forms, software, and training courses have been developed. As the program begins its tenth year, nearly 50 parks with fire management programs have incorporated these protocols into their programs. Regional Coordinator is Tim Sexton (208) 387-5223. Don Boucher (FMO) 202-619-7039 and Alan Biller are working on fire management plans for the National Capital Region parks.

GEOLOGICAL MONITORING

Maryland Geological Survey

The agency monitors groundwater quality. Samples are collected from over 100 sites around the state. Sites are being sampled to document ambient ground-water quality, particularly in unconfined aquifers. These data provide a baseline against which future water-quality data can be compared. The data are also used to address other questions about water quality such as:

- What effect do aquifer minerals have on ground-water quality?
- What is the relation between land use and ground-water quality?
- What areas of the state are most prone to ground-water contamination?

Groundwater Samples are routinely analyzed for a core of constituents which includes major ions, nutrients (nitrogen and phosphorus compounds), trace elements, radionuclides, volatile organic compounds, and pesticides. Additional constituents are often analyzed to address specific groundwater quality issues.

USGS

Monitors groundwater levels nationwide. Data is available sites in Maryland, Virginia, and West Virginia through: http://waterdata.usgs.gov/nwis/gw.

LANDSCAPE

MID-ATLANTIC INTEGRATED ASSESSMENT; HTTP://WWW.EPA.GOV/MAIA/

Contact Pat Bradley (bradley.patricia@epa.gov; 410-305-2744). This multi-agency partnership created "An Ecological Assessment of the United States Mid-Atlantic Region: A Landscape Atlas." The Atlas is an EPA report assessing relative ecological conditions across the Mid-Atlantic Region of the United States (encompassing Delaware, the District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia). The Atlas identifies patterns of land cover and land use across the region. It presents an ecological snapshot to help the reader visualize and understand the environmental conditions across the region, and how the pattern of conditions can be applied to community-based environmental decision making. The Atlas represents one of the first regional-scale ecological assessments of the Environmental Monitoring and Assessment Program (EMAP).

The report is based on data from satellite imagery and spatial databases on biophysical features such as soils, elevation, and human population patterns. It compares nine landscape indicators on a watershed-by-watershed basis for the lower 48 states (at a relatively coarse-scale resolution of 1 km), placing the Mid-Atlantic Region in the context of the rest of the country. Using finer-scale spatial resolution (e.g., 30-90 meters), the report then analyzes and interprets environmental conditions of the 125 watersheds in the Mid-Atlantic Region based on 33 landscape indicators. Results are presented relative to four general themes identified by stakeholders in the region: (1) people (potential human impacts), (2) water resources, (3) forests (forest habitat), and (4) landscape change. The indicators include: a. Forest Health (fragmentation, forest edge, interior forest habitat compared to edge habitat). b. Watershed Indicators (soil erosion, runoff processes). c. Riparian Indicators (landcover along streams, roads along streams).

Additional Mid-Atlantic Integrated Assessment products include:

1. Estuary Report
2. National Water-Quality Assessment (NAWQA) – groundwater streams and modeling pesticides
3. Stream Report for Maryland
4. Bird Project with Penn State (research) Tim O'Connel – used birds as indicator of ecological change
5. EMAP streams – fish and benthic IBI
6. Climate Change paper
7. Forest Report
8. Maryland Agriculture
9. Lesson Plans for teachers
10. Integrated Assessments
11. Regional Vulnerability Assessments (RCVA): The program will identify vulnerable areas in next 5–25 years and they will work with urban areas and smart growth
12. REMAP - Biodiversity Project – T&E Species, amphibian calling survey, bird community index, non-indigenous species
13. Non-indigenous species – conference in 2000

METEOROLOGICAL DATA

Meteorological data is available nearby all parks and is coordinated by the National Oceanic and Atmospheric Administration/National Weather Service. For precipitation data see:
http://www.noaa.gov/precipitation.html.

WATER QUALITY

ARLINGTON COUNTY	1. Environmental Services. The county has a National Pollutant Discharge Elimination System permit that requires the county to monitor storm water runoff at representative outfalls. 2. Dept of the Environment. The agency focuses on monitoring water quality using volunteers. Work is already being coordinated with George Washington Memorial Parkway which is using the same protocols and exchanging data. Protocols are the same as used by Audubon Naturalist Society (see below). Contact: Aileen Winquist (also Jay Papacasm at Department of Environmental Quality: 703-228-3613 and Scott Diabler 703-228-3403 in charge of trout program). In addition to the volunteer effort, Arlington County, does water quality monitoring at 4-mile run because of trout releases. They have, however, only collected data in 2001 and there is not enough information to analyze trends.
AUDUBON NATURALIST SOCIETY	Contact Cliff Fairweather (301-652-9188). For more information see: www.audubonnaturalist.org. The Audubon Naturalist Society is coordinating a regional water quality monitoring program using volunteers. Methods are standardized. Sampling focuses on macroinvertebrates.
DOD - USAG FORT BELVOIR	Contact: Dorothy Keough 703-806-0049; keoughd@belvoir.army.mil. Water quality, fish (including anadromous fish), and benthic surveys done in Dogue Creek, Accotink Creek, Mason Run and two unnamed streams on Fort Belvoir from 1999 through 2001. Survey protocol developed and executed by EA Science, Engineering and Technology. George Mason University, Contact: Dr. Donald Kelso (703-993-1061) and Dr. Chris Jones conducted aquatic surveys of Accotink Creek, Pohick Creek and Dogue Creek from 1995–1996. Also, George Mason University has been monitoring aquatic conditions in a dredge disposal site in the Potomac River, just off Fort Belvoir. Work is being performed for Baltimore Corps of Engineers (Mr. Bob Blama at 410-962-6068).
ENVIRONMENTAL PROTECTION AGENCY (EPA)	1. Total Maximum Daily Load (TMDL). EPA requires each state to set the maximum pollutant load that can be delivered to impaired waterbodies so that they can meet water quality standards. 2. Environmental monitoring and assessment program (EMAP). Set up to develop scientific tools necessary for monitoring status and trends in the biological integrity of surface waters and the relative magnitude of critical stressors. There are 638 sites in the Mid-Atlantic. Water quality data available online http://www.epa.gov/emap/html/dataI/surfwatr/data/index.html on benthic, fish, fish tissue and chemistry.
FAIRFAX COUNTY	Fairfax County is monitoring water quality. They are looking mainly at stream health using macroinvertebrates. The benchmark stream was identified in Prince William Forest Park. The county has developed an IBI. A report was issued January 2001: www.co.fairfax.va.us (look for stream protection strategy). The County also put together a report recently: www.co.fairfax.va.us/service/hd/strannualrpt.htm. The report provides information on fecal coliforms and nutrients. For more information contact Fred Rose Storm Water Management Plan 703-324-5800.
IZAAK WALTON LEAGUE OF AMERICA - SAVE OUR STREAMS	Since 1969, the Save Our Streams (SOS) Program of the Izaak Walton League of America has been a leader in citizen education in water quality monitoring, watershed restoration, and the importance of wetland protection.
MARYLAND BIOLOGICAL STREAM SURVEY	See MBSS under "FISH" above.

MONTGOMERY COUNTY – DEPARTMENT OF ENVIRONMENTAL QUALITY

The Department monitors fish and aquatic macro-invertebrate communities as indicators of water quality. Sampling sites are located throughout the county including Little Monocacy, Rock Creek, Cabin John Creek, Broad Run, Dry Seneca Creek, Muddy Branch, Watts Branch, and more.

USGS - NATIONAL WATER-QUALITY ASSESSMENT PROGRAM (NAWQA)–

The USGS began its NAWQA program in 1991. NAWQA collects chemical, biological, and physical water quality data from study units (basins) across the nation. Their goal is to describe the status and trends in the quality of the nation's ground- and surface-water resources and to provide a sound understanding of the natural and human factors that affect the quality of these resources. This information is gathered in every state by USGS scientists to minimize the loss of life and property from natural disasters, contribute to the sound conservation and the economic and physical development of the nation's natural resources, and enhance the quality of life by monitoring water, biological, energy, and mineral resources. As part of the program, investigations will be conducted in 59 areas called “study units” of which the Potomac River is one. Regional and national synthesis of information from study units will consist of comparative studies of specific water-quality issues using nationally consistent information.

VIRGINIA – DEPARTMENT OF ENVIRONMENTAL QUALITY

The Department is the lead agency for water quality monitoring. Currently monitors over 1,100 stations at least once a year. Site list available at: http://www.deq.state.va.us:4100/webapp/wqm.homepage. They produce the “Virginia Water Quality Assessment Report (305(b) Report” once every 2 years. They also submit “Total Maximum Daily Load Report (303(d) Report” every 4 years. The total maximum daily load establishes the amount of pollutants a body of water can accept while still meeting Virginia water quality standards. State standards are set by *Clean Water Act* include minimum physical, chemical, and biological parameters. States can develop standards that are more stringent than federal guidelines and usually start with citizen initiatives. There are currently no standards for sediments even though it is a major problem. There is currently a draft for nutrients (May 2000). Virginia promotes volunteer monitoring. DEQ has a full-time citizen monitoring coordinator. It seems that the state is putting a lot of responsibility on these citizen volunteers. In Northern Virginia, there are several monitoring sites including: Difficult Run, Four Mile Run, Hunting Creek (George Washington Memorial Parkway) and Bull Run (Manassas National Battlefield Park). There may be others. See “State of our Rivers Report for the Commonwealth of Virginia – January 2001.”

WASHINGTON DC - HEALTH DEPARTMENT - WATER QUALITY DIVISION

Contact: Peter May (202-535-2190; peter.may@dc.gov; www.dchealth.com/eha/wqd/welcome.htm).

The Program was established under the authorities of the DC Water Pollution Control Act and the federal *Clean Water Act*. The program has three principal components: Water Quality Control – this component fulfills the function of policy planning as well as regulatory control. In addition, it conducts special studies on pollutant fate and transport to identify probable sources and impacts, river/stream sediment and water column quality not covered by ambient monitoring, wet weather nonpoint source runoff quantity and quality, discharge related facility inspections and tracks permit violations. Water Quality Monitoring - encompass waterbody assessment, collection of ambient water quality data, periodic fish tissue analysis for parameters of concern such as PCB, Chlordane and DDT, periodic submerged aquatic vegetation survey, and bioassessment of wetlands and river fringes. Environmental Laboratory is charged with the analysis of samples for a variety of chemical parameters.

OTHER REGIONAL I&M PROGRAMS

USFWS

Ecosystem Management. USFWS has adapted an ecosystem management approach. The country is divided into 53 ecosystem units defined by USGS watersheds (http://offices.fws.gov/ecounits.html). The National Capital Region corresponds with Chesapeake Bay/Susquehanna River Ecosystem. Past projects include Anchored Gillnet Migratory Bycatch Study in cooperation with DR/DC, Bog Turtle Habitat

Restoration, Sturgeon Stock Assessment through Reward Program, Potomac River Water Quality Study, Regal Fritillary Butterfly Genetics Study, Endangered Bat Habitat Protection, and Outreach. Inventories and Monitoring: The USFWS is also initiating a national I&M program. Contact John Morton of Blackwater National Wildlife Refuge who is working on a USFWS I&M committee (410) 228-2692; john_m_morton@fws.gov. Their goal is to determine how information from its 570 refuges can be analyzed to evaluate the state of the refuges. The NE Region (5) is in the process of developing some regional I&M priorities and projects. Most likely, these will be superseded by national priorities once they are developed. There are already a number of national programs (not refuge programs but USFWS programs) that could be adapted by the refuges. For example, there are CBC, BBS, MAPS, NAAMP (see above for their descriptions), etc.

Long-Term Ecological Research Site. A research program supported by the National Science Foundation for ecological studies and experiments. Established in 1980. There are now 21 long-term ecological research sites that include two urban ones (Baltimore and Phoenix). The Baltimore Ecosystems Study is part of the long-term ecological research site and includes researchers from USGS, John Hopkins University, University of Maryland, USDA, etc. Contact: Stewart Picket (845-677-5343; cell 914-475-0843).

The Baltimore long-term ecological research site seeks to integrate research on ecological, physical, social, and infrastructural components to understand the metro area as a comprehensive system. The goal is to measure the effects of people on ecosystem study units. Social structure and processes are crucial components of the working model of the metro area that is human dominated. Ecosystem processes including nitrogen and litter dynamics, vegetation dynamics, soil characteristics, and the role of exotic species are a core focus. Permanent plots have been established in grass covered areas to complement existing forested plots. The vegetation is being examined using the forest inventory and analysis and a rigorous analysis of tree-covered patches. Intensive studies of riparian zones, including vegetation, soils, and heavy metals were initiated this year. The riparian studies complement our ongoing measurement of stream flow and water chemistry. Also looking at paleoecological studies that focus on the riparian zones and sediments in the Baltimore Harbor, where cores have been extracted to measure pollen, seeds, and heavy metals. This project has a strong environmental education component. The Central Questions of the Baltimore Ecosystem Study:

1. "What are the fluxes of energy and matter in urban ecosystems, and how do they change over the long term?"
2. "How does the spatial structure of ecological, physical, and socio-economic factors in the metropolis affect ecosystem function?"
3. "How can urban residents develop and use an understanding of the metropolis as an ecological system to improve the quality of their environment and their daily lives?"

Fairfax County – The county has 32,000 acres of undeveloped lands, of which 19,000 are in parks. The county is going through a Natural Resource Planning process that will identify additional monitoring needs. Contacts include: County Environmental Coordinator–Cambiz Agazi (703-324-1788); County Planner – County Executive Office –Mary Ashton (703-324-3408).

Planning Coordinator – Noel Caplan (Environmental Coordinator; Noel.kaplan@co.fairfax.va.us; 703-324-1369) is charged with coordinating this effort. In addition to planning there have been a few inventory projects by George Mason University about 10 years ago. Todd Bolton (with Park Authority 703-324-8675) is developing GIS maps based on the inventories. The County parks are also involved in some inventories but typically non-systematic surveys. Gary Orsen from Fairfax County Park Authority noted that Huntley Meadows has an extensive monitoring program covering plants, birds, butterflies, herps, dragonflies, etc.

Appendix J

Prioritization Matrix

	Significance to Mid-Atlantic:	Significance to Parks in the National Capital Region:					
Threat (stressor/ source combination)	Area (5 = most significant)*	Area (5 = most significant)*	Intensity (5 = most significant)*	Urgency (5 = most significant)*	Feasibility (5 = easy to implement)*	Monitoring Cost (5 = inexpensive)*	Total Score

* Ranking: Rank on a scale from 1–5 as indicated below.

FIELD DEFINITIONS

Significance to Mid-Atlantic

Area — How wide an area does the threat affect within the Mid-Atlantic (Northern Virginia, Central Maryland; Harpers Ferry? Is it going to affect the entire region? Or just a small area within the region?

5 = affects a large area; 1= affects a small area

Significance to Parks in the National Capital Region

Area — How wide an area does the threat affect? Is it going to affect multiple national parks or just a small area in one park?

5 = affects a large area or multiple national parks; 1= affects a small area or few national parks

Intensity — How strong is the impact of the threat to the resource? Will the threat destroy the resource completely? Or will it cause only minor damage?

5 = significant impact; 1 = little impact

Urgency — How important is it that immediate action take place to deal with the threat? Is the threat occurring now? Or is it only likely to be important 10 years from now?

5 = threat is immediate; 1 = threat is not immediate

Feasibility — How realistic is it that the National Park Service (NPS) can monitor this threat? Consider if another agency would be more likely to monitor and address this threat.

5 = NPS can address this threat; 1 = NPS cannot easily monitor the threat or monitoring would be more appropriate by another agency

Monitoring Cost — How expensive will it be to monitor this threat?

5 = monitoring cost is low; 1 = monitoring cost is high

Total — Summary of significance to national parks in the National Capital Region fields.

Approval Signatures

John Howard, Superintendent Antietam and Monocacy National Battlefields	Date
Mel Poole, Superintendent Catoctin Mountain Park	Date
Doug Faris, Superintendent Chesapeake and Ohio Canal National Historical Park	Date
Audrey Calhoun, Superintendent George Washington Memorial Parkway	Date
Don Campbell, Superintendent Harpers Ferry National Historical Park	Date
Robert Sutton, Superintendent Manassass National Battlefield	Date
John Hale, Superintendent National Capital Parks/East	Date
Robert Hickman, Superintendent Prince William Forest Park	Date
Adrienne Coleman, Superintendent Rock Creek Park	Date
William Crockett, Superintendent Wolf Trap Farm Park	Date

AMENDMENTS TO THE CHARTER OF THE NATIONAL CAPITAL INVENTORY AND MONITORING NETWORK

Amendment 1. This amendment recognizes that the Appalachian National Scenic Trail has become a part of the National Capital Network Inventory and Monitoring Network Board of Directors.

Passed by Board of Directors: 9/15/02

Amendment 2. This amendment recognizes a change in the name of the National Capital Network identified in the Introduction - second paragraph of the Charter. The name of the network is now formally recognized as the National Capital Region Network.

Passed by Board of Directors: 3/18/03

Amendment 3. This amendment recognizes that new due dates have been established for the completion of the National Capital Region Network Monitoring Plan. The Draft Phase 2 Report will be due to the Washington Support Office on 10/31/03. The Draft Phase 3 Report will be due to Washington Support Office on 12/15/04. The final Monitoring Plan will be due 10/1/05. The content of the phases are described in the Memo and its attachment to Regional Directors dated 2 May 2002 from Abigail Miller, Associate Director, Natural Resource Stewardship and Science /s/ Abigail Miller.

Passed by Board of Directors: 3/18/03

Amendment 4. This amendment designates a Point of Contact for the National Capital Region Network Databases as follows:

I. NCRN Point of Contact Justification — The National Park Species database ("NPSpecies") is one of a suite of Service-wide databases developed by the Inventory and Monitoring Program. NPSpecies is designed to document the occurrence of vertebrate and vascular plant species in national park units, and to substantiate these occurrence records by scientifically credible, high-quality references, vouchers, and observations. The master version of NPSpecies is a password-protected, web-based system; this is accompanied by a PC-based version that can be run from an individual computer using Microsoft Access.

The National Park Service, Service-wide Inventory and Monitoring Program has requested that parks designate Points of Contact (POC) for managing NPSpecies data for each park. This agreement establishes the NCRN Data Manager as the POC for all 11 park units within the National Capital Region Network. As of early 2003 network staff are continuing to populate the database and verify information. By the end of FY 2005 it is anticipated that a good first iteration of vascular plant and vertebrate species lists will be completed for most network parks. At this point the lists can reviewed and certified.

II. NCRN NPSpecies Point of Contact Responsibilities — Following is a description of NPSpecies Point of Contact responsibilities.

1. *Manage web-based NPSpecies access.* The POC will acquire login and password codes for all network park staff needing access to NPSpecies via the Internet, and will ensure that the appropriate level of database permissions and control are granted (e.g., read only, read-edit, or read-edit-delete access). The POC will cancel permissions in the event staff employment, duty station, or responsibilities change.

2. *Provide orientation, training, and technical support to park staff on NPSpecies use.* The POC will instruct NPSpecies users on the overall structure and function of NPSpecies (both web-based and local versions), provide explanations and documentation on its use; and assist with questions users may have on how to query or manipulate NPSpecies data.

3. *Convert legacy data sets into formats compatible with NPSpecies.* The POC will work with park staff to locate data sets containing NPSpecies-related information, and to merge any appropriate portions of these data sets into NPSpecies.

4. *Ensure that voucher data obtained by the Washington Support Office from national data mining efforts is accurately converted to NPSpecies and reviewed.* As the Washington Support Office staff obtains park-specific data from national and regional museums and herbaria, the POC will ensure that these data are accurately converted to NPSpecies and that these data are made available for review by park-based staff.

5. *Ensure any new NPSpecies-related data collected from I&M or park projects are incorporated into NPSpecies.* The POC will work with I&M cooperators and park resource management staff to ensure that NPSpecies is properly updated to reflect any new data collected in the course of park research or management projects.

6. *Ensure that sensitive data are designated as such, and that access to these data is restricted to the appropriate level.* The POC will request that park resource management staff identify those species that may be vulnerable to disturbance if information from NPSpecies on their location or status is made available outside the park unit, or outside the National Park Service. The POC will ensure that these sensitive records are appropriately coded in NPSpecies and that distribution of the data is limited appropriately.

7. *Ensure that species lists are reviewed by appropriate individuals and certified.* The completeness and accuracy of species-list data in NPSpecies will be assessed by qualified reviewers (park staff or other) on a regular basis (DO #11B: Ensuring Quality of Information Disseminated by the National Park Service). The POC will be responsible for ensuring this review and certification process is undertaken and completed.

8. *Ensure that new species vouchers destined for entry into ANCS+ are also entered into NPSpecies.*

   Data associated with species vouchers are now compatible between ANCS+ and NPSpecies. The POC will coordinate with parks so that, to the extent possible, voucher data are entered directly into NPSpecies then exported electronically to ANCS+, thus avoiding duplication of data entry.

9. *Ensure that species nomenclature used for park species lists is referenced and accepted by leading authorities, and, to the extent possible, is compatible among network parks.*

10. *Ensure that all sources of NPSpecies records are documented, and that additions, changes or deletions to records are substantiated and performed with the concurrence of park staff.*

    Successful NPSpecies development and administration depends on ongoing coordination and good communication between the POC and park staff. A close working relationship between the POC and park resource management and curatorial staff will be emphasized at all times.

III. NPSpecies Point of Contact Designation — By this agreement, the National Capital Region Network, Inventory and Monitoring Program Data Manager is designated as the NPSpecies 'Point of Contact' (POC) on NPSpecies issues and management for each of the 12 park units within NCRN. As POC for each park the NCRN Data Manager will meet the responsibilities listed under Section II of this agreement. A centralized effort at the network level helps ensure high quality control standards and relieves park resource management staff from many of the ongoing tasks related to NPSpecies database management. Database work will be closely coordinated between the NCRN Data Manager and individual park staff and NPSpecies data will be readily accessible and available to park personnel. The NCRN Data Manager will serve in the POC role for each park until such time that park species list development and certification is complete. At this juncture individual parks will have the choice of taking over the role of POC or continuing with designation of the NCRN

Data Manager as the park POC. It is anticipated that most parks within the network will want the NCRN Data Manager to continue as their POC over the long-term. However, some park units with sufficient natural resource staff and expertise may desire to take over the POC role and on-going data base maintenance and quality control once individual park species lists have been developed and certified. In this case a park may request that the POC designation be changed. The NCRN Data Manager will keep track of POC designations for network parks if they change in the future.

Passed by Board of Directors: 3/18/03

Appendix K

Priority Projects Identified by the Invertebrate Working Group

Project 1 — Basic Invertebrate Inventory

Justification. There is a paucity of invertebrate data for the parks of the National Capital Region Network (NCRN). Comprehensive inventories are needed to provide basic information on the park's biodiversity, invasive species, rare species, and potential indicators and provide reference information to evaluate restoration and other management activities (Kjar 2002). Given the overall complexity of completing an inventory, the workgroup recommended pursuing two strategies:

1. Comprehensive inventory of certain groups of alveolates and invertebrates.

2. Comprehensive inventory of all groups at select sites.

Given the large number of orders and families, the cost of complete inventories will be high and take a long time. A series of steps were identified before field surveys begin:

i. Generate list of expected species. The first phase is to generate as much information as possible from published literature and park lists.

ii. Review collections. The second phase is to add information to the list from collections (e.g., Smithsonian Institution).

iii. Implement fieldwork. The third phase is to add information from samples obtained from the parks.

Fieldwork should consider the following:

i. Identify sites for site-specific inventories. Sites should include unique/rare sites or exemplary common sites.

ii. Funding. Partnerships could be developed to fund sites.

iii. Education and outreach could be an integral component.

iv. Infrastructure would have to be coordinated (volunteer processing center, bio-blitzes, parataxonomists, field equipment).

The workgroup listed priority families that should be inventoried including: butterflies, microhymenoptera, ground beetles, orthopterans, bees, moths, ants, and molluscs. Many other groups, however, were considered and a final list was not agreed.

The information from inventories can be used to develop checklists or field guides, and can be used for interpretive programs highlighting the parks' overall biodiversity. Future monitoring may be able to apply the resulting arthropod data to an Index of Biological Integrity (Feinsinger 2001).

Project 2 — Identify and Evaluate Invertebrate Indicators for Management and Restoration Projects

Justification. The National Park Service (NPS) is undertaking a variety of management projects designed to reestablish native habitats including the eradication of exotic plant species or the restoration of native grassland. These types of management activities, however, rarely consider effects on invertebrate populations even though they are an integral aspect of the native biota.

The invertebrate working group suggests that future management and restoration activities:

1. Compare species diversity and abundance between managed and natural representative locations in the NCRN.

2. Monitor changes before and after management activities to determine if native invertebrates return.

Management projects provide a unique opportunity to incorporate invertebrate monitoring that would provide useful information to the parks. Monitoring invertebrates would generate additional information about the effects of management and restoration efforts to native biota.

Project 3 — Identify Invasive Species

Justification. Invasive Invertebrate Species represent a threat to important resources on NPS lands. Some invasive species are well known such as gypsy moths, which are already being monitored by the National Capital Region's Integrated Pest Management coordinator and the U.S. Department of Agriculture Forest Service. Dogwood anthracnose and wooly hemlock adelgid are already known to be in the NCRN and are monitored by parks. There may, however, be many more species that have not yet been discovered in the region. Developing a list of suspected invasive species for the NCRN parks was considered a high priority. Once a list has been developed, monitoring needs can be evaluated on a case-by-case basis.

Project 4 — Rare Invertebrate Species

The inventory workgroup also identified a project relating to monitoring rare invertebrates. This issue was also addressed by the Rare, Threatened and Endangered Species working group. Two additional project relating using invertebrates as indicators of rare or exemplary habitats or high quality habitats. The projects, however, required basic inventories to identify potential indicators first and were incorporated into project 1 above.

Appendix L

Summary of Priority Vital Signs Proposed at the National Park Service at the Monitoring Workshop 7–11 July 2002, for the National Capital Region Network

No.	Vital Sign	Threat	Monitoring Goal	Monitoring Objectives	Notes
1	Vegetation community structure	Ozone damage; ecosystem eutrophication	Monitor changes in components vegetative communities known to be sensitive to high ozone concentrations and N deposition.	1. Identify appropriate plot scale. 2. Quantify baseline community structure (e.g., percent of sensitive species). 3. Track changes over timescales appropriate to the community and compare to air pollution trends.	This vital sign ensures that any further changes in plant community structure in the National Capital Region (NCR) will be quantified, and sets baselines for studying the precise effects of both ozone and N deposition as ecosystems stressors.
2	Acid neutralizing capacity (ANC)/alkalinity and watershed nutrient export	Ecosystem eutrophication	Monitor changes in the capacity of NCR watershed to assimilate and neutralize N and S deposition.	1. Quantify alkalinity/ANC (requires one filtered and one non-filtered sample) for streams draining watersheds that drain National Park Service (NPS) lands. 2. Quantify NO_3^-, NH_4^+, and Dissolved Oxygen in same streams (another sample) to aid in assessing total nutrient export for mass balance comparisons with modeled deposition.	This vital sign provides a the critical data needed to determine if the ecosystems in National Capital Region Network (NCRN) watershed continue to retain the N that airborne pollutants contribute to the landscape. This is a critically important ecosystem function in the greater Chesapeake Bay watershed, where eutrophication is causing algal blooms and dead zones in the bay itself.
3	Mercury (an inorganic air toxic) body burden in piscivorous organisms	Mercury bioaccumulation	Monitor the mercury body burden in predators at the top of the NCR food web, where the effects of Hg deposition will first manifest themselves.	1. Quantify body burden in herons or other top-predators in the aquatic food web (mg/g).	Since mercury (Hg) deposition is often bidirectional, involves many site-specific factors and chemical intermediates, and is in only measured in the wet fraction of deposition for one area north of the Washington DC area (Catoctin Mountain Park [CATO]), the best way to look for Hg effects at the regional level is to look in the place where the bioaccumulation will first be manifest: piscivorous organisms at the top of the aquatic food web (Morel 1998).

No.	Vital Sign	Threat	Monitoring Goal	Monitoring Objectives	Notes
4	Precipitation chemistry	Eutrophication and acidification from N and S deposition, Hg bioaccumulation	Aggregate and collate the N, S, and Hg measured in wet deposition, as measured by the National Atmospheric Deposition Network (NADP), The Clean Air Status and Trends Network.	Keep a continually updated, web-based summary of Hg, N, and S wet deposition in the NCR, for comparison with other ecosystem trends (i.e., Vital signs 3.2.1.1, 3.2.1.2, and 3.2.1.3).	NADP monitoring is already conducted in the region and will not require new monitoring. Data, however, should be maintained by NCRN I&M Program.
5	Visibility	Increasing particulate matter impact NCR visibility and visitor experience	Aggregate and collate the particulate matter measurements (and establish deciviews for NCR).	Keep a continually updated record of both PM2.5 concentrations and of visibility in the region available from IMPROVE network monitoring sites.	IMPROVE stations already established in the region. There is no need to add additional monitoring stations.
6	Sediment loading and deposition, wetland extent and condition	Erosion and sedimentation	Use survey and analysis methods to evaluate, sediment loading, and flow rates.	1. Measure loss of soil, growth of gulleys, changes in streambanks…. 2. Track sedimentation history, effects, and impacts (including streams and ponds, hillslopes and gulleys).	Can be combined with shoreline change.
7	Physical failure, rock falls, landslides, sinkhole collapse	Geo-hazard	Use survey and analysis methods to evaluate and provide an early warning of physical failure in order to protect the resource, visitors, and park infrastructure.	Identify hazard-prone areas in individual parks and maintain a schedule of routine surveys to limit the potential for physical / structural failure in a timely manner.	Though geo-hazards are a significant issue in some parks such as Harpers Ferry National Historical Park (HAFE) and George Washington Memorial Parkway (GWMP), areas prone to physical failure are limited and not significant region-wide. A monitoring program at HAFE already exists and is being coordinated with USGS.
8	Soil and ground water chemistry	Nutrient and chemical contamination	Use an input/output approach to understand nutrient and contaminant cycling in the ecosystem.	1. Measure nutrient and contaminant inputs from sources pertinent to each park unit. 2. Measure nutrient and contaminant outputs from each park unit. 3. Tie information from numbers 1 and 2 to the hydrologic cycle, flood history, flood effects, and flood impacts to determine and nutrient and contaminant "mass balance" within park watersheds.	Monitoring water chemistry was also a priority vital sign listed (below).

No.	Vital Sign	Threat	Monitoring Goal	Monitoring Objectives	Notes
9	Inundation of wetlands, erosion and sedimentation processes	Shoreline change	Use mapping or survey methods to track shoreline change and depositional patterns.	Monitor shoreline change using aerial photos or photo points.	Monitoring sediment loading was also a priority vital sign listed under the water section (below). Although an ideal remote sensing tool for monitoring change in topography and shoreline change, LIDAR is very expensive and will not likely be used. Other tools including aerial photography or using photo points may be used to monitor specific areas for shoreline change.
10	Compaction, runoff, chemical composition, soil profile and structure, biodiversity	Lack of understanding of urban soils and engineered lands	A lack of information regarding highly disturbed / engineered / or urban soils is a widespread phenomena. In order to begin understanding these soils, recent soil surveys and soil classifications must be done to describe the soils of the Washington, DC area. Following a detailed soil inventory of these urban soils, it may be possible to understand the functioning and components of urban soils engineered landscapes and their effects upon resident biota. Components include: highly impacted soil (compaction in and around trails, visitor centers), landfills, engineered soil, etc.	1. Initiate and complete a new soil survey of the Washington, DC area. 2. Measure changes to physical components of urban soils and engineered lands and correlate with changes in urban development and resident biota (and exotic species).	Recent discussions of urban soils indicate the need for greater understanding of the classification and functioning of this largely unstudied category of soils. While it is recognized that there is a lack of understanding of urban soils, it was believed that the completion of a recent soil inventory, followed by specific research projects that link urban development, soil, soil flora and fauna, and soil processes, will lead to a greater understanding of the potential of urban soils.

No.	Vital Sign	Threat	Monitoring Goal	Monitoring Objectives	Notes
11	Invertebrate indicators of management projects	Land use change	Monitor key invertebrate populations in order to evaluate management and restoration activities.	1. Compare species diversity and abundance between managed and representative locations in the NCRN. 2. Monitor changes before and after restoration activities occur.	The NPS is undertaking a variety of restoration and management options with the intent of reestablishing native habitats including grassland restoration and eradication of exotic plant species. The effects of these active management programs on invertebrate populations, however, are not well understood and are rarely monitored. Management projects, however, provide a unique opportunity to incorporate invertebrate monitoring that would provide useful information to the parks. Monitoring invertebrates would generate immediate feedback on the success of management and restoration efforts because invertebrates typically respond quickly to habitat changes. In addition, invertebrates are easily sampled and collected. Inventory information, however, is needed to allow comparisons of historic invertebrate communities to those in restored areas. Restoration and management sites, however, could be compared to reference sites inside or outside of the parks. Inventory of unique habitats or exemplary sites of common habitats would be very beneficial to serve as reference sites to restoration areas.
12	Rare invertebrates	Specific threats are not known because rare invertebrates and their important sites in NCRN have not been identified	Identify and monitor rare invertebrate species or communities.	Compare species diversity and abundance between managed and representative locations in the NCRN.	The Rare, Threatened, and Endangered Species workgroup is prioritizing rare species including invertebrates. Federally listed threatened and endangered species must be monitored on National Parks. Status of invertebrates, however, are not well known given limited inventory and monitoring data.
13	Rare and exemplary habitats	Threats are not known because rare and exemplary habitats have not been identified	Identify and monitor invertebrate diversity and populations- especially in rare communities and exemplary common communities.	1. Monitor species and population changes in rare and exemplary habitats. 2. Monitor rare and exemplary habitats to ensure their preservation.	Biodiversity of invertebrates is largely unknown because of limited inventories in the region. The cost to monitor overall biodiversity will likely be high because of numerous inventory protocols needed to cover all species. Priority monitoring was place on 1. Invertebrates found in rare communities 2. Common habitats that well preserved and exemplary in the NCRN. Both habitat types can be identified by vegetation mapping or by natural heritage.
14	Habitat quality	Specific threats are not known because rare and exemplary habitats have not been identified	Select key invertebrates to monitor as indicators of habitat quality.	1. Monitor species and population changes in rare and exemplary habitats. 2. Monitor rare and exemplary habitats to ensure their preservation.	Monitoring invertebrates in rare and exemplary habitats as discussed in 3.2.3.3 above can be extremely difficult given the immense species diversity. Monitoring rare communities or common representative communities, however, represent a high priority. It may be much more efficient to identify appropriate invertebrate indicators if they are known for priority sites. Butterflies and aquatic insects including dragonflies, mayflies, and stoneflies were suggested.

No.	Vital Sign	Threat	Monitoring Goal	Monitoring Objectives	Notes
15	Invasive invertebrate species	Invasive species are a threat to flora throughout the region	Monitor population trends of invasive invertebrate species (native and exotic).	1. Identify potential invasive species and survey for their presence. 2. Monitor populations of invasive species and quantify their damage to native biota.	Invasive Invertebrate Species represent a threat to important resources on NPS lands. Some invasive species are well known such as gypsy moths that are already being monitored by the NCR's Integrated Pest Management coordinator and the U.S. Department of Agriculture Forest Service. Dogwood anthracnose and wooly hemlock adelgid are already known to be in the NCRN and are monitored by parks. There may, however, be many more species that have not yet been discovered in the region. Developing a list of suspected invasive species for the NCRN parks was considered a high priority. Once a list has been developed, monitoring needs can be evaluated.
16	Basic inventory	Lack of data	Inventory and monitor population trends of key invertebrate species and populations.	1. Identify invertebrate species populations in the NCRN. 2. Monitor key populations trends and species diversity in important habitats. 3. Monitor priority species.	Every aspect of monitoring identified in 3.2.3.1-6 would benefit from extensive inventories.
17	Bird community index (BCI)	Any development, habitat fragmentation / amount of edge (forest interior habitat)	Monitor quality of forest interior habitat.	Monitor status and trends of forest interior birds to determine quality of forest interior habitat within the Lower Chesapeake Bay Watershed for 5 years.	A BCI has been developed to monitor quality of forest interior habitat for the highlands of the piedmont region (O'Connel et al. 2000). A similar index could be created for the forested areas of NCRN in order to monitor key habitats and to monitor a taxonomic group considered a high priority by the Wildlife workgroup.
18	Amount of forest interior habitat	Any development, habitat fragmentation / amount of edge (forest interior habitat)	Monitor quantity of forest interior habitat.	Monitor the number of forest interior patches of greater than or equal to 5000 ha within the Lower Chesapeake Bay Watershed for 5 years.	Using remote sensing tool in order to monitor forest cover would complement the BCI identified as a priority in 3.2.4.1 above. In addition, a variety of additional indices can be calculated and monitored such as size / edge index.
19	Connectivity of habitat of interest	Fragmentation, any development, land use practices (corridors)	Monitor the connectivity of green and blue space.	Monitor the percent of protected, number of patches, and contiguity of green and blue space within the Lower Chesapeake Bay Watershed for 5 years.	This vital sign would supplement information listed in 3.2.4.2 by calculating the number of breaks in corridors or the distance between habitats.
20	Habitat cover	Land use, land use practices (species specific natural habitats)	Monitor species specific natural habitat.	Monitor percentage and distribution of the targeted species suitable habitat within the Lower Chesapeake Bay Watershed for 5 years.	Monitoring habitat for targeted species may prove to be challenging because of the fine scale resolution needed to identify specific habitats using remote sensing. Similarly, specific habitats may not be well described. Gross features such as land cover types, however, may be available.

No.	Vital Sign	Threat	Monitoring Goal	Monitoring Objectives	Notes
21	Change in land ownership	Land ownership, demographics, legislation, fragmentation of decision making (landscape matrix)	Monitor environmental decision making.	Monitor the public and private demographics of land ownership jurisdictions within the Lower Chesapeake Bay Watershed for 5 years.	As discussed above, developing a variety of GIS data layers can be used to model and identify future threats and direct preservation efforts
22	Forest habitat types	Land use, land use practices (total forest habitat)	Monitor forest habitat types.	Monitor the percent cover of forest habitat types within the Lower Chesapeake Bay Watershed for 5 years.	While monitoring habitats may be difficult, monitoring key vegetation types identified by the National Vegetation Classification System may be feasible. In 2001, the NCRN began a vegetation mapping program covering all of its parks in order to provide a baseline data layer.
23	Viewshed	Land use, land use practices (viewshed)	Monitor the viewshed.	Monitor the number of physical structures viewable from park units and other green space within the Lower Chesapeake Bay Watershed for 5 years.	Viewsheds may be monitored using remote sensing or photopoints at select areas. Areas significant for protecting viewsheds, will have to be identified in order to evaluate the best monitoring methods.
24	Ambient monitoring (digital camera) of visibility	Particulates / aerosols	Monitor particulates/aerosols for visibility	Interpret the value of visibility.	While land use change can affect viewsheds, so can visibility. In addition, visibility is an intrinsic value of air resources and has also been identified as a priority in section 2.2.1.
25	Priority species	Varies by species and location of occurrence	Monitor priority species.	Monitor sites containing priority species to evaluate level of threat and trigger management actions.	Given the long list of species with varying ecological needs there was a need to prioritize species based on rarity and their viability (Noss et al. 2002). The RTE workgroup developed criteria to prioritize species reflecting legal protection following guidelines DO-77-8 Section 3.1 and 3.2 (NPS 2002a) and rarity and viability based on heritage ranks (NatureServe 2002).
26	Priority Sites	Varies by site	Monitor priority sites.	Monitor sites containing priority species to evaluate level of threat and trigger management actions.	Many of priority species identified in 3.2.5.1 occurred in close proximity and could potentially be monitored together. The workgroup adopted a site based monitoring approach similar to one developed by the Heritage Programs and The Nature Conservancy (The Nature Conservancy 2000). Site based conservation has proven to be more efficient and effective than the species based approaches.
27	Species composition and number of downed trees and exposed roots in flood plain	Stream bank and channel erosion	Monitor effects of erosion on riparian habitat.	Determine the number of fallen trees and exposed roots annually on vertical bank slopes and the change of species composition every 5 years in floodplain habitat.	Erosion has significant impacts on riparian habitats in some areas in the NCRN. Monitoring and trigger points are needed to initiate management.

No.	Vital Sign	Threat	Monitoring Goal	Monitoring Objectives	Notes
28	Exotic species cover	Exotic and especially invasive species are a threat to native vegetation and other biota (e.g., birds)	Determine the ratio of native to exotics, species richness, percent cover of exotics and natives, density/stem counts.	Estimate the species cover in 11 park units yearly until 2008 in 1% of naturally established vegetative areas.	NCRN currently has an exotic plant management team (EPMT) that is centrally located. Their management priorities are based on standards unique to each park. Mapping efforts implemented by the EPMT indicate location of invasive and exotic species but are not comprehensive and do not quantify or estimate rate of spreads. Additional monitoring needs include measurements of the rate of spread of invasives in addition to targeted searches for new outbreaks.
29	Change in vegetation	Change in land use inside the parks	Monitor change in forest health conditions.	Monitor variety of forest health indicators (age, cover, species composition, etc.).	Monitor vegetation changes. Maintain GIS layer of change in land use inside the parks including development and maintained/ landscaped areas (update annually) and evaluate potential impacts to vegetation changes.
30	Fragmentation Indices	Change in land use (fragmentation)	Monitor fragmentation indices.	Obtain fragmentation (at various scales) indices using annual satellite imagery and aerial photography every 5 years. Develop and maintain georeferenced GIS database of fragmenting features with in each park (road, trails, etc.).	A variety of indices have been developed in order to monitor fragmentation. Examples include: ratio of edge to interior, patch size, distribution, composition (vegetation vs. urban), proximity of patches to each other and to development or other fragmenting features.
31	Vegetation composition change as a function of distance from development	Change in land use (External Development)	Determine vegetation composition change as a function of distance from development.	Maintain GIS layer of near external development (update annually). Identify internal areas likely to be affected by changes in hydrology and weed sources. Monitor vegetation composition changes.	Development outside of the parks has significant impacts on the parks themselves. This vital sign was chosen as a way to identify the impacts of development on vegetation resources such as the spread of exotic species inside the parks.
32	Gypsy moths	Gypsy moths are a threat to native vegetation, especially oak trees	Determine acres defoliated by gypsy moths as well as egg mass density. Monitor vegetation composition under defoliated area. Determine the area of forest tree canopy defoliated that is attributable to gypsy moth. Measure the area and distribution and treatment type of gypsy moth treatment blocks.	Estimate the number of egg masses (and mean size) in vegetation types susceptible to gypsy moth defoliation.	The Integrated Pest Management Coordinator is already working with the USDA to monitor Gypsy Moths and maps the impacts on vegetation annually in order to prioritize management efforts. Spraying with Bt or GypCheck is implemented when egg masses reach a critical level.

No.	Vital Sign	Threat	Monitoring Goal	Monitoring Objectives	Notes
33	Vegetation sensitive to air pollutants	Air pollution	Determine number of lichens per plot and species richness and composition. Also determine leaf damage to ozone sensitive species and thickness of algae layers in lichens.	Establish long-term monitoring plot for lichens at a range of sites. Monitor lichen cover and composition and correlate with regional O3, NxOx and SxOx levels. Monitor every 5 years to establish trends. Monitor O3 damage to vascular plants.	Monitoring the effects of ozone was also identified as a high priority for air resources.
34	Political influence on park management decisions	Politics	Identify political influence on natural resource management.	Document the number of times per year that political mandates effect resource management decisions and acres lost or vegetation resources compromised.	Resource managers and superintendents are often required to make management decisions that are not based on scientific evidence or go against the known scientific evidence. Monitoring political influence may be useful in evaluating how well science-based management can be integrated into park management. A variety of monitoring protocols have been suggested but remain untested. These include monitoring: percent superintendents with a resource management experience; number of political actions that overturn resource management decisions; number of politically mandated actions that affect the resource per year, including the number of times politics prevents the best management of resources.
35	Number and extent of social trails; number of visitors/year	Visitor use	Monitor effects of visitors on park resources.	1. Monitor the number of social trails and their length. 2. Estimate the area (length and width) of social trails within the highest visitor use areas at the 11 parks every three years.	NCRN has the highest visitation of any region in the NPS. Knowing the locations of social trails and prioritizing them by the amount of impact each one has can help mitigate the negative impacts park visitors may have on the natural resources.
36	Vegetation composition change	White-tailed deer	Identify impact of deer on vegetation.	Monitor relationship between population size and vegetation changes.	Preliminary results of deer density monitoring program indicate that deer in the NCRN range from 12 deer/km^2 (Prince William Forest Park [PRWI]) to 38 deer/km^2 (CATO). Deer prefer some species over others, which is changing the composition of native vegetation. Anecdotal evidence, for example, suggests that there has been no seedling regeneration in some areas of CATO in approximately 15 years. Monitoring the effects of deer is critical to being able to build evidence that deer have a significant impact on the natural resources in the parks.
37	Benthic macroinvertebrates index	Development	Monitor macroinvertebrates in priority streams.	Evaluate trends of macroinvertebrates.	Apply protocols developed for Maryland Biological Stream Survey. See Priority Monitoring Sites below for how priority streams are selected. Include an area on the field form to note what amphibians and reptiles are present. Analyze data once per year.

No.	Vital Sign	Threat	Monitoring Goal	Monitoring Objectives	Notes
38	Physical habitat index (PHI)	Development	Monitor PHI in priority streams.	Monitor trends of habitat features in and adjacent to streams.	Apply protocols developed for Maryland Biological Stream Survey. This will include information regarding stream geomorphology, channel and wetland vegetation community structure, riparian zone and floodplain vegetation structure, watershed/riparian/stream morphology, and sediment accumulation. Perhaps also include presence/absence of macro algae. See Priority Monitoring Sites below for how priority streams are selected.
39	Fish index	Development	Monitor Fish communities and populations in priority streams.	Monitor population trends.	Apply protocols developed for Maryland Biological Stream Survey. See Priority Monitoring Sites below for how priority streams are selected. Include an area on the field form to note what amphibians and reptiles are present. Analyze data once per year.
40	Nutrients	Development	Monitor nutrient levels in surface and groundwater.	Monitor trends of nutrient levels.	Measured with Hach test kits as part of the Core Water Parameters. Core Water Parameters include temperature, DO, pH, flow/stage/water level, specific conductance, clarity, ANC/alkalinity.
41	Groundwater level	Development	Monitor groundwater levels in parks throughout the region.	Establish and monitor groundwater levels.	Follow USGS permanently referenced well protocols (Lapham et al. 2003).
42	Precipitation	Climate change	Monitor weather stations in the parks.	Monitor precipitation trends.	This was also a priority for the Air workgroup. Monitoring is already being done in or near all parks in the NCRN. Collate data from other sources.
43	Specialized water quality parameters	Development	Monitor to address park-specific water quality needs.	Identify park specific water quality concerns and monitor accordingly.	Follow USGS NAWQA water monitoring protocols. The specific parameter depends on the park's needs, but should include any impairment for 303d listing of waters within the park. These may include: pesticides, industrial chemicals, landfill pollutants (HG and/or PCBs), potable standards (monthly in wells, bacteria in sewage and septic systems (monthly), pharmaceuticals, endocrine disruptors, aluminum, lead, arsenic, and petroleum.

No.	Vital Sign	Threat	Monitoring Goal	Monitoring Objectives	Notes
44	Amphibians	Poorly understood	Monitor amphibians in the NCRN.	Monitor population trends.	Amphibian monitoring was a high priority because of their importance as indicators on a world-wide scale. Population declines have been noted in many parts of the world. The causes for declines, however, are poorly understood. Population trends in NCRN are unknown. Coordinate with Amphibian and Reptile Monitoring and Inventory (ARMI) program. Consider size stages to determine population structure (index of recruitment); focus on streams (duskys, spring, two-lined) and ponds (mole salamanders, ramids, frog hybrids, toads); information on species richness, abundance (percentage area occupied), age/size, structure; consider road kill data as potential information sources. Monitoring amphibian disease can be easily conducted in association with this vital sign.
45	White-tailed deer	Currently none; deer are considered a threat, however, to other native biota	Monitor deer.	Monitor deer population trends at all eleven NCRN parks.	Deer ranked as a high priority for monitoring because of their significant impacts on the spread of exotic species, prevention of tree regeneration, and impacts to small mammal, amphibian, and bird populations. Peer review and implement draft regional deer monitoring protocols and coordinate with other regional deer information (state agencies).
46	Birds	Fragmentation of forest and grassland habitat; development	Monitor bird populations.	Monitor bird population trends at all eleven NCRN parks.	Birds ranked high because they are easy to monitor and standard protocols are widely used. In addition, their habitat associations are generally well understood and can be used as indicators of habitat change. Waterfowl, raptors, and shorebirds were considered, but their numbers are very low in the NCRN. In contrast, NCRN has considerable cover suitable to forest and grassland passerines. Adapt national I & M bird monitoring protocol; refer to monitoring protocol in use at C&O Canal and others in region; consider taxa not included in standard research (i.e., nocturnal), taxa with specialized habitat, and migratory phrenology; coordinate with other regional studies
47	Amphibian disease	Poorly understood	Monitor the prevalence and incidence of disease in amphibians within the regional network.	Monitor for malformation, chytridiomycosis, and iridovirus.	Monitoring amphibian disease could easily be done in conjunction with ARMI.

Morel, F.M.M., A.M.L. Kraepiel, and M. Amyot. 1998. The chemical cycle and bioaccumulation of mercury. Annual Review of Ecology and Systematics 29: 543–566.

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Appendix M

Justification for Vital Sign Removal

This appendix provides detailed justifications for why vital signs were removed during the second cut of vital sign selection.

Vital Sign Removed—Local development effects on vegetation communities

Justification — This vital sign was initially selected because development inside and outside of the parks likely has significant impacts on parks resources. Monitoring on-the-ground changes to vegetation would provide evidence that shows how a park may be changing and the information could be used to predict future responses. This type of information is essential to provide alternatives during the National Environmental Policy Act (NEPA) compliance process. While critical, this vital sign was removed because it is considered local in scope and will likely vary from site to site depending on local habitat and type of development. If the information is required to fulfill NEPA compliance, site-specific data may need to be collected. Research projects that evaluate localized impacts may be more appropriate.

Vital Sign Removed—Politics

Justification—Resource managers and superintendents are often required to make management decisions that are not based on scientific evidence or that go against known scientific evidence. Monitoring political influence may be useful in evaluating how well science-based management is integrated into park management. A variety of monitoring protocols have been suggested but remain untested. These include monitoring the percent of superintendents and upper level park management with resource management experience; number of political actions that overturn resource management decisions; number of politically mandated actions that affect the resource per year, including the number of times politics prevents the best management of resources. While it was recognized that politics plays a critical role in park management in the NCRN, monitoring political influence was considered outside of the scope of monitoring natural resources by the I&M Program.

Vital Sign Removed—Change in land ownership

Justification — Monitoring ownership of private lands is recognized as politically sensitive. Relevant data such as census demographics, however, are available and can be incorporated into data analyses if desired. Similarly, land cover and land use can be easily monitored and do not bring up privacy rights issues.

Vital Sign Removed—Urban soil profiles, soil structure (compaction, soil profile and structure, biodiversity)

Justification—A lack of information regarding highly disturbed, engineered, or urban soils is a widespread phenomena. In order to gain a better understanding, soil surveys and soil classifications must be done in the Washington, DC area. Following a detailed soil inventory, it may be possible to understand the functioning and components of urban soils in engineered landscapes and their effects upon resident biota. Of special interest: highly impacted soil (compaction in and around trails, visitor centers), landfills, engineered soil, etc.

Vital Sign Removed—Invertebrates

Justification—All vital signs related to invertebrates were removed because priority projects identified by the working group were largely related to inventories. The entomologists involved in the planning process believed that monitoring could not be adequately addressed until there is a better understanding of species in the NCRN. It was not known at the time if any particular groups or species of invertebrates would make good indicators in NCRN. It was recognized, however, that there may be important invertebrates for monitoring and the question should be revisited.

Appendix N

Protocol Development Summaries

(LAST UPDATE: 5/8/05)

Protocol—Ozone

Parks Where Protocol will be Implemented

Antietam National Battlefield (ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield (MANA), Monocacy National Battlefield (MONO), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap Park for the Performing Arts (WOTR).

Justification/Issues Being Addressed

Ozone damages human health, vegetation, and many common materials. It is also a key component of urban smog. Ozone threatens people with respiratory and pulmonary sensitivities (Gent 2003) and also damages vegetation (Dizengremel 2001). The extent of such damage, even to ozone sensitive species (Skelly et al. 1999), is uncertain for NCRN landscapes because ozone exposure in plants (as in people) depends not just on the concentration, but also on how active the plant is physiologically (Kurpius et al. 2002). What is certain is that this region experiences some of the highest ozone concentrations in the country and has been designated by the Environmental Protection Agency (EPA) as a severe non-attainment area for the human-health based National Ambient Air Quality Standard (NAAQS). Additionally, research has shown that vegetative damage thresholds are lower than the current regulatory thresholds, so that even areas that are in attainment with the NAAQS may experience ozone damage to plants, especially in humid regions where lack of drought stress allows plants to take up air (and ozone) more freely (Grunhage and Jager 1994, Panek and Goldstein 2001, Grunhage and Jager 2003). Thus, it is likely that ozone is damaging plants in the NCRN and that the damage increases with increasing concentrations (though not in a linear fashion). Monitoring ozone concentrations, although only a partial solution, is the simplest way to begin to evaluate the potential for ozone damage. As models and data that can account for the microsite conditions that drive plant ozone uptake in the NCRN improve (e.g., Massman 2004), it may be possible to use ozone concentrations and detailed GIS maps of microsite factors to calculate actual doses to plants. Until then, we will rely on ozone concentration as an indicator of the potential for ozone damage.

Specific Objective to be Addressed in the Protocol

1. Report on seasonal and annual status and trends of ozone concentrations in NCRN parks using metrics that are indicative of human health (e.g., 8-hour average) and plant response (e.g., SUM06).

Basic Approach

Ozone is monitored by the, Maryland Department of Natural Resources, Metropolitan Washington Council of Government (MWCOG), and Virginia Department of Environmental Quality. The agencies use EPA's standard reference methods for the measurement of ozone (http://www.epa.gov/ttn/amtic/criteria.html) and have strict quality assurance and control requirements for data reporting. Data are entered into a web-accessible database maintained by EPA. Monitoring specialists at the NPS Air Resources Division (ARD) will download relevant ozone data from the database and summarize the data in ways that will be most useful to parks and I&M Networks. NCRN will rely on data summaries and graphics provided by the ARD to report on status and trends in ozone concentration in Network parks. As appropriate, NCRN will supplement information obtained from ARD with data summaries and interpretations available on the MWCOG website (http://www.mwcog.org/environment/air/).

Since ozone may impact plants at leaf, whole plant, and plant community scales, any significant trends in ozone concentration may be related to trends in other vital signs for plant health, including plant community structure (especially any measures that involve the ozone sensitive species) and overall plant productivity. NCRN will evaluate correlations between ozone concentrations and plant health indicators, and initiate monitoring or research of identified relationships, if warranted. .

Principal Investigators and NPS Lead

The NPS ARD will be responsible for analyzing, summarizing, and providing NCRN access to ozone concentration data. NCRN will be responsible for obtaining data summaries from ARD and presenting the ozone summaries and other relevant information in Network reports.

Development Schedule, Budget, and Expected Interim Products

Protocol development will focus on obtaining and reporting ozone concentration data collected in and near the NCRN parks. The primary data source will be the NPS ARD, and the secondary data source will be the MWCOG website. The ozone protocol developed by NPS ARD will be used by NCRN. NCRN will add information on the siting and operation of NCRN ozone monitors. No NCRN funds will be expended for protocol development.

LITERATURE CITED

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Panek, J.A. and A.H. Goldstein. 2001. Response of stomatal conductance to drought in ponderosa pine: implications for carbon and ozone uptake. Tree Physiology 21, 337-344.

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PROTOCOL DEVELOPMENT SUMMARY (LAST UPDATE: 5/8/05)

Protocol—Wet Nitrogen and Sulfur Deposition

Parks Where Protocol will be Implemented

Antietam National Battlefield (ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield (MANA), Monocacy National Battlefield (MONO), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap Park for the Performing Arts (WOTR).

Justification/Issues Being Addressed

The Chesapeake Bay Watershed (which includes the NCRN) receives some of the highest deposition of nitrogen (N) and sulfur (S) among the estuarine watersheds of the eastern seaboard (Lynch et al. 2000, Meyers et al. 2000, Sheeder et al. 2002). Concentration and deposition of S (10–14 kg S ha^{-1} yr^{-1}) and the associated hydrogen ion creating “acid rain” have decreased markedly since the implementation of the Clean Air Act Amendments of 1990 (Lynch et al. 2000) that required a reduction in sulfur dioxide emissions. Unlike S, N concentration and deposition has not decreased nationwide, and continues to cause both acidification in poorly buffered upland streams, and eutrophication at the bottom of watersheds. A substantial portion of the N deposited to the Chesapeake Bay Watershed (5–12 kg N ha^{-1} yr^{-1}) escapes to its estuary, where it causes toxic algal blooms and lowers levels of the dissolved oxygen aquatic organisms require to breathe (Castro et al. 2001; Meyers et al. 2000). Upstream of the estuaries (i.e., parks like Catoctin Mountain Park and Prince William Forest Park), N deposition can affect plant community structure and cause leaching of important minerals from soils (Fenn et al. 2003). While S deposition has decreased since the early 1990s, it is still elevated over pre-industrial levels, and may be contributing to surface water acidification in NCRN parks. N deposition is also significantly elevated over pre-industrial levels.

Specific Objective to be Addressed in the Protocol

1. Report on seasonal and annual status and trends of N and S concentration and deposition in precipitation in NCRN parks.

Basic Approach

State and federal agencies, and others, who monitor wet deposition chemistry through the National Atmospheric Deposition Program/National Trends Network (NADP/NTN), use NADP/NTN’s monitoring protocol (http://nadp.sws.uiuc.edu/QA/) and follow the program’s quality assurance/quality control guidelines. NADP/NTN posts site-specific and programwide data on their website. NPS ARD will provide trend data annually for parks with NADP/NTN monitoring. As appropriate, NCRN will supplement information obtained from ARD with data summaries, interpretations and graphics available on the NADP/NTN website. Monitoring specialists at the NPS ARD are developing guidance on downloading data from the NADP/NTN site and conducting relevant analyses of the data in ways that will be most useful to report on status and trends in N and S concentration and deposition in Network parks.

Since N and S deposition may affect water quality parameters (e.g., acid neutralizing capacity) and soil characteristics (ion exchange capacity) and N deposition is hypothesized to encourage invasive plant establishment, any significant trends in N or S deposition may affect surface waters, soils or plant communities in NCRN parks. NCRN will evaluate correlations between N and S concentration and deposition and other ecological parameters, and initiate monitoring or research in this area, if warranted.

Principal Investigators and NPS Lead

The NPS ARD will be responsible for providing NCRN guidance on downloading N and S wet deposition and concentration data and conducting relevant analyses. NCRN will be responsible for presenting data summaries and other relevant information in Network reports. NPS ARD will provide annual trend data on N and S concentration data that are national in scope.

Development Schedule, Budget, and Expected Interim Products

Protocol development will focus on obtaining and reporting of N and S concentration and deposition data collected in and near NCRN parks. The primary data source will be the NPS ARD, with the NADP/NTN website as a secondary data source. By June 2005, ARD will develop the deposition protocol that will be used by NCRN. NCRN will add information on the siting and operation of deposition monitors in the network. No NCRN funds will be used for protocol development.

LITERATURE CITED

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PROTOCOL DEVELOPMENT SUMMARY (LAST UPDATE: 4/5/05)

Protocol—Visibility and Particulate Matter

Parks Where Protocol will be Implemented

Antietam National Battlefield (ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield (MANA), Monocacy National Battlefield (MONO), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap Park for the Performing Arts (WOTR).

Justification/Issues Being Addressed

Atmospheric fine particles with diameter of less that 2.5 µm ($PM_{2.5}$) are known to be an important influence on the clarity of the atmosphere, due their light-scattering and light-absorbing properties (Malm et al. 1994; Finlayson-Pitts and Pitts 2000). Fine particles are also known to be a human health hazard, especially to active individuals (e.g., hikers and children; Romieu et al. 1996, Korrick et al. 1998, Pope 2000, Gent et al. 2003), and to people with asthma and other respiratory disorders (Romieu et al. 1996; Gent et al. 2003). In the presence of ozone, effects appear to be intensified (Romieu et al. 1996, Korrick et al. 1998, Gent et al. 2003). Many of the precursors of $PM_{2.5}$ in the NCRN are also precursors of ozone and contribute to N and S deposition. Monitoring status and trends of $PM_{2.5}$ and other particles will allow NPS to document changes in air quality that should occur as a result of the recently enacted Regional Haze Regulation.

Specific Objectives to be Addressed in the Protocol

1. Report on seasonal and annual status and trends of fine particle concentrations and composition in NCRN parks as they pertain to visibility impairment and human health.

2. Track and interpret visual impairment with cameras.

Basic Approach

Particle monitoring is conducted by the Maryland Department of Natural Resources, District of Columbia, Virginia Department of Environmental Quality and NPS. The NPS monitoring is part of the Interagency Monitoring of Protected Visual Environments (IMPROVE) program, a national program focused on monitoring visibility in national parks and wilderness areas. The IMPROVE particle monitoring protocol (http://vista.cira.colostate.edu/improve/Publications/SOPs/ucdsop.asp) is consistent with the EPA protocol used by the states (http://www.epa.gov/ttn/amtic/pmfrm.html). Both IMPROVE- and state-collected data are entered into a web-accessible database maintained by EPA. In addition to particle data, optical data are collected at a number of IMPROVE sites. Optical monitoring helps validate the particle data, and through the use of digital photos and web-enabled cameras, provides a means of providing and interpreting visibility data to the public (http://www2.nature.nps.gov/air/webcams/parks/nacccam/washcam.htm).
IMPROVE posts site-specific and programwide data on the VIEWS (http://vista.cira.colostate.edu/views/) website. NPS ARD will provide fine particle trend data annually for parks with IMPROVE monitoring. As appropriate, NCRN will supplement information obtained from ARD with data summaries, interpretations and graphics available on the VIEWS website. Monitoring specialists at the NPS ARD are developing guidance on downloading information from the VIEWS site in ways that will be most useful to report on status and trends in visibility in Network parks.

Principal Investigators and NPS Lead

The NPS ARD will be responsible for providing NCRN guidance on accessing visibility information and relevant data analyses. NCRN will be responsible for presenting data summaries and other relevant information in Network reports. NPS ARD will provide annual trend data on visibility parameters that are national in scope.

Development Schedule, Budget, and Expected Interim Products

Protocol development will focus on obtaining and reporting of particle and optical data collected in and near NCRN parks. The primary data source will be the NPS ARD, with the MWCOG website as a secondary data source. By June 2005, ARD will develop the deposition protocol that will be used by NCRN. No NCRN funds will be used for protocol development.

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PROTOCOL DEVELOPMENT SUMMARY (LAST UPDATE 4/5/05)

Protocol—Mercury Deposition

Parks Where Protocol will be Implemented

Antietam National Battlefield (ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield (MANA), Monocacy National Battlefield (MONO), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap Park for the Performing Arts (WOTR).

Justification/Issues Being Addressed

Mercury is a persistent, toxic, and volatile heavy metal that is globally distributed via the atmosphere. While its elemental form (Hg^o), is relatively harmless at ambient concentrations, its derivative organic forms (e.g., MeHg) are potent neurotoxins that bioaccumulate in aquatic food webs, directly harming humans, animals, and the ecosystem structure on which both depend (Morel et al. 1998). Although watershed factors, as opposed to atmospheric deposition, can often dominate MeHg production (Mason et al. 2002), recent research has shown that freshly deposited atmospheric mercury is more likely to be converted to the toxic form (MeHg) than "old" mercury (Babiarz et al. 2003). Although the NCRN experiences some of the highest deposition of atmospheric mercury in the US (Mason et al. 2000a, Mason et al. 2000b), this mercury appears to be largely retained in NCRN watersheds (Mason et al. 1999; Lawson et al. 2001), and fish tissue concentrations appear to be decoupled from atmospheric deposition as a result (Benoit et al. 1998, Mason et al. 1999). Although Benoit et al. (1998) implicate high sulfide (which inhibits methyl mercury production at high levels in substrate) as one reason for this decoupling, researchers are uncertain as to what watershed factors maintain this decoupled state. Data analysis should compare mercury deposition results with fish tissue concentrations available from EPA (http://epa.gov/waterscience/fish/states.htm) as an indicator of the risk to the watershed from atmospherically deposited Hgn. Simultaneous increases in atmospheric mercury deposition and fish tissues will be evidence of atmospheric contributions to NCRN mercury methylation, while increases in only fish tissue concentrations may indicate that watershed factors are contributing NCRN mercury methylation.

Specific Objectives to be Addressed in the Protocol

1. Report on seasonal and annual status and trends of mercury concentration and deposition in precipitation in NCRN parks.

Basic Approach

State and federal agencies, and others, who monitor mercury in wet deposition through the Mercury Deposition Network (MDN), use MDN's monitoring protocol (http://nadp.sws.uiuc.edu/QA/) and follow the program's quality assurance/quality control guidelines. MDN posts site-specific and programwide data on their website. NPS ARD will provide trend data annually for parks with NADP/NTN monitoring, when sites have an adequate data record (approximately 7–10 years). As appropriate, NCRN will supplement information obtained from ARD with data summaries, interpretations and graphics available on the MDN website. Monitoring specialists at the NPS ARD are developing guidance on downloading data from the MDN site (http://nadp.sws.uiuc.edu/mdn/) and conducting relevant analyses of the data in ways that will be most useful to report on status and trends in mercury concentration and deposition in Network parks.

Principal Investigators and NPS Lead

The NPS ARD will be responsible for providing NCRN guidance on downloading mercury wet deposition and concentration data and conducting relevant analyses. NCRN will be responsible for presenting data summaries and other relevant information in Network reports. NPS ARD will provide annual trend data on mercury concentration data that are national in scope, when a sufficient data record is available.

Development Schedule, Budget, and Expected Interim Products

Protocol development will focus on obtaining and reporting of mercury concentration and deposition data collected in and near NCRN parks. The primary data source will be the NPS ARD, with the MDN website as a secondary data source. By June 2005, ARD will develop the deposition protocol that will be used by NCRN. No NCRN funds will be used for protocol development.

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Mason, R.P., C.L. Miller, et al. 2002. Factors controlling the production, fate and transport of mercury and methylmercury in sediments. Abstracts of Papers of the American Chemical Society 223, U525-U525.

Morel, F.M.M., A.M.L. Kraepiel, et al. 1998. The chemical cycle and bioaccumulation of mercury. Annual Review of Ecology and Systematics 29: 543–566.

PROTOCOL DEVELOPMENT SUMMARY (LAST UPDATE: 12/13/04)

Protocol—Weather and Climate

Parks Where Protocol will be Implemented

Antietam National Battlefield (ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield (MANA), Monocacy National Battlefield (MONO), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap Park for the Performing Arts (WOTR).

Justification/Issues Being Addressed

Temperature and precipitation, taken over time scales of years, decades or longer, are the basic components of climate. Climate provides the physical constraints that determine plant and animal survival and drives the basic processes that underpin ecosystems. Current climate models predict substantial climate related changes climate of this region, and in the ecology as a result. These include (1) changes in forest species composition (i.e., loss of sugar maples in the north, encroachment of savannah in the south); (2) increased frequency of heavy precipitation events and flooding; and (3) an overall increase in the heat index of 8–20°F (National Assessment Synthesis Team 2000).

Monitoring the basic components of climate will help to discern whether these predictions are accurate for the NCRN, and help managers to anticipate these changes in their management practices. For example, if the climate no longer supports sugar maples, management plans should allow for that.

Specific Monitoring Objectives to be Addressed by the Protocol

1. Determine variability and long-term trends in climate for all NCRN parks through monthly and annual summaries of descriptive statistics for selected weather parameters, including air temperature and precipitation.

2. Identify and determine frequencies and patterns of extreme climatic conditions for common weather parameters.

Basic Approach

Monitoring is already being done in or near all parks in the NCRN. The data are currently managed by the National Oceanic and Air Administration (NOAA).

Principal Investigators and NPS Lead

The NPS Lead is Marian Norris, Water Resources Specialist, National Capital Region.

Development Schedule, Budget, and Expected Interim Products

Protocol development will consist primarily of writing a protocol that meets NPS standards (Oakley et al. 2003) and incorporates existing standard protocols. We will need to write new sections in the protocol narrative and SOPs to make the standard protocols specific to NCRN parks, such as describing nearest sampling locations and documenting how data will be entered into NPS computers, analyzed, and reported. Protocols will be submitted with the Phase III draft.

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PROTOCOL DEVELOPMENT SUMMARY (LAST UPDATE: 6/14/2005)

Protocol—NCRN Biological Stream Survey

Parks Where Protocol will be Implemented

Antietam National Battlefield (ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield (MANA), Monocacy National Battlefield (MONO), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap Park for the Performing Arts (WOTR).

Justification/Issues Being Addressed

Because impacts to water quality are so diverse and variable in duration, chemical monitoring alone may fail to detect many of them (Karr 1991, Karr 1981). A variety of biological parameters will be collected in addition to chemical data to provide an overall condition assessment of aquatic resources. Trends in macroinvertebrate and fish diversity serve as useful indicators of shifts in the condition of a stream ecosystem as it responds to anthropogenic actions. Physical habitat information provides additional necessary components of complex aquatic systems.

Aquatic macroinvertebrate Index of Biotic Integrity (Macro IBI). Macroinvertibrates are the food source for many other organisms in the ecosystem. The various species respond differently to different environmental stressors, are relatively easy to collect, and can be analyzed at many different levels of precision. Aquatic macroinvertebrates, therefore, are an important tool to understand and detect changes in ecosystem integrity over time. Aquatic macroinvertebrate indices of biotic integrity can provide an assessment of the ecological ramifications of water quality and water quantity trends based on what organisms are present and what conditions these organisms require (Gerritsen 1995, Kerans and Karr 1994, Kerans and Karr 1992, Karr 1991).

Fish Index of Biotic Integrity (Fish IBI). Different components may not equally reflect the presence or magnitude of stressors in the system (e.g., Berkman et al. 1986). Fish, for example, utilize different portions of the stream and different food sources than macroinvertebrates. They also reflect different time frames of exposure to conditions. The Fish IBI provides an additional layer of information about the health of the environment (Gerritsen 1995, Kerans and Karr 1994, Kerans and Karr 1992, Karr 1991).

Physical Habitat Index (PHI). Physical habitat affects fish diversity more than water quality does (Gorman and Karr 1978). The PHI has been adapted by the Maryland Biological Stream Survey as a way to monitor physical habitat and can be easily adapted to the NCRN parks. PHI describes the surrounding riparian components that provide important habitat wildlife and ecological services such as trapping sediment, modifying flood flows, and increasing groundwater recharge (Heinz Center 2002). The PHI also measures a variety of physical components including fish habitat structure, river depth, stream and floodplain vegetation composition, stream geomorphology, sediment accumulation, channel morphology, substrate quality, and riparian condition. In addition, a PHI can be used to identify non-point sources of pollution, determine the effects of local land-use on a stream or other body of water, and in determining these effects indicate how to remedy them (Petersen 1992).

This protocol is being adapted from the Maryland Biological Stream Survey (MBSS). Monitoring in the NCRN streams is based on the watershed approach, such that inferences based on the conditions of monitored streams will also indicate the condition of the entire watershed.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol

Measurable Objectives

1. Determine current conditions and track long-term trends in the Physical Habitat Index (PHI) and its components.

2. Determine trends in species composition and functional groups of benthic invertebrates and fishes.

3. Detect invasions of nonnative fishes.

Basic Approach

The Protocol is an adaptation of the Maryland Biological Stream Survey for all NCRN parks including those in Virginia and the District of Columbia. Virginia streams are part of the Potomac River watershed and are sufficiently close that biological, chemical, and physical attributes will be comparable to streams in the existing MBSS sampling universe. This not only extends the monitoring program within NCRN, but also puts NCRN sites within a regional context.

The NCRN has prioritized watersheds for each park based on the degree of NPS management influence. The highest priority watersheds are those where the NPS exerts direct control over the entire watershed. The lowest priority watersheds for monitoring are those where most of the watershed is outside of the NPS boundary.

Index of Biotic Integrity. Fish and macroinvertebrate sampling following this protocol will allow for both local (site specific) and regional (by stream order and physiographic region) data interpretation. The strongest inferences can be made on the regional scale because NCRN collected data can be compared to the entire MBSS dataset for the state of Maryland. At the local scale, NCRN has modified the MBSS protocol to allow for inferences specific to the smaller watersheds that are important at the scale of individual parks. Also at the local scale, and because of the infrequent sampling, the NCRN monitoring effort will result in a series of 'snapshots' of the status of these resources. A legitimate trend, at the local scale, will take twenty years to document unless there is a catastrophic event that dramatically decreases the resource. All sampling will be constrained to 1st - 3rd order, nontidal, freshwater streams. Macroinvertebrate samples will be collected annually in summer (July – August). Fish sampling will be carried out by electroshocking. Samples will be collected annually in summer (July – August).

Physical Habitat Index (PHI). The PHI can vary widely on the same stream, depending upon where the measurement is taken. PHI information is most useful when pooled with sampling sites of similar habitat (stream order and physiographic province). This allows for regional inferences of status and trends. In the event that the PHI procedure can be used on a regular basis during monthly water quality sampling a substantial dataset will be created within a couple of years. The PHI protocol measures instream habitat, channel character, riparian zone habitat, and aesthetic condition. All sampling will be constrained to 1st - 3rd order, nontidal, freshwater streams.

Principal Investigators and NPS Lead

The Principal Investigators are Dr. Bob Hilderbrand (University of Maryland Center for Environmental Sciences, Cambridge, MD, 21613); Dr. Rich Raesly (Frostburg State University, Frostburg, MD, 21532); and Paul Kayzak (Maryland Dept. of Natural Resources, Annapolis, MD, 21401). NPS Lead is Marian Norris, Water Resources Specialist, National Capital Region.

Development Schedule, Budget, and Expected Interim Products

A Water Quality Pilot project began in 2004 and included the Fish and Macroinvertebrate IBIs and the PHI. The protocols will be submitted as the project's final report in October 2004. This project used FY03 funds and cost $60,000.

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PROTOCOL DEVELOPMENT SUMMARY (LAST UPDATE: 12/13/04)

Protocol—Surface Water Dynamics

Parks Where Protocol will be Implemented

Antietam National Battlefield (ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield (MANA), Monocacy National Battlefield (MONO), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap Park for the Performing Arts (WOTR).

Justification/Issues Being Addressed

One of the more basic water resource components that can be influenced by human development is the flow regime of a stream. The most fundamental hydrological measurement that characterizes all stream ecosystems is discharge. Discharge is measured by the volume of water flowing through a cross section of a stream channel per unit time (velocity X stream cross-section X stream stage). Discharge provides an indication of stream power or the ability of the river to do work. The work performed by the stream influences the distribution of suspended sediment, bed material, particulate organic matter, and other nutrients. The distribution of these materials has substantial influence on the distribution of riverine biota. In addition, discharge and stream power combine with other basin conditions to influence meander patterns and floodplain dynamics (Gore 1996), which are important in providing habitat for flora and fauna (Allan 1995).

An analysis of the manner in which discharge varies over time, or the hydrograph, provides insight into the characteristics of the watershed that influence such conditions as runoff and storage (Gore 1996). Examination of the shape of a daily hydrograph during a storm event can indicate the condition of the stream and its basin: infiltration capacity of the catchment, size of the basin, storage capacity, absorptive surface, and channel size (Gore 1996).

The intensity of the exposure to potential stressors for stream organisms depends on how fast that water is traveling past the organisms, and on the dilution factor, which depends on how much water is in the stream. Surface water dynamics data provides key "support" data for other vital signs indicators including freshwater quality, groundwater dynamics, stream threatened and endangered species and fish assemblages, threatened and endangered amphibians and reptiles, erosion and deposition, wetlands, and riparian habitat.

Specific Monitoring Objectives to be Addressed by the Protocol

Determine long-term trends in seasonal and annual stream hydrology (velocity, discharge, and flood characteristics) at selected sites in NCRN streams.

Basic Approach

USGS will develop monitoring protocols including standard operating procedures as discussed by Oakley et al. (2003). USGS will also provide hands-on training to NCRN staff for taking flow readings in the field and data analysis. Protocols and SOP are being adapted from existing NPS and USGS protocols.

Stream flow will be measured at 24 sampling locations by handheld meters and existing USGS gauging stations. Flow measurements will be obtained monthly during the summer (in conjunction with station maintenance and downloading) with portable flow meters or current meters following the USGS standard protocol (Rantz 1982). Stage will be measured by water level loggers and stage gages. Water level monitors (pressure transducers) will be utilized as well at staff gauges or staff plates. Discharge-ratings curves and hydrographs will be developed for all sampling sites.

Principal Investigators and NPS Lead

Principal Investigators are USGS PI- Gary T. Fisher, Surface Water Quality Specialist, USGS Water Resources Division Maryland-Delaware-DC District Office, Baltimore, MD 21237. NPS Lead is Marian Norris, Water Resources Specialist, National Capital Region.

Development Schedule, Budget, and Expected Interim Products

The PI will produce draft water quantity protocols and implementation plan and deliver a final protocol document (4 paper copies plus 1 electronic copy) that addresses peer review comments no later than 1 June 2005. USGS (In kind contribution) expenditure of $8,644.00. NPS expenditure of $39,258.00, for a total cost of $47,902.00.

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PROTOCOL DEVELOPMENT SUMMARY (LAST UPDATE 12/13/04)

Protocol—Water Chemistry and Water Nutrients

Parks Where Protocol will be Implemented

Antietam National Battlefield (ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield (MANA), Monocacy National Battlefield (MONO), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap Park for the Performing Arts (WOTR).

Justification/Issues Being Addressed

All NCRN parks contain one or more water bodies that drain into the Potomac River and ultimately into the Chesapeake Bay, both of which are of regional importance. Water chemistry is a major concern to the NCRN parks. It integrates many important ecological drivers and stressors, and can provide insights into ecological patterns and processes, including nutrient cycling, land use, soil erosion, air quality, vegetation communities, aquatic habitats, fish assemblages, and aquatic macroinvertebrates. Water chemistry parameters to be monitored in the NCRN include temperature, conductivity, pH, dissolved oxygen (DO), acid neutralizing capacity (ANC), nitrate, ammonia, DON, nitrite, and orthophosphate.

Water Temperature. Temperature influences the density of water, the solubility of constituents (especially oxygen) in water, pH, specific conductance, the rate of chemical reactions, gas-diffusion rates, chemical-reaction rates, the settling velocity of particles, and biological activity in water (Radtke et al. 1998).

Specific Conductance (SC). SC is a function of the types and quantities of dissolved, electrically charged substances (ions) in water (Radtke, Davis, and Wilde 1998). Collectively, all substances in solution exert osmotic pressure on the organisms living in it, which in turn adapt to the condition imposed upon the water by its dissolved constituents. With excessive salts in solution, osmotic pressure becomes so high that water may be drawn from gills and other delicate external organs resulting in cell damage or death of the organism. Some common sources of pollution that can affect specific conductance are deicing salts, dust reducing compounds, and the liming of agricultural fields (Stednick and Gilbert 1998).

pH. Changes in pH affect the dissociation of weak acids or bases, which in turn affects the toxicity of many compounds. For example, hydrogen cyanide toxicity to fish increases with lowered pH; rapid increases in pH increase NH_3 concentrations; and the solubilities of metal compounds are affected by pH. Also, in order to estimate the toxicity of ammonia, aluminum, and some other contaminants requires accurate pH values as metadata (MacDonald et al. 1991).

Dissolved Oxygen (DO). The presence and amount of DO in surface water determines the extent to which many chemical and biological reactions will occur. DO is vital to respiration of both plants and animals and is affected by numerous natural phenomena and human activities (Stednick and Gilbert 1998). Conditions that contribute to low DO levels include warm temperatures, low flows, water stagnation and shallow gradients (streams), organic matter inputs, and high respiration rates (MacDonald et al. 1991).

Acid Neutralizing Capacity (ANC). It is important to monitor for Acid Neutralizing Capacity (ANC) in the NCRN due to the threat from air pollution and acid rain.

Nutrient Contamination. Nutrient contamination can cause changes in soil and ground water chemistry, reduced water quality, fishery health, and aquatic invertebrate communities and populations. High levels of nitrogen and phosphorous are a known problem due to fertilizer runoff in the Mid-Atlantic (EPA 2002). It is important to determine watershed nutrient export, which is a critical ecosystem function in the greater Chesapeake Bay watershed where eutrophication is causing algal blooms and dead-zones. Phosphorus is singled out as an especially important indicator in the Heinz Center Report (2002) on the state of nation's ecosystems.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol

Water chemistry monitoring in the NCRN streams is based on the watershed approach, such that inferences based on the conditions of monitored streams will also indicate the condition of the entire watershed. The NCRN has prioritized watersheds for each park based on the degree of NPS management influence. The highest priority watersheds are those where the NPS exerts direct control over the entire watershed. The lowest priority watersheds for monitoring are those where most of the watershed is outside of the NPS boundary. All sampling will be constrained to 1st–4th order, nontidal, freshwater streams. Sampling following this protocol will allow for both local (site specific) and regional (by stream order and physiographic region) data interpretation.

Monitoring Questions to be Addressed by the Protocol:

- What are the long-term changes of water quality in the parks?
- What are key pollution sources to streams in NCRN parks?
- How well are the NCRN streams faring compared to those in adjacent watershed.
- Is the ANC sufficient in streams within the NCRN to withstand regional acidity inputs?

The measurable objectives of the protocols are to:

Determine long-term trends in water temperature, pH, specific conductance, dissolved oxygen, Acid Neutralizing Capacity, nitrite, and orthophosphate in selected freshwater sites in NCRN parks.

Basic Approach

Monitoring protocols for the core water chemistry parameters (pH, DO, specific conductance, temp) and ANC are being adapted from existing USGS and NPS protocols. NCRN water quality monitoring efforts will be coordinated with ongoing monitoring efforts conducted by the parks and other state and local agencies. Where feasible, NCRN will augment existing activities and help with data analysis and interpretation.

Principal Investigators and NPS Lead

The NPS Lead is Marian Norris, Water Resources Specialist, National Capital Region.

Development Schedule, Budget, and Expected Interim Products

Protocols are being developed by the NCR Water Resources Specialist hired through funding from Water Resource Division (WRD). Draft protocols will be submitted with the Phase III draft for peer review.

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PROTOCOL DEVELOPMENT SUMMARY (LAST UPDATE: 6/2/05)

Protocol—Forest Vegetation Monitoring

Parks Where Protocol will be Implemented

Antietam National Battlefield (ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Park (MANA), Monocacy National Historical Battlefield (MONO), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap Park for the Performing Arts (WOTR).

Justification/Issues Being Addressed

All parks in the NCRN have significant areas covered by Eastern deciduous forests including riparian and upland forests. A variety of unique communities have been identified within these forests including 28 identified by NatureServe (2004) A variety of factors affect vegetation composition in the NCRN parks. Ecological factors include soils and geology, rain patterns, and nutrient availability. Anthropogenic stressors include air pollution, loss of habitat due to development (inside and outside of parks), erosion, and visitor use. The most significant threats, however, are recognized as exotic and invasive species (Cohn 2004; NPS and TNC 2001; NPS 1999) and white-tailed deer (Bates, pers. comm.).

In this region, invasive plants are reducing the indigenous biological diversity of the parks, and disrupting natural ecological processes. The known ecological impacts of invasive plants include loss of threatened and endangered species, altered structure and composition of vegetation communities, and reduction in plant species diversity. In addition, alteration of ecosystem processes occurs, such as changes in natural succession, prevention of seedling establishment of native plants, disruption of insect-native plant associations, alteration of natural fire regimes, hybridization with native plant species resulting in altered genomes, and introduction of reservoirs for harmful plant pathogens (NPS 1999; Randall and Marinelli 1996; NPS and TNC 2001).

Vegetation community changes are also apparent because of growing deer populations in the NCRN parks. Preliminary results of the NCRN deer density monitoring program indicate that deer in NCR parks range from 12 deer/km^2 (PRWI) to 38 deer/km^2 (CATO). Deer prefer some species over others, which is changing the composition of native vegetation. For example, anecdotal evidence suggests that there has been no seedling regeneration in some areas of CATO in approximately 15 years. Monitoring the effects of deer will provide critical information to park managers.

This protocol will provide park managers with comprehensive long-term data about the status of the parks' vegetation resources including the effects of ecological and anthropogenic stressors. Permanent plots will be used to provide basic information on status and trends of forest composition and structure. Data will be collected on native and non-native species frequency and abundance. Specific measures will be taken to assess the effects of deer browse. Additional vital signs will also be used to address the rate of spread of invasive species and will alert park managers of potential or new infestations (see Protocols: Occurrence of Selected Invasive Plant Species for details).

Specific Monitoring Objectives to be Addressed in the Protocol

The measurable objectives of the protocols are to:

1. Determine long-term trends in plant species composition

2. Determine long-term changes in percent cover of native and nonnative herbaceous species and woody vines in forest communities.

3. Determine long-term changes in stem density of native shrub and tree species in forest communities.

4. Determine long-term changes in stem density of exotic and invasive shrub and tree species in forest communities.

Basic Approach

The protocol being developed will modify the Forest Service Forest Inventory and Analysis (FIA) plot design and grid structure. It will consist of long-term vegetation monitoring plots which will measure stand basal area, density of trees, pole trees, saplings, and seedlings, standing shrub stem density and herbaceous cover. The protocol used will be a modification of the Forest Service's FIA circular plots. Instead of the four 1/24 acre subplots used by FIA, our modified plots will be a single circular plot with a 14.7 meter radius. Within this circular plot, there will be several nested subplots, which will be used to measure pole trees, saplings, and seedlings, as well as the cover and or stem density of herbaceous plants.

This design will also allow the NCRN monitoring program to collect information on many parameters of forest structure and composition to provide information on exotic invasive plants in the NCRN, such as change in cover of native and non-native herbaceous plants, change in stem density of shrubs, both native and exotic, stem density and basal area change of native and exotic tree species,.

In addition, the protocol will collect information on several parameters of forest structure and composition that will contribute towards understanding the effects of white-tailed deer on vegetation, such as change in cover of herbaceous plants and stem density of seedlings, saplings, shrubs and pole trees.

Principal Investigators and NPS Lead

The NPS Lead for the protocol development is Dr. John Paul Schmit, Quantitative Ecologist for the National Capital Region Network. This protocol is based on an earlier version for which the Principal Investigator was Dr. David Chojnacky of the Forest Inventory Research, Enterprise Unit and the NPS Lead was Mikaila Milton, Bio-Technician, National Capital Region Network.

Development History and Schedule

A draft protocol was completed in December 2004. Based on initial reviews, the protocol was revised substantially Jan-June 2005. The first year of data collection will take place in the summer of 2006. A preliminary review of the protocol will take place after the first year of data collection and if need the protocol will be revised in early 2007.

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PROTOCOL DEVELOPMENT SUMMARY (LAST UPDATE: 3/30/05)

Protocol—Invasive and Exotic Plant Species

Parks Where Protocol will be Implemented

Antietam National Battlefield (ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield (MANA), Monocacy National Battlefield (MONO), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap Park for the Performing Arts (WOTR).

Justification/Issues Being Addressed

Invasive non-native plants occur throughout the NCRN and have been identified as high management priorities (NPS 1999). Alien species are considered to be one of the most critical threats to the resources in the Potomac Gorge, which is home to some of the most diverse and rare communities in the country (Cohn 2004; NPS and TNC 2001). In this region, invasive plants are reducing the indigenous biological diversity of the parks and disrupting natural ecological processes.

The known ecological impacts of invasive plants and include loss of threatened and endangered species, altered structure and composition of vegetation communities, and reduction in plant species diversity. In addition, alteration of ecosystem processes occurs, such as the disruption of natural succession, prevention of seedling establishment of native plants, disruption of insect-native plant associations, alteration of natural fire regimes, hybridization with native plant species resulting in altered genomes, and introduction of reservoirs for harmful plant pathogens (NPS 1999; Randall and Marinelli 1996; NPS and TNC 2001).

While long-term changes associated with invasive species are being monitored through other protocols (see Protocol Development Summary (PDS) – Forest Vegetation Monitoring), it is also critical to catch new populations of exotic species early in their invasion of new and sensitive natural areas (see also PDS Rare, Threatened, and Endangered Species, for a discussion of monitoring sensitive species and their threats). Only when invasions are caught early on will the chance of eradication remain high. Invasive species are a significant management concern nationwide and the national Inventory and Monitoring program and the USGS are collaborating on a project to develop a protocol for the early detection of exotic invasive plants (Brad Welch, Exotic Species Coordinator, WASO, pers. Comm.).

While the use of remote sensing for early detection (Smith et al. 2004) has been considered for this region, having more knowledgeable eyes in the field is more applicable in the small and narrow parks of the NCRN parks (Brad Welch, pers. comm.). The focus of early detection in this region will focus on educating all field crews, cooperators, resource managers, and volunteers on invasive species identification.

Specific Monitoring Objectives to be Addressed in the Protocol

The measurable objectives of the protocols are to:

1. Detect the presence and spread of selected invasive plant species

Basic Approach

The focus of this protocol is to educate field crews to enable them to detect presence of target invasive exotic plants in NCRN parks while implementing monitoring protocols such as vegetation and rare, threatened, and endangered species. The NCRN IM staff, cooperators, resource managers, and volunteers will be spending considerable time in the field to monitor various vital signs including vegetation and rare, threatened, and endangered species. The new eyes and ears in the field will be able to detect signs of invasive species through the course of their normal work.

In addition, an Exotic Plant Management Team (EPMT) and park staff are already actively searching for new invasive species. The IM Program will coordinate with EPMT to develop training material for new staff including field identification guides. Much of this information is already available online and maintained by The Nature Conservancy (The Nature Conservancy 2005). Once new populations or new species occurrences are detected, field staff will identify species and their locations on datasheets. The datasheets will be used to alert appropriate resource managers and the EPMT for further management evaluation. Protocols will help determine if additional searches or mapping and management is warranted.

Principal Investigators and NPS Lead

The IM staff will work closely with the NCR EPMT Liaison, Sue Salmons and the Regional IPM Coordinator, Jil Swearingen, to develop training material including a field guide about exotic species including their likely habitat and phonologies for each year's field personnel. NPS I&M Lead is John Paul Schmit, Quantitative Ecologist, National Capital Region Network.

Development Schedule, Budget, and Expected Interim Products

The protocol will consist of training material for the identification of invasive and exotic plant species, field data-sheets, and a tracking database. The training material will be updated annually as the list of expected pest species grows. Field sheets will be also developed in order to ensure the communication of pertinent notes and/or photographs to the IPM officials. The complete protocol will be developed in-house in summer and fall of 2006 in order to be prepared for implementation by spring 2007.

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PROTOCOL DEVELOPMENT SUMMARY (LAST UPDATE: 12/13/04)

Protocol—Amphibians

Parks Where Protocol will be Implemented

Antietam National Battlefield (ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield (MANA), Monocacy National Battlefield (MONO), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap Park for the Performing Arts (WOTR).

Justification/Issues Being Addressed

Amphibian monitoring is a high priority because of their importance as indicators on a world-wide scale. Population declines have been noted throughout the world due to disease, introduced predators, loss of habitat, acidification, or ultraviolet-B radiation damage to eggs. The life histories, dispersal abilities and physiological tolerances of this clade of organisms and the introduction of multiple, synergistic stressors at many life history stages make them potentially more susceptible to environmental change than other species (Corn 2000; Sparling et al. 2000; Semlitsch 2003). Because of these characteristics, amphibians may be good indicators of local and regional ecosystem change and perturbation, and many researchers have urged greater attention to this taxon (Semlitsch 2003 and chapters therein). Certain families (e.g., plethodontidae) may be especially valuable indicators in the NCRN (Welsh and Droege 2001).

Though amphibians are being inventoried in most NCRN parks (Gray and Koenen 2001), additional information needs to be collected on available habitats (Pauley, pers. comm.). Also, local population trends are unknown. Population assessments can be coordinated with Amphibian and Reptile Monitoring and Inventory (ARMI) program.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol

- What are the long-term changes in region-wide amphibian species diversity?

The measurable objectives of the protocols are to:

1. Determine trends in proportion of area occupied for viable amphibian populations within wetland and upland habitats of NCRN parks

2. Determine long-term changes in amphibian species richness among all NCRN parks

Basic Approach

Recently, the proportion of area occupied (PAO) metric has been developed to aid the U.S. Geological Survey's Amphibian Research and Monitoring Initiative (ARMI) in the collection of large-scale data on amphibians in the United States (MacKenzie et al. 2002, 2003; Bailey et al. 2004; MacKenzie *in press*). This approach is robust to variation in detectability due to species, habitats, and other biotic and abiotic variables. In addition, the model allows the incorporation of covariates to test specific hypotheses about factors influencing the distribution of amphibians while providing methods to estimate occupancy despite missed observations at a site (MacKenzie et al. 2002). The specific objective is to provide spatial and temporal estimates of change in species occupancy within the area of inference, which is defined prior to the initiation of the study and can include individual management areas, parks, or regions.

The PAO methodology will be adapted to the NCRN parks. Results from concurrent monitoring efforts will be integrated with collection of amphibian occupancy data as is feasible, so that hypotheses may be tested with respect to covarying changes in other abiotic and biotic parameters (e.g., water quality, aquatic invertebrates).

Principal Investigators and NPS Lead

Protocol development will be done through an Inter-Agency Agreement with USGS Patuxent Wildlife Research Center, Laurel Maryland 20708). Principal Investigator will be Robin Jung. NPS I&M Lead is Marian Norris, Water Resources Specialist, National Capital Region Network.

Development Schedule, Budget, and Expected Interim Products

Regional- and national-level protocols already exist for the USGS ARMI and NAAMP programs. Protocol development will, however, require field research to identify appropriate habitats for sampling. A pilot project must also be established in 2004 in order to estimate appropriate sample size for long-term monitoring. Draft protocols for the pilot project will be submitted to NPS by February 2005. Field sampling will be conducted February through October 2005. Draft protocols including SOP that meets NPS standards (Oakley et al. 2003) will be submitted to NPS for peer review in December 2005. Final protocols incorporating peer review comments are due January 2006. We have budgeted $51,842 for in FY 2004 for protocol development and testing.

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PROTOCOL DEVELOPMENT SUMMARY (LAST UPDATE: 6/6/05)

Protocol—Grassland and Forest Bird Communities

Parks Where Protocol will be Implemented

Grassland bird communities at: Antietam National Battlefield (ANTI), Manassas National Battlefield (MANA), and Monocacy National Battlefield (MONO).

Forest Bird Communities at: Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap Park for the Performing Arts (WOTR).

Justification/Issues Being Addressed

The region around the NCRN parks provides habitat for a high diversity of avian species. Biological inventories also indicate that the parks host a variety of species of conservation concern including grassland and forest species (Sinclair et al. 2003; Brewer 2001). Previous studies in the region also show that the urban landscape in and around Washington including the downtown parks (e.g., ROCR, NACC), provides diverse habitats that hosts nearly as many species as the surrounding suburbs (Hadidian et al. 1997).

The use of birds as ecological indicators has been questioned because determining the effect of environmental changes on bird populations is very difficult given the myriad of factors that can cause population changes (Temple and Wiens 1989; Morrison 1986). Monitoring bird populations, however, is important in order to determine if viable populations exist in the parks (Temple and Wiens 1989).

Key reasons for monitoring birds in network parks are that they are protected under the (1) Migratory Bird Treaty Act; and (2) The Migratory Bird Executive Order signed by President Bill Clinton in 2000. In addition, birds represent a popular taxanomic group that can be readily sampled and comparable regional and national datasets exist including the Breeding Bird Surveys (BBS) and the Christmas Bird Counts (CBC).

Specific Monitoring Questions and Objectives to be Addressed by the Protocol

Some of the specific monitoring questions that will be addressed by this protocol include:

- What are the long-term trends in species composition and abundance of the grassland and forest bird communities?
- What is the natural level of variation in population distribution and abundance of the forest bird communities?
- How do management activities affect the composition and abundance of grassland or forest bird species?

The measurable objectives of the protocols are to:

1. Determine long-term trends in species composition and abundance of birds in grassland and forested communities of NCRN parks.

Basic Approach

Available grasslands will be evaluated to determine if the parks in the National Capital Region Network contain suitable habitat for sustaining bird populations. The protocol is being developed in conjunction with the adjoining networks including Mid-Atlantic and Eastern Rivers and Mountains. As a result, multiple networks will use an identical protocol to monitor grassland birds that will allow analysis of the data on a wider geographic scale. In addition, ongoing monitoring programs in the NCRN will be evaluated for their effectiveness to meet the listed objectives including the Breeding Bird and Mid-Winter Bird Counts at CHOH; Breeding Bird Survey at PRWI (modified BBS); the Breeding Bird Survey (non-standard BBS) at Dyke Marsh of the GWMP; and Breeding Bird Survey (non-standard BBS) conducted by the Northern Virginia Audubon Society at MANA.

Principal investigators will make recommendations for the need to monitor bird populations. Various standard monitoring protocols including Variable Circular Plot (VCP distance sampling) counts, mist-netting and banding (MAPS protocol), nest searching and monitoring (BBIRD protocol) and may be added to complete coverage. In addition, specialized surveys may need to be considered for monitoring taxa not included in standard research (i.e., nocturnal) or for taxa with specialized habitat. Monitoring Avian Productivity and Survivorship (MAPS) have already been established at Fort Belvoir in Fairfax County (Nott et al. 2002) and may also be useful to evaluate and monitor resource management in the NCRN. Data should be consolidated with National Point Count database if appropriate.

Principal Investigators and NPS Lead

Forest bird protocols will be developed through an Inter-Agency Agreement with USGS (Patuxent Wildlife Research Center, Laurel Maryland 20708). The Principal Investigator is Deanna Dawson. NPS I&M Lead is Geoff Sanders, Data Manager, National Capital Region Network.

Grassland bird protocols are being developed through a multi-network Inter-Agency Agreement with USGS (Patuxent Wildlife Research Center, Laurel Maryland 20708). The Principal Investigator is Bruce Peterjohn. The NPS I&M Lead is Jim Comiskey, Mid-Atlantic Network and John Paul Schmitt, Quantitative Ecologist, National Capital Region Network.

Development Schedule, Budget, and Expected Interim Products

Regional- and national-level protocols already exist for the MAPS and BBIRD programs and for distance sampling using variable circular plot counts. Therefore, protocol development will not require field research and will consist primarily of writing a protocol that meets NPS standards (Oakley et al. 2003) and incorporates existing standard protocols. We will need to write new sections in the protocol narrative and SOPs to make the standard protocols specific to NCRN parks, such as describing sampling locations and documenting how data will be entered into NPS computers, analyzed, and reported. The PIs will produce a draft protocol ready for review by Spring 2005. After peer review, revision and approval, we hope to implement the protocol in Summer 2006. We have budgeted $40,525.00 for in FY 2004 for protocol development and testing.

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PROTOCOL DEVELOPMENT SUMMARY (LAST UPDATE: 6/6/05)

Protocol—White-tailed Deer

Parks Where Protocol will be Implemented

Antietam National Battlefield(ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield (MANA), Monocacy National Battlefield (MONO), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap Park for the Performing Arts (WOTR).

Justification/Issues Being Addressed

The number of deer is increasing nationally and has significant ecological and economic impacts on the region (Flather et al. 1999). In many areas they are overabundant (Flather et al 1999). Deer ranked as a high priority for monitoring in this network because of their significant impacts on the spread of exotic species, prevention of tree regeneration, and impacts to small mammal, amphibian, and bird populations. In addition, the number of car collisions with deer have increased dramatically during the last 20 years (Flather et al. 1999) and are a concern in parks that have commuter routes running through or adjacent to them, including CHOH, GWMP, MONO, NACE, and ROCR. Preliminary results from a pilot deer density monitoring program indicate that deer in the NCRN range from 12 deer/km2 (PRWI) to 38 deer/km2 (CATO) (Bates, pers. comm.). The key reason for monitoring deer in NCRN is that data are needed to support development of Environmental Impact Statements for management activities.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol

Some of the specific monitoring questions that will be addressed by this protocol include:

- What are the long-term trends in deer abundance in NCRN parks?
- What is the natural level of variation in population abundance?
- Are long-term changes in deer abundance correlated with long-term changes in vegetation and/or bird populations?

The measurable objectives of the protocol are to:

1. Detect long term changes in deer abundance in NCRN parks.

Basic Approach

The NCRN has a history of monitoring deer using an established, field-tested protocol developed by Dr. Brian Underwood (SUNY, Ithaca, N, 13210) that uses distance estimation procedures. The protocols will be written by the NCR – Regional Wildlife Biologist in order to meet NPS guidelines (Oakley et al. 2003).

Principal Investigators and NPS Lead

Protocol development will be completed by the NCR Regional Wildlife Biologist Scott Bates. NPS I&M Lead is Shawn Carter, Inventory and Monitoring Coordinator, National Capital Region.

Development Schedule, Budget, and Expected Interim Products

Distance sampling has been conducted since 2001 and protocol development will not require field research. Work will consist primarily of revising an existing, peer-reviewed and field-tested protocol to meet NPS standards (Oakley et al. 2003). We will need to write new sections in the protocol narrative and SOPs to make the standard protocols specific to NCRN parks, such as describing sampling locations and documenting how data will be entered into NPS computers, analyzed, and reported. The Regional Wildlife Biologist will produce a draft protocol ready for external peer review by May 30, 2004. After peer review, revision and approval, we hope to implement the protocol in Spring 2005.

Additionally the NCRN is currently developing a project to test some of the assumptions of distance sampling. The NCRN will compare the results of distance samples with that of sampling using cameras to determine if distance sampling along roads gives an accurate measurement of deer density in the forest interior.

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Oakley, K., L. Thomas, and S. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bull. 31:1-3.

PROTOCOL DEVELOPMENT SUMMARY (LAST UPDATE: 6/7/05)

Protocol—Rare, Threatened, and Endangered (RTE) Species

Parks Where Protocol will be Implemented

Antietam National Battlefield (ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Manassas National Battlefield (MANA), Monocacy National Battlefield (MONO), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), and Rock Creek Park (ROCR).

Justification/Issues Being Addressed

National Parks are required under law to protect federally listed threatened and endangered species. Policy directs NPS to protect state listed species to the extent possible (DO-77-8 Section 3.1 and 3.2; NPS 2002). In addition to legal and policy priorities, rare species often hold significant interest to the public.

The RTE workgroup of the NCRN Science Advisory Committee developed criteria to prioritize species reflecting legal protection and guidance based on heritage ranks (NatureServe 2002): 1. any species listed as threatened or endangered by the federal or state government (only Maryland and Virginia have state listings); 2. species listed rare throughout their entire range (Global Ranks = G1 and G2). Given the amount of time it takes to list species, subject matter experts may also recommend species for inclusion.

Nine of the 11 NCRN parks have identified RTE species with viable populations. The parks of the National Capital Region offer some of the last remaining habitats for rare species in a rapidly urbanizing landscape (Ewing et al. 2005). Monitoring these populations is a high priority to give parks the ability to plan management actions and preserve species according to the legal and policy mandates.

Specific Monitoring Objectives to be Addressed by the Protocol

1. Determine long-term trends in the abundance of rare, threatened, and endangered species at priority sites of NCRN parks.

Basic Approach

Heritage databases from the District of Columbia, Maryland, Virginia, and West Virginia were searched to develop initial species lists. Species that did not meet the criteria for prioritization or non-viable populations were removed from the list. Although a site-based approach (TNC 2000, Poiani et al. 1998) was originally considered, a spatial analysis conducted by Virginia Polytechnic Institute (VPI) indicated that occurrences were generally widespread (Klopfer 2005, pers. comm.). Varying phenologies of flowering plants further made a site based monitoring approach difficult.

A simple monitoring approach, however, is being developed in order to enable resource managers and volunteers to determine annual status of priority species in each park. VPI is reviewing phenologies in order to evaluate the most efficient timing for site visits. In addition, VPI will be making site visits for each species in order to create an accurate site map. Initial data will include a count of how many individuals are present, photograph, and list of potential threats. Data will be entered into Database Template.

Principal Investigators and NPS Lead

Protocols are being developed by Virginia Polytechnic Institute, Blacksburg, Virginia, 24061. Jeff Waldon is the universities key official. Principal Investigators include Dr. Allison Wells and Scott Klopfer. NPS I&M Lead is Sean Carter, Inventory and Monitoring Coordinator, National Capital Region.

Development Schedule, Budget, and Expected Interim Products

RTE data is maintained by NPS and State Heritage Programs. Protocols will be developed to meets NPS standards (Oakley et al. 2003). VPI will produce draft protocol by Spring 2005. Upon completing an internal review, VPI will implement the protocols in summer 2005 in order to describe exact sampling locations and test the data entry, analysis, and reporting processes. An external peer review will be conducted in fall 2005. We have budgeted $80,000 from FY 2003 for protocol development and testing and $100,000 from FY 2005 for implementation. The implementation cost is expected to decrease significantly after the first year.

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PROTOCOL DEVELOPMENT SUMMARY (LAST UPDATE: 6/7/05)

Protocol—Insect Pest Species

Parks Where Protocol will be Implemented

Antietam National Battlefield (ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield (MANA), Monocacy National Battlefield (MONO), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap Park for the Performing Arts (WOTR).

Justification/Issues Being Addressed

A diverse range of exotic insect, fungal and bacterial forest pest species have been identified collectively as a priority vital sign for the NCRN. Known pests already include the hemlock-wooly adelgid, dogwood anthracnose, bacterial leaf scorch, and gypsy moths. Most of these are already monitored at the park and/or regional level. New pests, however, are constantly emerging. In 2004, for example, the emerald ash borer was first identified and treated just outside of Wolf Trap Farm Park, and sudden oak death has been identified by the associate director of natural resources as a potential threat in the near future. Constant vigilance is required to identify potential pests and enact management efforts.

Key reasons for monitoring pests at NCRN are

- Exotic insect, fungal and bacterial species pose significant individual and collective threats to park forest tree species across the region;
- Both specific forest tree species and communities are major focal resources for park management;
- Yearly detection of invasive forest pests offers park managers their best opportunity to develop appropriate responses to these threats, and;
- Park and network-wide forest pest monitoring can contribute to wide-scale and multi-agency efforts at understanding and combating these important threats to our native resources.

Specific Monitoring Objectives to be Addressed by the Protocol

1. To determine if select insect pests are present in the forest habitats in NCRN parks.
2. To determine changes in the extent of select pest species in forest habitats in NCRN parks over a four year time period.

Basic Approach

The focus of this protocol is to educate field crews to enable them to detect presence of target pest species in NCRN parks while implementing monitoring protocols such as vegetation and rare, threatened, and endangered species. The NCRN IM staff and cooperators will be spending a considerable amount of time in the field in order to monitor various vital signs including population status of various wildlife species, vegetation and water quality. The new eyes in the field will be able to detect signs of pest species if they know what to look for. A more detailed search will be made in the plots monitored as part of the forest vegetation monitoring protocol. The National Capital Region and each of the parks already have active Integrated Pest Management (IPM) programs. The IM program will coordinate with the regional and park based IPM officials in order to educate field personnel about potential pests and appropriate detection methods. Once new populations or new species occurrences are detected, field staff will identify species and their locations on datasheets. The datasheets will be used to alert appropriate resource managers and the IPM staff for further management evaluation. Protocols will help determine if additional searches or mapping and management is warranted. IPM staff already coordinate much of their work with other agencies including USDA Forest Service in order to monitor pests such as the gypsy moth (USDA 2004a, 2004b, and 1995). Additional coordination may be needed if new pests are detected.

Principal Investigators and NPS Lead

The NPS I&M Lead is John Paul Schmit, Quantitative Ecologist,, National Capital Region Network. Regional Integrated Pest Management Coordinator is Jil Swearingen.

Development Schedule, Budget, and Expected Interim Products

The protocol will consist of training material for the identification of potential pest species, field data-sheets, and a tracking database. The training material will be updated annually as the list of expected pest species grows. Field sheets will be also developed in order to ensure the communication of pertinent notes and/or photographs to the IPM officials. The complete protocol will be developed in-house in summer and fall of 2006 in order to be prepared for implementation by spring 2007

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PROTOCOL DEVELOPMENT SUMMARY (LAST UPDATE: 5/9/05)

Protocol—Landscape Dynamics and Land Cover Change

Parks Where Protocol will be Implemented

Antietam National Battlefield(ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield (MANA), Monocacy National Battlefield (MONO), National Capital Parks – East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap Park for the Performing Arts (WOTR).

Justification/Issues Being Addressed

Changes in spatial patterns of land cover both within and adjacent to National Parks can greatly affect biological and physical processes within those parks. Specifically, landscape patterns related to disturbance, fragmentation, buffers, and land cover change have been shown to affect the abundance of rare and endangered species, levels of biodiversity, potential for invasion by exotic plants, habitat for birds, amphibians and other animals, water quality, and in-stream habitat for fish and other aquatic organisms. To address such concerns, aerial photography and satellite imagery (collectively, remote sensing) can be used to monitor the spatial extent of changes in land cover (i.e., conversion) or land condition. The benefit of remote sensing for monitoring is that it provides complete spatial coverage compared to point or plot samples. Remote sensing therefore complements survey data by providing information on the context of data sampled at points while also facilitating extrapolation of point measurements across landscapes. The results from remote sensing change detection analyses can also be used to identify areas of rapid change to target management efforts. Because remote sensing data and analysis methods are changing rapidly with evolving technologies, protocols are essential to ensure consistent data sources and analytical practices.

Specific Monitoring Questions and Objectives to be Addressed in the Protocol

- What are the annual changes in land cover (areal extent of Anderson Level II) within and adjacent to park lands (i.e. how much land of major cover type changed)?
- In what way did land cover change (contextual change) within and adjacent to park lands (i.e. what are average patch sizes, densities, edge/core areas, inter-patch distances, etc.)?
- Does the areal extent of riparian buffer habitats along second- to fourth-order freshwater streams change annually?
- Does the areal extent of land along the tidal portions of the Potomac and Anacostia Rivers change annually?
- Does the areal extent of forest canopy cover damaged by gypsy moth outbreaks change annually in the parks (e.g., have the forests been disturbed by gypsy moths)?

The measurable objectives of the protocols are to:

1. Determine status and trends in the areal extent and configuration of land-cover types (Anderson Level II) on park lands (Anderson et al. 1976). This will be pilot tested at ANTI, ROCR, and PRWI and possibly HAFE, CATO and the lower portion of CHOH. Land cover will be mapped at 4 pixel resolution sizes (~1m, 4m, 10m and 30m) to determine the extent to which grain size influences the ability to map important land cover classes. The parks selected for pilot study represent a range of park types in the NCR, including urban environments (ROCR), linear parks (lower CHOH), mixed land use (ANTI, HAFE) and forests (PRWI, CATO). Accuracy assessments will be performed.

2. Determine status and trends of key landscape metrics to determine land use patterns within each park and including a buffer outside of the park. Critical categories of metrics include p (proportion of area in different cover types), patch metrics (number and density of patches, mean patch size), perimeter and core area metrics, and measures of landscape connectivity including nearest neighbor metrics. Metrics will be computed at 4 levels of resolution to determine the influence of grain size on these measurements.

   Justification. These metrics provide measures of the distribution and fragmentation of patches and land cover on the landscape. The quantitative representation of fragmentation through time facilitates the assessment of the park as habitat for different species, and permits the tracking of trends in improving or declining habitat suitability.

   Biota rarely respect park boundaries; therefore areas adjacent to parks may represent critical source habitats or resource use patches. In addition, water quality and quantity within the park is clearly impacted by land use in watershed areas above the park boundaries. As such, this analysis will provide information on patterns within the park in the context of their regional setting. The results will inform management concerns outside the park boundary that influence resources within the park.

3. Determine status and trends of land-use and width of riparian buffers along streams in NCRN parks. Riparian buffers will be mapped at 4 levels of resolution to determine the grain size at which these important features can be mapped.

   Justification. Riparian buffers have been hypothesized to be critical to the maintenance of water quality, reduction of runoff and erosion, and for providing habitat for aquatic species. This task will demonstrate the extent and relative size of riparian buffers within the parks, thus allowing the determination of areas requiring management activities to improve buffer quality.

4. Determine status and trend of shoreline changes in parks along tidal portions of the Potomac and Anacostia Rivers.

   Justification. Seal level change combined with erosive factors contribute to significantly to local shoreline changes. Wetlands such as those found at Dyke Marsh have been eroding over many years but the extent has not been quantified. This task will demonstrate the extent of lands lost and help identify and/or evaluate restored areas.

5. Determine long-term changes in frequency and extent of insect and disease outbreaks (e.g., gypsy moth defoliation).

   Justification. Defoliation by the gypsy moth caterpillar is a major disturbance to oak forests of the mid-Atlantic, with consequent impacts on forest health and beauty, as well as water quality and habitat. Although similar in theory to 5 above, this analysis addresses change in condition rather than conversion of land cover type, and therefore requires differing protocols for application/implementation

Basic Approach

We are developing specific protocols to:

1. Map land cover to Anderson Level II classes. This protocol includes methods on selecting appropriate imagery for mapping, image processing, mapping procedures, and map error assessment. Mapping of riparian buffers is a subset of this protocol.

2. Map land cover change (remote sensing change detection). This protocol includes methods for comparing thematic maps (land cover conversion) and methods for identifying changes in land condition (specifically, gypsy moth defoliation).

3. Assess landscape pattern. This protocol includes methods on implementing FRAGSTATS (McGarigal and Marks 1995) and RULE (Gardner 1999) to calculate key landscape metrics, including:

   a. proportion of area per land cover class
   b. number of patches and patch density (number of patches normalized by area)

c. amount of edge (perimeter) and edge density
d. amount of core area and core area density
e. mean nearest neighbor distance

In the process of pilot testing these protocols, we will assess the importance of grain size (i.e., spatial resolution of the pixel size) to these three protocols and the importance of buffer delineation around the park (i.e., mapping extent) to change detection and computation of landscape metrics.

We will pre-process imagery from IKONOS, SPOT and Landsat for ANTI, PRWI and ROCR to map Anderson Level II land cover for all three parks and a predefined buffer around each park. If aerial imagery for CHOH becomes available to NPS, we will also map the lower portion of CHOH. These efforts will include acquisition and importation of recent imagery and image preprocessing (geocorrection, orthorectification). Land cover maps will be generated through spectral classification (e.g. ISODATA or maximum likelihood classification using IMAGINE) or contextual delineation (using eCOGNITION). Land cover maps will be evaluated for accuracy and compared to determine the relative trade-offs of grain size and mapping methodology. For ANTI, we will focus specifically on mapping riparian corridors, paying attention to the importance of grain size to delineating these features.

We will compute landscape metrics for these parks using FRAGSTATS and RULE to assess landscape pattern and fragmentation. We will compare results at different grain sizes and identify the appropriate spatial scales for computing landscape metrics using different assumptions about the landscape (e.g., the scale of organism response to the landscape, the number of relevant classes in the analysis, etc.). We will also test the importance of different buffering schemes to the analysis: (a) no buffer, (b) 1 km fixed buffer, (c) a patch-based buffer (i.e., buffer by intersecting patches, regardless of distance from the park), and (d) a watershed (upslope contributing area) buffer.

We will conduct a retrospective land cover conversion analysis for one park and its adjacent buffer (likely HAFE or ANTI) using one resolution of imagery (at present expected to be 10m). We will also conduct a remote sensing change detection analysis of forest condition for either PRWI or CATO to map gypsy moth defoliation for a year of known defoliation. For the retrospective analysis, we will assess changes in p and other landscape metrics through time using simple map overlays. We will use image algebra or change vector analysis to identify areas of forest disturbance (Townsend et al. 2004).

Standard operating procedures for protocol implementation will be based on these pilot studies. The resulting protocol will include a cost-benefit analysis to assess the relative trade-offs in monetary costs, analysis time and map/metric accuracy based on differing assumptions of NPS needs (e.g., the spatial scale of response relevant biological resources).

Principal Investigators and NPS Lead

Protocol development will be done through a cooperative agreement with the UMCES Appalachian Laboratory (301 Braddock Road, Frostburg, MD, 21532, 301-689-7100). Principal Investigators are Philip Townsend and Robert Gardner. NPS contact is Shawn Carter, Regional Inventory and Monitoring Coordinator, National Capital Region.

Development Schedule, Budget, and Expected Interim Products

The PIs will acquire remote imagery and develop processing protocols during 2004, implement and evaluate all pilot studies by June 1, 2005. A draft remote sensing protocol will be prepared for review by July 1, 2005, with follow-up studies, revisions, formal documentation and a workshop completed during the second half of 2005. After peer review, revision and approval, the protocol should be available for implementation by January 1, 2006. In addition, we will acquire multiple resolution imagery suitable for implementation of the land cover mapping protocol for all NCR parks except CHOH following completion of the pilot studies. We have budgeted approximately $128,000 for protocol development and $80,000 for image acquisition.

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Appendix O

CATO – Park Status Report

(LAST UPDATE: 7/5/04)

I. Biological Inventories

1. Completed Inventories funded by NCRN I&M Program

   - *Bird Inventory* – PI John Sinclair and volunteer effort. Completed Fall 03. Total Project Budget: None.
   - *Small/Medium Sized Mammals* – PI Bill McShea (Smithsonian Inst.). Completed Fall 03. Total Project Budget: $53,500.

2. Ongoing Inventories funded by NCRN I&M Program

   - *Bats* – PI Ed Gates (UMCES). Expected Completion Fall '04. Total Project Budget: $110,994.
   - *Fish* – PI Rich Raesley (Frostburg State University). Expected Completion Fall '04. Total Project Budget: $70,457.
   - *Macro-Fungi Inventory* – PI Lauraine Hawkins (Pennsylvania State University. Expected Completion Spring '07. Total Project Budget: 130,000.00
   - *Paleo. Resources* – PI Vincent Santucci (GWMP). Expected Completion Fall '04. Total Project Budget: $7,000
   - *Sedges and Rushes Inventory* – PI Katia Englehard (UMCES). Expected Completion Spring '07. Total Project Budget: $60,872.77.
   - *Herps* – PI Tom Pauley (UMCES). Expected Completion Fall '04. Total Project Budget: $114,000.
   - *Vegetation Mapping* – NPS Lead: Diane Pavek. Partial funding received from I&M. Total Project Budget from IM Program (FY01-FY03 only): $210,854 (more may be added FY04).

3. Inventory Projects Planned

   - Complete QA/QC and data certification for all completed inventories in FY04 and FY05.

II. Monitoring

1. Ongoing Monitoring Projects

   i. Vital Sign Selection

The I&M planning process has identified a variety of potential vital signs based on input from park managers and subject matter experts. Final selection of vital signs will be based on prioritization once monitoring protocols and costs are known. The Science Advisory Committee and Board of Directors must also approve the final selection of vital signs. See appendix L for list of draft vital signs.

ii. Protocol Development

Current monitoring project focus on the development of monitoring protocols. The I&M staff is working with a variety of principal investigators to identify sampling methods, sampling sites, reporting and analyses mechanisms. Note that sample sites have not yet been selected and they may or may not occur in CATO.

- *Amphibians* – IAA with Patuxent Wildlife Research Center. PI is Dr. Robin Jung. Focus will be on species diversity and distribution. Expected Completion Fall '05. Total Project Budget: $51,842.
- *Forest Bird Species* – IAA in development with Patuxent Wildlife Research Center. PI is Deanna Dawson. Focus will be on species diversity and abundance. Expected Completion Spring '06. Total Estimated Budget: $25,000.
- *RTE Species* – CA with Virginia Polytechnical Institute. PI is Jeff Waldon/Allison Wells. Focus will be on species meeting I & M RTE criteria. Expected Completion Fall '06. Total Project Budget: $77,146.
- *Remote Sensing* – CA with Frostburg. PI is Phil Townsend and Bob Gardner. Focus is on monitoring change of major landcover types in park and region. There will also be a classification of land use intensity. Expected Completion Spring '06. Total Project Budget: $150,000.
- *Vegetation Monitoring* – IAA with USDA Enterprise Unit. PI is David Chojnacky. Focus will be on forest health indicators including deer browse and cover of invasive and exotic species. Expected Completion Spring '06. Total Project Budget: $130.000.
- *Vital Sign Conceptual Model* – CA with Frostburg. PI is Phil Townsend and Bob Gardner. Focus is on developing scientific basis for conceptual models that describe ecosystems in NCRN parks. Expected Completion Spring '06. Total Project Budget: $71,792.
- *Water Quality* – CA with Bob Hildebrand (UMCES). Focus is on core water quality parameters required by WRD. Monitoring will also include macroinvertebrate and nutrient monitoring, fish index of biological integrity. Expected Completion Fall '04. Total Project Budget: $61,207.
- *White-tailed Deer* – Distance Sampling. PI is Scott Bates (CUE). Expected Completion Fall '04.

III. Data Management

I&M Inventory database (NPSpecies) contains 1,121 records (table 1). The bird data has been certified and QA/QC will continue during FY04 and FY05.

IV. GPRA Goals Summary

The I&M program generates data that can be used in part to report GPRA goals. Only two GPRA goals relate specifically to I&M and are reported by the Washington Support Office (Ib1 and Ib3). Table 2 summarizes natural resource related GPRA goals.

V. Research Questions

Every year, the I&M Program identifies research questions as they come up through ongoing inventory and monitoring efforts. The questions below have come up during previous meetings with CATO resource management staff.

1. What is the long-term impact of deer browse on forest regeneration?
2. What is the significance of the Table Mountain Pine and the role of fire ecology for sustaining it?
3. What is the fire history in the park and surrounding region?

TABLE 1: SUMMARY STATISTICS OF DATA MANAGED BY I&M IN NPSPECIES (UPDATED 7/5/04)

Taxonomic Group	Number of Species Entered
– Amphibians	33
– Birds*	173*
– Fish	17
– Mammals	59
– Reptiles	29
– Plants	818
– Non-Vertebrates	171
– Fungi	101
–Monera	0
– Protista	0
References (also in NatureBib)	32
Observations	2,120
Vouchers	258

*Data met QA/QC requirements and has been certified by CATO.

TABLE 2: GPRA GOALS (FY03) THAT PERTAIN TO INFORMATION GENERATED BY THE INVENTORY AND MONITORING PROGRAM OF THE NATIONAL CAPITAL REGION NETWORK

GPRA GOAL	Goal #	Parks with this goal										
		ANTI	CATO	CHOH	GWMP	HAFE	MANA	MONO	NACE	PRWI	ROCR	WOTR
Disturbed lands restored	Ia1A	X	X	X	X		X		X			
Disturbed lands (other)	Ia01A										X	
Exotic vegetation contained	Ia1B	X	X		X	X	X	X	X	X	X	X
Species of concern populations have improved status	Ia2X								X			
Natural resource inventories*	Ib1											
Natural Resource Inventories (park based)	Ib01	X		X	X			X	X			X
Vital signs for natural resource monitoring identified*	Ib3	X	X	X	X	X	X	X	X	X	X	
Water quality improvement	Ia04		X							X		

*Indicate GPRA goals tracked by the Washington Support Office I&M Program. Source: Table 1.2 from the Draft Monitoring Plan

ANTI = Antietam National Battlefield
CATO = Catoctin Mountain Park
CHOH = Chesapeake and Ohio Canal National Historic Park
GWMP = George Washington Memorial Parkway
HAFE = Harpers Ferry National Historical Park
MONO = Monocacy National Battlefield
NACE = National Capital Parks – East
PRWI = Prince William Forest Park
ROCR = Rock Creek Park
WOTR = Wolf Trap Farm Park

VI. Summary Highlights (FY04)

- Bird inventory is complete and data is has been certified in NPSpecies.

- I&M Program has summarized vital signs for CATO (table 3). Next steps include approval from SAC and BOD. Protocol development is already underway.

- Total budget for I & M projects involving CATO: $1,022,798.00 (FY01-FY04)

TABLE 3: VITAL SIGNS FOR CATO
(SHOWN IN HIGHLIGHTED ROW)

Level 1 Name	Level 2 Name	Level 3 Name	Network Vital Sign Name	Vital Sign Measures	ANTI	CATO	CHOH	GWMP	HAFE	MANA	MONO	NACE	PRWI	ROCR	WOTR
Air and Climate	Air Quality	Ozone	Ozone*	Atmospheric ozone concentration	X	X	X	X	X	X	X	X	X	X	X
		Wet and dry deposition	Wet and dry deposition*	Wet deposition chemistry (pH, NO3-, SO4=), NADP	X	X	X	X	X	X	X	X	X	X	X
		Visibility and particulate matter	Visibility and particulate matter*	Visibility (PM 2.5 mass fraction)	X	X	X	X	X	X	X	X	X	X	X
		Air contaminants	Mercury deposition*	Mercury Deposition Network	X	X	X	X	X	X	X	X	X	X	X
	Weather and Climate	Weather and Climate	Weather*	Ambient temperature, precipitation, wind speed, wind direction	X	X	X	X	X	X	X	X	X	X	X
Geology and Soils	Geomorphology	Coastal / oceanographic features and processes	Shoreline features	Rate of shoreline change			X	X				X			
		Stream / river channel characteristics	Physical Habitat Index (PHI)	Stream habitat structure, river depth, vegetation composition on adjacent lands	X	X	X	X	X	X	X	X	X	X	X
Water	Hydrology	Surface water dynamics	Surface water dynamics	Discharge (CFS), gauge/stage height, lake elevation	X	X	X	X	X	X	X	X	X	X	X
	Water Quality	Water chemistry	Water chemistry	core parameters (pH, DO, conductance, temp), cations (Ca, Mg, Na, K), anions (PO4, NO2, Br, SO4, Cl, acid neutralizing capacity), turbidity, suspended sediments, BOD, COD, alkalinity, Secchi disc	X	X	X	X	X	X	X	X	X	X	X
		Nutrient dynamics	Nutrient dynamics	Nitrate, Ammonia, DON, Nitrite, Orthophosphate, Total K	X	X	X	X	X	X	X	X	X	X	X

TABLE 3: VITAL SIGNS FOR CATO (CONTINUED)
(shown in highlighted row)

Level 1 Name	Level 2 Name	Level 3 Name	Network Vital Sign Name	Vital Sign Measures	ANTI	CATO	CHOH	GWMP	HAFE	MANA	MONO	NACE	PRWI	ROCR	WOTR
		Aquatic macroinvertebrates and algae	Aquatic macroinvertebrates	Species composition and abundance	X	X	X	X	X	X	X	X	X	X	X
	Invasive Species	Invasive/Exotic plants	Invasive/exotic Plants	Early warning predictive models of incipient invasions	X	X	X	X	X	X	X	X	X	X	X
	Infestations and Disease	Insect pests	Gypsy Moths*	Gypsy moth egg mass counts	X	X	X	X	X	X	X	X	X	X	X
		Forest vegetation	Forest and grassland vegetation	Species diversity, age and size classes, woody debris	X	X	X	X	X	X	X	X	X	X	X
		Fishes	Fish Index of Biological Integrity (FIBI)	Spp. Composition and abundance	X	X	X	X	X	X	X	X	X	X	X
		Amphibians and Reptiles	Amphibians	Spp. Composition and abundance, malformations	X	X	X	X	X	X	X	X	X	X	X
		Birds	Landbirds	Spp. Composition and abundance	X	X	X	X	X	X	X	X	X	X	X
	Focal Species or Communities	Mammals	White-tailed Deer	Deer density	X	X	X	X	X	X	X	X	X	X	X
Biological Integrity	At-risk Biota	T&E species and communities	T&E species and communities	Spp. Abundance, presence and absence, status, threats	X	X	X	X	X	X	X	X	X	X	X
	Land Cover / Land Use	Land cover / Land use	Land cover/Land use	Area of dominant land cover types, connectivity, core/edge ratio of dominant forest communities, are weighted average patch size, adjacency matrix	X	X	X	X	X	X	X	X	X	X	X
Ecosystem Pattern and Processes	Productivity	Productivity	Landscape condition	Land use intensity, disturbance status	X	X	X	X	X	X	X	X	X	X	X

* Already being monitored.

Source: Table 1 in Draft Monitoring Plan - Summary of Priority Vital Signs for the NCRN

Park News

National Park Service
U.S. Department of the Interior

The Monitor

A Quarterly Newsletter of the National Capital Region's Inventory and Monitoring Program

Meeting of the Networks
3rd Annual I&M Meeting was a Success

The National Capital Region Network (NCRN) was selected earlier this year to host the Third Annual "Meeting of the Inventory and Monitoring Networks". The meeting was held August 18-22 at the National Conference Center in Lansdowne, Virginia. More than 100 people from the National Park Service, US Geological Survey and research institutions attended to learn more about the current status of the program and to provide input for the program's future direction.

The main focus of the annual meeting was to provide a general overview of the history and current status of the program for new staff and to provide a forum for information exchange between the networks. The NCRN is just one of 32 networks nationwide tasked with developing a long-term ecosystem monitoring program. The annual meeting brought the networks together so that they could discuss their different approaches to developing a monitoring program and could then share and learn from each other's successes and failures. Several panel discussions and an evening poster session were scheduled into the meeting to achieve this goal.

The annual meeting also provided national-level Inventory and Monitoring (I&M) staff the opportunity to update networks as to the latest status of the nationwide inventory initiatives, such as soils and vegetation mapping, and to make them aware of new products coming out of the I&M Program. The networks were also given the opportunity to provide suggestions for other products they'd like to see developed and for the direction they would like to see the I&M Program take.

Dr. Michael Soukup, Associate Director, Natural Resource Stewardship and Science, addresses participants during a session of the 2003 Annual Inventory and Monitoring Meeting

On a special note, Marcus Koenen, the NCRN Network Coordinator, was presented with an award for Outstanding Achievement by a Network Coordinator from Associate Director Mike Soukup. We're all very proud to congratulate Marcus on his achievement.

For those who would like to read more about the "Meeting of the Networks" or the I&M Program, information can be found at the national Inventory and Monitoring web site:

http://science.nature.nps.gov/im/index.htm

Coordinator's Corner

By Dr. Jim Sherald
Chief, Natural Resources and Science

Natural Resource Year in Review

As I am sure you are aware, the National Park Service has just published the "Natural Resource Year in Review – 2002." This publication highlights items of significant interest concerning natural resource stewardship and science in the National Park System. Although many people view the National Capital Region's (NCR) parks as more cultural than natural resource oriented, our parks do have significant natural resources that face many pressures associated with urbanization. With that said, it is a strong testament to the quality of our regional and park staff that five articles in this year's publication highlight our region's natural resources and stewardship.

Of the five articles in this year's publication, two were submitted by the regional Inventory and Monitoring (I&M) Program, and the other three were submitted by park staff. The I&M Program's articles were titled "National Capital Region Network: A milestone in the making" and "Volunteers vital in completing National Capital Region bird inventories." The first highlights the continued progress of the monitoring program, and the second discusses the benefits of utilizing citizen scientists. In addition, National Capital Parks - East biologist, Brent Steury, had an article published, "Small parks, big biodiversity," that again confirmed the value of small natural areas to a region's overall biodiversity. Catoctin Mountain Park resource manager, Jim Voigt, published an article, "Restoring our native dogwood," that discusses the planting of "Appalachian Spring," a flowering dogwood cultivar that originated in Catoctin and has been found to be resistant to dogwood anthracnose. The fifth article was submitted by Gopaul Noojibail, of National Capital Parks – Central, and was titled "Creating pollinator-

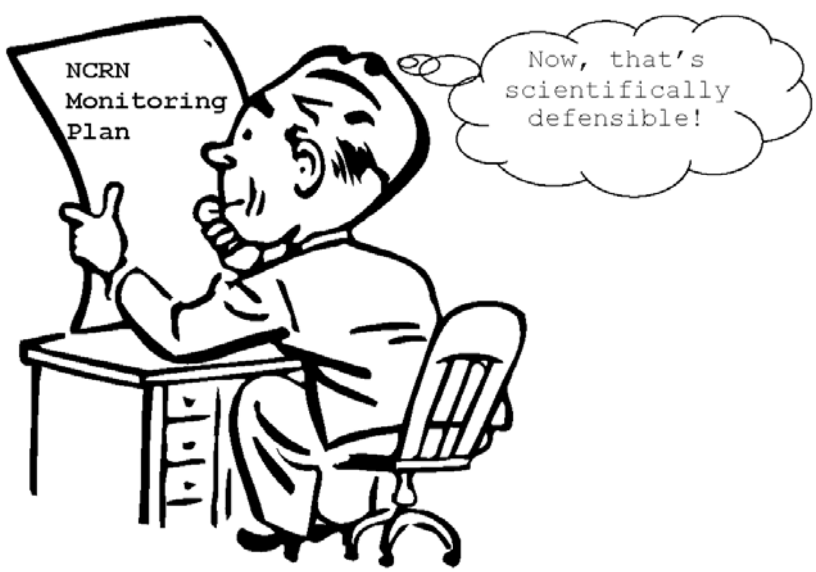
(continued page 4)

Baby Steps to a Full Strut: I&M Takes on Protocol Development

"51 vital signs down to seven…" was where we left our readers concerning the status and direction of the National Capital Region Network Inventory and Monitoring (I&M) Program in the last issue of "The Monitor." But, to refresh your memory, the I&M Program was faced with 51 priority vital signs that, when monitored, could provide an early warning of environmental change within the parks' natural resources. Upon further review of those 51 vital signs, the I&M Program staff determined that many of the vital signs could be grouped together by monitoring method. Therefore, developing several general monitoring protocols could address numerous vital signs. In fact, the I&M Program has taken initial steps to begin or contract out protocol development for: remote sensing, RT&E, vegetation, water, and wildlife.

You may be asking yourself, what is in a protocol, and why is so much time being devoted to the development of these documents. Simply put, a protocol provides the roadmap of how to conduct the monitoring and provides for consistency over time. Even if monitoring personnel changes, a well-written protocol will ensure data is comparable. To help simplify the development of the monitoring protocols, the I&M Program is following a standard set of guidelines. The guidelines provide recommended content for inclusion in the protocol narrative, and include background and objectives, sampling design, field methodology, data handling, analysis and reporting, personnel requirements and training, operational requirements, and a list of references. Using these guidelines will ensure that all protocols discuss the same topics no matter who authors the document. Furthermore, after each protocol has been developed, it will be peer-reviewed to provide a level of scientific credibility to our monitoring program.

Protocol development will be a key to the success of our monitoring program. Although modifications to protocols may occur during the first few years of monitoring implementation, the initial protocol should provide the framework for all future monitoring efforts concerning the subject area.



Aquatic Insects Provide Insight into Water Quality

Some readers of "The Monitor" may be given the impression that the National Park Service (NPS) is not currently conducting any natural resource monitoring because of all the articles concerning the planning of our monitoring program. However, this is not true. Many monitoring programs began prior to the Inventory and Monitoring Program's existence and provide valuable information. The water quality assessment program at Wolf Trap National Park for the Performing Arts (WOTR) is one such program.

Wolf Trap Creek, Vienna, Virginia

NPS staff along with the Audubon Naturalist Society began a project in the fall of 1998 to begin developing an effective water quality sampling program for the National Capital Region. The project was designed to compare the insect populations of WOTR streams with Quantico Creek, a healthy stream that shares similar geographic properties and should have similar insect populations. Quantico Creek lies within the boundaries of Prince William Forest Park and is minimally affected by urban land use. Comparing the insect populations of these two streams can allow for an interpretation of how WOTR streams are affected by urban land use.

Four years of survey data shows that WOTR streams exhibit some degree of degradation when compared to Quantico Creek. To determine specific causes of the degradation would require a more extensive study, but preliminary results suggest that organic pollution combined with heavy frequent run-off from urban areas are significant contributors to the conditions of the streams and the differences in the insect populations. The findings support the general observations that widespread urban development seriously degrades macroinvertebrate populations in both quantity and quality. The monitoring results indicate that although WOTR streams are in fair health for urban streams, they are degraded compared to a stream like Quantico Creek.

If you would like more information concerning the ongoing water quality monitoring program at WOTR, please contact the Regional Hydrologist at National Park Service, 4598 MacArthur Blvd, NW, Washington, DC 20007.

NPSpecies Becomes More than a Species List

Are you tired of looking in NPSpecies (the National Park Service's (NPS) species database) and being unsure about some of the data? Have you wondered if anyone has been updating the information, or if anyone has attempted to verify if the information is correct? Well, I have some answers to those questions and others, but let me start at the beginning.

For some time, the Inventory and Monitoring (I&M) Program has been entering species-related information into NPSpecies. The data, concerning a particular species at a particular park, comes from a variety of sources, including published papers, reports, voucher specimens, and observations. With this information, NPS staff could create a list of the species that have been documented to occur in their park, but little else.

A goal of the I&M Program is to conduct quality control and assurance procedures on the information within NPSpecies to verify the data's credibility. The I&M Program refers to this procedure as "data certification," and it simply means that an individual with knowledge of a particular taxonomic group and park has reviewed the data and confirmed the information is correct to the best of their knowledge. This process will be repeated over time to keep the information relevant. However, individuals using the database will also be able to view the last date the data was "certified" and make their own assumptions as to the current relevancy.

So, that is the background, but I am sure you would like me to answer your questions. The National Capital Region parks have just completed the "data certification" for birds. Park representatives, along with Regional and National I&M staff, conducted a three-day workshop and reviewed each park's bird related information. Therefore, when you look at the bird-related data in NPSpecies, you can get more specific information, including the species status (present, probably present, unconfirmed, historic, etc.), abundance (abundant, common, rare, etc.), residency (park breeder, migrant, etc.), and nativity (native, non-native, etc.). NPSpecies also links synonym names within the database so that each species shows up under one scientific name.

The "certified" bird data will soon become available on-line for your

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National Park Service
U.S. Department of the Interior

Center for Urban Ecology
Inventory and Monitoring Program
4598 MacArthur Blvd., NW
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"The Monitor" is a quarterly newsletter of the National Capital Region's Inventory and Monitoring Program.

To Subscribe send your name and mailing address to the address below.

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Coordinator's Corner

(continued from p.2)

friendly plant communities in an urban park." The article discusses the restoration of native plant communities along the East Potomac Golf Course and the significant natural and interpretive benefits of the project.

All five articles demonstrate the outstanding natural resource stewardship that is ongoing within the NCR. If you have not had a chance to read these articles or any of the "Natural Resource Year in Review," I encourage you to do so.

NPSpecies…

(continued from p.3)

park to use, and we will continue to work towards the "data certification" of other taxonomic groups. The "certification" process took a lot of time and effort, so we hope you will utilize all of NPSpecies' capabilities, and not just use it as a species list source.

The Changing Faces of I&M

The National Capital Region Inventory and Monitoring (NCR I&M) Program is undergoing significant personnel changes. As you recall, Regional Coordinator, Dr. Ellen Gray, left in October of 2002, and recently, Dr. Christina Wright, the Data Manger, departed for a similar position with the Southeast Coast Network in Atlanta. Now we are faced with the imminent departure of John Sinclair, our Inventory Coordinator. John has accepted a position with the Animal Plant and Health Inspection Service and will begin his new position on September 22. As has been frequently mentioned, the NCR I&M Program has set a high standard, and Ellen, Christina and John, along with the rest of the team, should be very proud of their contribution. Hopefully, we will be able to fill all of these vacancies soon and maintain our pace and progress.

Appendix Q

Online Newsletter December 2003 Final

NCRN INVENTORY AND MONITORING PROGRAM ONLINE NEWSLETTER
Number 006
December 2003

(1) NEW STAFF
(2) NEW WEB ADDRESS
(3) MONITORING PLANNING CONTINUES
(4) WHAT HAVE WE DONE LATELY?

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1. I & M Team Welcomes New Staff

Filling the Regional I & M Coordinator position has been a long time in the making. Please join us in welcoming Dr. Shawn Carter to the helm as the Regional Coordinator. Dr. Carter comes to us from Syracuse NY where he was working on a Post Doctoral position involving ecosystem health monitoring. He has also collaborated with the NE Temperate Network in developing conceptual models.

In addition, we welcome Briana Sanders to the team. Some of you may already be familiar with her through her previous work as a Bio-Technician for the IPM Program. She has already been working extremely hard by adding lots and lots of new data to the inventory database (NPSpecies).

For more information about our new staff contact Shawn Carter (202-342-1443 x227; Shawn_Carter@nps.gov). You may also take a look at our website http://www.nature.nps.gov/im/units/ncrn/index.html).

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2. New Website Address

The NCRN website continues to be updated with Board of Directors meeting minutes, Newsletters, and annual report and workplans. Please note that the web address has changed to: http://www.nature.nps.gov/im/units/ncrn/index.html.

For more information about the website, contact Mikaila Milton (202-342-1443 x225; Mikaila_Milton@nps.gov).

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3. Protocol Development Begins

In order to start the drafting of monitoring protocols, the I & M staff has been coordinating meetings between parks and principal investigators to evaluate existing monitoring programs and discuss the implementation of region-wide monitoring that complements existing park efforts. Most recently, MANA hosted a meeting for parks, CUE staff, and Dr. Dave Chojnacky of the USDA Forest Service who is collaborating with I & M staff to develop vegetation monitoring protocols. In addition, PRWI hosted a meeting to discuss water resources monitoring for the region. Other meetings that have been held include a remote sensing meeting with I & M staff and Drs. Phil Townsend and Bob Gardner and an RTE monitoring meeting with Jeff Waldon of Virginia Tech. More planning sessions will take place throughout the year.

For more information about the progress planning process, contact Shawn Carter, Regional I&M Coordinator (202-342-1443 x227) or Marcus Koenen, Monitoring Coordinator (202-342-1443 x 216; Marcus_Koenen@nps.gov).

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4. Recent Products

The I & M team has been busy this fall. We have just completed our annual report which is posted on our web page. While many annual reports are great cures for insomnia, you'll note that the I&M Annual Report is full of interesting tidbits about the region. In it you'll note that the first year of the bat inventory found the greatest diversity at ROCR despite its urban surroundings. One of our cooperators also found a significant population of the rare Alleghany Woodrat at CHOH. Take a look to see what other interesting facts may be available about your park.

To download a copy of the report go to http://www.nature.nps.gov/im/units/ncrn/index.html and select products. For additional questions contact Marcus Koenen (202-342-1443 x 216; Marcus_Koenen@nps.gov).

This Newsletter is sent quarterly by the National Capital Region Network Inventory and Monitoring Program. The staff is based out of the NPS Center for Urban Ecology, 4598 MacArthur Blvd. NW, Washington DC 20007. Please pass it on to interested individuals. If you would like to be added to or deleted from the mailing list, please contact Marcus Koenen (Marcus_Koenen; 202-342-1443 x 216).

Appendix R

Peer Review Form Provided to Reviewers for the Phase I Review

NPS VITAL SIGNS MONITORING PROGRAM
PHASE I REPORT

INSTRUCTIONS FOR REVIEWERS

The Vital Signs Monitoring Program of the National Park Service is intended to provide scientifically sound information on the status and trends of significant natural resources in national parks over the long term. Parks have been organized into networks of parks to work collaboratively to develop programs according to guidance provided by the Servicewide Inventory and Monitoring Program. Networks are to design integrated programs that monitor a suite of important physical and biological resources. Funding will be limited, so it is recognized that these programs will only monitor a core of important variables ("vital signs") and opportunities to leverage other programs and funding sources will be sought. Additionally, a major emphasis of the effort is to make the information readily available and useful to decision makers, scientists, and the public.

Networks are to develop Vital Signs Monitoring Plans that describe the purpose of the monitoring program and the rationale for the final selection of vital signs to be monitored. The plans will ultimately also describe the sampling design, protocols, plans for data management and reporting, and general administration of the program.

The National Park Service recognizes that the development of monitoring programs is a complex process that requires significant planning and design effort in the early stages prior to implementation. Accordingly, networks are required to follow a 3-phase approach to the planning and design effort that includes peer review and approval of each phase, as described in the May 2, 2002 guidance. This approach allows for peer review of early development of the monitoring plan to ensure that the plan addresses relevant and significant questions, has clear and measurable objectives, and will generate the kind of data appropriate for addressing the objectives. Phases 1 and 2 serve as progress reports or early drafts of the monitoring plan. The 3-phase design process is an iterative process, and the final monitoring plan will "cut and paste" much of the material from the Phase 1 report, but will include additional detail that is developed during Phase 2 and 3 of the design process.

You have been asked to review Phase 1 of this process and these review questions are specific to that phase. The Phase 1 Report includes background and introductory material and describes the conceptual framework for the monitoring program (chapters 2 and 3 of the Monitoring Plan Outline). The report should describe the results of the work involved in summarizing the existing data and understanding of park ecosystems, defining goals and objectives for the monitoring, developing draft conceptual models, and other background work that should be done before the selection of vital signs. The review should focus on the scientific basis for the planning and design of the program. Some of the details that will be included in the final monitoring plan, such as identification of specific measurable objectives, will be developed later in the process.

Please respond to the questions on the following pages with your evaluation on a scale of 1-5 of how well each point is addressed, and provide additional comment for each point as you wish. Additional space is provided for your overall evaluation of the strong and weak points of the proposed approach.

Please return your completed review form and any comments you may have made on the Phase 1 Report itself to Marcus Koenen by email or in hard copy by November 15, 2002. Your comments will be taken into consideration both in revising this report and as the network progresses into subsequent phases of developing their Monitoring Plan.

On behalf of the National Park Service staff involved in the Inventory and Monitoring Program in the National Capital Network, I personally thank you for your time and consideration of this document and our proposed approach to the monitoring program described therein.

Sincerely,

Marcus Koenen
Monitoring Coordinator, National Capital Network

PHASE I PEER REVIEW FORM

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
Introduction and Background		
• Is the purpose of the monitoring program explained? • Is a summary of legislation, NPS policy and guidance, servicewide and network-specific goals for monitoring, servicewide and park-specific strategic goals for performance management that are relevant to monitoring, and any statements from park enabling legislation that establish the need to monitor natural resources presented? • Does this report answer the question, "who is interested in the information provided by monitoring, and why?		
• Are the objectives of the monitoring introduced? (Note that specific, measurable objectives will be defined at later stages of program development.)		
• Is an overview of the important resources in each park in the network presented and is their importance in a regional or national context described?		
• Is water quality monitoring included? If applicable, lists of waters having protective designation for water quality standards, such as Clean Water Act 303d waters or Outstanding National Resource Waters, should be presented. If this information is not presented, does the report explain why not?		
• Are the most important management and scientific issues summarized for each park, and are the most important agents of change presented in a meaningful way?		
• Is an overview of other monitoring efforts, within and outside NPS, presented so as to demonstrate how the program will learn from and build upon these efforts?		
Does the report describe the overall process used, or to be used, to determine the goals and objectives for the monitoring program and for selecting vital signs to monitor?		
II. Conceptual Models		
• Does the report present an overview of the current understanding of the region's ecosystem, focusing on aspects of the ecosystem that are relevant to the monitoring program? • Do the conceptual models that are presented appear to be useful and relevant to the development of the monitoring program?		

General Comments:

Does this Phase I Report provide a sound foundation for a scientifically credible monitoring program that will ultimately meet the most important information needs of the parks in the network?

Which areas of the report require additional work, in your view, before the network moves into the next phase of program development?

Additional Comments:

1. Comments from Dr. Phyllis Adams, Monitoring Coordinator, Midwest Region, NPS.

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
Introduction and Background		
• Is the purpose of the monitoring program explained? • Is a summary of legislation, NPS policy and guidance, servicewide and network-specific goals for monitoring, servicewide and park-specific strategic goals for performance management that are relevant to monitoring, and any statements from park enabling legislation that establish the need to monitor natural resources presented? • Does this report answer the question, "who is interested in the information provided by monitoring, and why?	3	The servicewide goals are not those reviewed and presented in 3-Phase document (NPS 2002). These goals are less specific and more policy oriented. There is no mention of park GPRA goals and whether they were reviewed. Also, park enabling legislation is not outlined. This report includes a well-written summary of relevant legislation. The report failed to specifically address the question of who is interested in the information and why.
• Are the objectives of the monitoring introduced? (Note that specific, measurable objectives will be defined at later stages of program development.)	2	Specific monitoring needs are not expressed as monitoring objectives or monitoring questions.
• Is an overview of the important resources in each park in the network presented and is their importance in a regional or national context described?	4	This report does an excellent job of describing each park and its important resources. The regional overview is especially well done and provided an outstanding introduction to the area and its resources.
• Is water quality monitoring included? If applicable, lists of waters having protective designation for water quality standards, such as Clean Water Act 303d waters or Outstanding National Resource Waters, should be presented. If this information is not presented, does the report explain why not?	5	The water quality monitoring section thorough and well presented. Good job.
• Are the most important management and scientific issues summarized for each park, and are the most important agents of change presented in a meaningful way?	4	The report provides a good overview of management and scientific issues. The important agents of change are clearly outlined in the models.
• Is an overview of other monitoring efforts, within and outside NPS, presented so as to demonstrate how the program will learn from and build upon these efforts?	5	Good job on this section. The information is thorough and presented in a very readable manner.
• Does the report describe the overall process used, or to be used, to determine the goals and objectives for the monitoring program and for selecting vital signs to monitor?	4	The section on process was clearly described and provided a useful level of detail. I haven't read the workshop report yet, but find no discussion about the development of park specific goals and objectives.
II. Conceptual Models		
• Does the report present an overview of the current understanding of the region's ecosystem, focusing on aspects of the ecosystem that are relevant to the monitoring program? • Do the conceptual models that are presented appear to be useful and relevant to the development of the monitoring program?	4	These models focus on the prioritized resources and stressors. They nicely outline the ecosystem components (resource component, stressor, source, and ecological effects), but don't deal with processes. Also, linkages between the components are described in the text, but are not clearly summarized in the tables. The models should provide a good foundation for guiding the development of the monitoring program.

General Comments:

Does this Phase I Report provide a sound foundation for a scientifically credible monitoring program that will ultimately meet the most important information needs of the parks in the network?

Yes. This report does a good job of providing background information in a well-organized and succinct manner. The focus has been on identifying the information needs of the parks. With this approach I would expect to see this network produce information that would be easily translated to usable management information.

Which areas of the report require additional work, in your view, before the network moves into the next phase of program development?

The network should clearly describe the specific monitoring objectives and questions. For example, it is unclear whether the monitoring program will focus totally on strategic management objectives in developing the monitoring program or whether some questions about general ecosystem health will be important across the network or at some parks.

Additional Comments:

In general, I think this is a good report that provides a sound background for the further development of the monitoring program. It is well organized and concise.

Specific editorial comments:

- Use metrics.

Page Number	Comment
7	• under Monitoring Vital Signs: "environmental and biological resources" would better describe the program goals than "physical and biological".
10	• Groundwater: Two sentences need rearranging—"In bedrock, ground water…………..." and "Discharge from the groundwater flow…………." (Is ground water one or two words?) Be consistent.
11	• end of 2nd paragraph: Sixty nine percent of ground water samples <u>contained radon</u> greater than the ……
11	• Surface water, 2nd sentence has an extra period.
12	• Near bottom of 1st paragraph: Chlorinated organic compounds, mercury, and lead are present in streambed sediment in concentrations that have ~~come~~ potential to ……..
12	• Anacostia River: replace ; with , in two places.
12	• Climate: Annual temperature is approximately 13C
14	• Is it suburban or sub-urban?
21	• 1st paragraph: Workgroups focusing on each important resource met during ~~each~~ subsequent meetings to
24	• Visibility: Add commas in next to last sentence of 1st paragraph.

2. Comments by Dr. Steven Fancy, National Monitoring Coordinator, NPS. Date: Oct. 7, 2002.

Report Section	Rank (1=Inadequate 5=Excellent)	Comments
Introduction and Background		
• Is the purpose of the monitoring program explained? • Is a summary of legislation, NPS policy and guidance, servicewide and network-specific goals for monitoring, servicewide and park-specific strategic goals for performance management that are relevant to monitoring, and any statements from park enabling legislation that establish the need to monitor natural resources presented? • Does this report answer the question, "who is interested in the information provided by monitoring, and why?	2	Additional material should be added to better explain 'who is interested in the information and why'. Monitoring goals should follow the section on Purpose (move to page 8). I recommend deleting the 5 servicewide I&M Program programmatic goals shown on page 15, since they will confuse people (these are program goals of the national I&M program that deal with both inventory and monitoring). All networks are REQUIRED to use the five goals for vital signs monitoring listed in the May 2, 2002 memo. The 4 network goals listed on Page 15 could be presented as subgoals to the 5 monitoring goals (if they really are different from the 5 goals), or as programmatic goals of the National Capital network. What about performance goals (GPRA)? Need to at least include the servicewide GPRA goals for NR, if none of the network parks have any specific NR goals that are applicable. See the Northern Colorado Plateau network's Phase 1 treatment of Performance Goals for a good example.
• Are the objectives of the monitoring introduced? (Note that specific, measurable objectives will be defined at later stages of program development.)	2	A draft set of objectives, or alternatively, a set of monitoring questions, is needed before you can make much progress on focusing in on some indicators. On Page 46 you list a 'monitoring goal' for invertebrates, which is actually an objective. Scattered throughout the report in various tables you've presented monitoring objectives and questions, but they are scattered. The Phase II report will need a much better organization and presentation of monitoring objectives.
• Is an overview of the important resources in each park in the network presented and is their importance in a regional or national context described?	5	Yes – very good job on this.
• Is water quality monitoring included? If applicable, lists of waters having protective designation for water quality standards, such as Clean Water Act 303d waters or Outstanding National Resource Waters, should be presented. If this information is not presented, does the report explain why not?	5	Yes, very good job on this.
• Are the most important management and scientific issues summarized for each park, and are the most important agents of change presented in a meaningful way?	5	Yes, very good job.
• Is an overview of other monitoring efforts, within and outside NPS, presented so as to demonstrate how the program will learn from and build upon these efforts?	5	Yes, very good job.
• Does the report describe the overall process used, or to be used, to determine the goals and objectives for the monitoring program and for selecting vital signs to monitor?	4	Needs additional explanation of how you will take all of the background material you've presented and prioritize monitoring objectives/questions as you work towards selecting specific indicators and methods.

II. Conceptual Models		
• Does the report present an overview of the current understanding of the region's ecosystem, focusing on aspects of the ecosystem that are relevant to the monitoring program? • Do the conceptual models that are presented appear to be useful and relevant to the development of the monitoring program?	3	All of the material has been gathered, but you really need a series of diagrams to more clearly organize and present the conceptual framework. The various components right now appear to be disjunct; a 'big-picture' figure or figures are needed to show how they all tie together, and then a series of more detailed diagrams should be included for the various components (air, water, geology, wildlife, etc.) that summarize the material you present in tables and text. Models from the Greater Yellowstone Network will be available soon and are recommended to give you ideas. Also, rather than referring multiple times to Appendix M to explain how the conceptual models were developed, I recommend cutting and pasting some material from Appendix M (the workshop report) to the beginning of chapter 3 to explain how the models were developed.

General Comments:

Does this Phase I Report provide a sound foundation for a scientifically credible monitoring program that will ultimately meet the most important information needs of the parks in the network?

This is a good start on chapters 2 and 3 of the monitoring plan, but several sections are incomplete and need to be further developed before the network can move to Phase 2 of selecting indicators. In particular, the section on Goals needs considerable work, and a draft set of objectives or monitoring questions should have been included in this report for people to react to. The prioritization of these objectives or questions, which is part of Phase 2, needs to be done as soon as possible to allow further development of conceptual models, identification and evaluation of relevant data sets, initial decisions on which indicators and protocols to use, and identification of potential partnerships. Getting everyone to agree on the goals and objectives is critically important before you get into any of the detailed design work.

What about park GPRA goals. Isn't there any monitoring needed to determine progress towards meeting performance goals?

Which areas of the report require additional work, in your view, before the network moves into the next phase of program development?

Chapter 2 needs additional work to better explain the goals of the monitoring and to better answer the question of who is really interested in the data you are proposing to collect. One of the concerns of Congress is that we'll end up collecting a lot of data that nobody will use. Who will use the data? How will the three parks use the data? The network needs to use the five monitoring goals included in the May 2, 2002 memo.

Chapter 3 needs some figures (box and arrow diagrams) to organize all of the material and show how the various components (e.g., air, water, geology, invertebrates, landscape, etc.) interrelate. I think that all of the material is there, in various tables and paragraphs, but one or two overall figures and then a series of more detailed diagrams that summarize each component will go a long way towards facilitating communication across disciplines and among managers and scientists. I recommend looking at the conceptual models done for the Greater Yellowstone network.

Additional Comments:

I have not yet read the report from the July 2002 Shepherdstown workshop, but I suspect that you'll be able to extract sections from it to include in this Phase 1 report. Also, I recommend that you get a copy of the report from OLYM by Kurt Jenkins et al. (they should be ready to release it in another two weeks or so) that is an excellent conceptual framework and justification for potential vital signs, many of which are pertinent to your ecosystems.

Summary of Response to Phase I Review Comments

- Typos and other corrections were made as suggested.
- National goals and network goals were maintained because the network believed that there was a need to ensure that network needs would be met. The network goals were also important to ensure that parks' input was being seriously considered as driving forces of the I & M planning process. The network goals are not intended to replace the national goals but they are intended to supplement them as indicated in the text.
- Additional information was provided on legislation driving the parks needs. GPRA goals, however, were not discussed because they were extremely broad did not provide additional guidance to the I&M Program. Park GPRA goals relating to I&M adapted the national goals which stated that vital signs would be identified. Interviews with several parks indicated that they were hoping that the I & M planning process would be helpful in developing more refined GPRA goals for the parks rather than the other way around.
- Monitoring goals and objectives were refined to some extent. There were differences, however, among the multiple workgroups about what a goal and objective should be. We adapted the workgroups' interpretation. In addition, it was recognized that goals and objectives would be greatly refined as the planning process continued and additional input was sought from subject matter experts. We expect that they will continue to improve as the Phase II and Phase II plans are developed.
- Conceptual models were maintained in chapter 2 because it was believed to be important to show every issue that was initially considered by the planning process. It was our understanding that the monitoring plan should show what things were considered and what was not. New graphical models were developed and presented in chapter 2 to demonstrate how resources and threats interacted among the priority vital signs. The chapter also presented further information about how vital signs were summarized.

Appendix S

Peer Review Form Provided to Reviewers for the Phase II Review

NPS VITAL SIGNS MONITORING PROGRAM
PHASE II REPORT

INSTRUCTIONS FOR REVIEWERS

The Vital Signs Monitoring Program of the National Park Service is intended to provide scientifically sound information on the status and trends of significant natural resources in national parks over the long term. Parks have been organized into networks, led by a regional inventory and monitoring team, to work collaboratively in the development of a program guided by the Servicewide Inventory and Monitoring Program. Networks are to design integrated programs that will monitor a suite of important physical and biological resources. Funding will be limited, so it is recognized that these programs will only monitor a core of important variables ("vital signs"), and opportunities to leverage other programs and funding sources will be sought. Additionally, a major emphasis of this effort is to make the information gained by the inventory and monitoring program readily available and useful to decision makers, scientists, and the public.

Networks are to develop Vital Signs Monitoring Plans that describe the purpose of the monitoring program and the rationale for the final selection of vital signs to be monitored. The final version of the monitoring plans will also describe the sampling design, protocols, plans for data management and reporting, and general administration of the program.

The National Park Service recognizes that the development of monitoring programs is a complex process that requires significant planning and design effort prior to implementation. Accordingly, networks are required to follow a 3-phase approach to the planning and design of monitoring plans that includes peer review and approval of each phase. This approach allows for peer review of early phases of the monitoring plan to ensure that the plan addresses relevant and significant questions, has clear and measurable objectives, and will generate the kind of data appropriate for addressing those objectives. Phases 1 and 2 serve as progress reports or early drafts of the monitoring plan. Phase 3 will include the final list of indicators and the plan for monitoring them including protocols and possible field testing.

You have been asked to review Phase 2 of this process, and these review questions are specific to that phase. The Phase 2 Report includes background and introductory material, describes the conceptual framework for the monitoring program, and identifies proposed vital signs, including monitoring goals and Objectives (Chapters I - III of the Monitoring Plan). The review should focus on the scientific basis for the planning and design of the program and answer the questions posed below. Some of the details that will be included in the final monitoring plan, such as identification of specific measurable objectives, will be developed later in the process.

Please respond to the questions on the following pages with your evaluation on a scale of 1-5 of how well each point is addressed, and provide additional comment for each point as you wish. Additional space is provided for your overall evaluation of the strong and weak points of the proposed approach.

Please return your completed review form and any comments to me by email or in hard copy by September 22, 2003. Your comments will be taken into consideration both in revising this report and as the network progresses into subsequent phases of developing their Monitoring Plan.

On behalf of the National Park Service staff involved in the Inventory and Monitoring Program in the National Capital Network, I personally thank you for your time and consideration of this document and our proposed approach to the monitoring program described therein.

Sincerely,

Dr. Jim Sherald
Chief of Natural Resources and Science
National Capital Region
4598 MacArthur Blvd. NW
Washington DC 20007
(202) 342-1443
Jim_Sherald@nps.gov

PHASE II PEER REVIEW FORM

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
Chapter 1: Introduction and Background		
• Is the purpose of the monitoring program explained? • Are the following included and adequate: – summary of legislation relating to inventory and monitoring – NPS policy and guidance – servicewide and network-specific goals for monitoring, – servicewide and park-specific strategic goals for performance management that are relevant to monitoring, – statements from park enabling legislation that establish the need to monitor natural resources presented? • Does this report answer the question, “who is interested in the information provided by monitoring, and why?”		
• Are the objectives of the monitoring introduced? (Note that specific, measurable objectives will be defined at later stages of program development.)		
• Is an overview of the important resources in each park in the network presented and is their importance in a regional or national context described?		
• Is water quality monitoring included? If applicable, lists of waters having protective designation for water quality standards, such as Clean Water Act 303d waters or Outstanding National Resource Waters, should be presented. If this information is not presented, does the report explain why not?		
• Are the most important management and scientific issues summarized for each park, and are the most important agents of change presented in a meaningful way?		
• Is an overview of other monitoring efforts, within and outside NPS, presented so as to demonstrate how the program will learn from and build upon these efforts?		
• Does the report describe the overall process used, or to be used, to determine the goals and objectives for the monitoring program and for selecting vital signs to monitor?		

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
Chapter 2: Conceptual Models		
• Does the report present an overview of the current understanding of the region's ecosystem, focusing on aspects of the ecosystem that are relevant to the monitoring program?		
• Do the conceptual models that are presented appear to be useful and relevant to the development of the monitoring program?		
• Was the overall process that was used to develop the models clearly described? • If so, does this process appear to be unbiased and reasonable, and to have resulted in a representative list of important resource components, resource stresses and their sources, and ecological effects?		
• Is enough information provided to clearly describe the models?		
Chapter 3: Vital Signs		
• How well is the need for prioritization of vital signs discussed?		
• Is the prioritization process well explained and does it appear free of bias?		
• Does the report present the vital signs clearly and justify why each one is a priority?		
• Are vital sign monitoring goals and objectives clearly stated?		
• Are the reasons for grouping vital signs monitored with similar protocols clearly explained?		
• Is it clear why protocols are being developed for some vital signs and not for others?		
• Is it clear what questions will be answered by monitoring the priority vital signs?		

General Comments:

Does this Phase II Report provide a sound foundation for a scientifically credible monitoring program that will ultimately meet the most important information needs of the parks in the network?

Which areas of the report require additional work, in your view, before the network moves into the next phase of program development?

Additional Comments:

1. Comments from Dr. John Gross, Ecologist, NPS and Dr. Steve Fancy, National Monitoring Coordinator. Date: 10/17/2003.

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
Chapter 1: Introduction and Background		
• Is the purpose of the monitoring program explained? • Are the following included and adequate: – summary of legislation relating to inventory and monitoring – NPS policy and guidance – servicewide and network-specific goals for monitoring, – servicewide and park-specific strategic goals for performance management that are relevant to monitoring, – statements from park enabling legislation that establish the need to monitor natural resources presented? • Does this report answer the question, "who is interested in the information provided by monitoring, and why?"	3	There was a good description of servicewide goals (p. 10-11) and relevant policy that established and described implementation of the program, but much more information is necessary to articulate the relationship between the I&M program and performance goals. What are park performance goals, and how will the monitoring program support them? Who do you expect to use the information and how? What specific Park goals (GPRA and other) will the monitoring program • support? The report includes "Network Goals" on pages 10-11, and revision is needed to comply with the I&M Program decision to abolish Network-specific goals (e.g. call them objectives or desired attributes, but don't use the term "goal"). The "program goals for all 32 networks are the same and there should not be separate 'Servicewide Goals' and network or program goals. You could note that to achieve Servicewide goals, your more specific NCRN objectives are to ... (put "NCRN monitoring goals" here). I did not locate any GPRA goals, and these should be included. For a good example, see Appendix B of the SCPN Phase 1 report.
• Are the objectives of the monitoring introduced? (Note that specific, measurable objectives will be defined at later stages of program development.)	—	Network and park-specific objectives are problematic and we are reviewing the "goals and objectives" section of the monitoring plan guidelines.
• Is an overview of the important resources in each park in the network presented and is their importance in a regional or national context described?	5	Yes. Very complete.
• Is water quality monitoring included? If applicable, lists of waters having protective designation for water quality standards, such as Clean Water Act 303d waters or Outstanding National Resource Waters, should be presented. If this information is not presented, does the report explain why not?	5	Yes. Very complete.
• Are the most important management and scientific issues summarized for each park, and are the most important agents of change presented in a meaningful way?	5	The summaries in Appendices D & F were excellent.
• Is an overview of other monitoring efforts, within and outside NPS, presented so as to demonstrate how the program will learn from and build upon these efforts?	4	There's an excellent summary of the many(!) monitoring and some inventory efforts in the area. The brief descriptions were helpful. It's not yet completely clear how NCRN will build on these effort or what it's learned from them.

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
• Does the report describe the overall process used, or to be used, to determine the goals and objectives for the monitoring program and for selecting vital signs to monitor?	2	There needs to be an overarching conceptual framework for the program as a whole. This framework should describe linkages between broad categories of vital signs and overall program goals, and provide guidance for identifying vital signs that are of highest priority.
Chapter 2: Conceptual Models		
• Does the report present an overview of the current understanding of the region's ecosystem, focusing on aspects of the ecosystem that are relevant to the monitoring program? • Do the conceptual models that are presented appear to be useful and relevant to the development of the monitoring program?	1	Lots of information was presented, but the fundamental goal of using a systems approach was not achieved. The presentation of material needs to be vastly improved so that readers can easily determine which processes or stresses are of primary importance. The conceptual models, as presented, did not articulate connections between ecosystems or ecosystem components. Thus a key feature the interactions between components/systems - was unclear. The relationships in the conceptual model need to be much more carefully considered and supported by data See comments below.
• Are resource stresses, the sources of each stress, and consequent ecological effects clearly identified?	2	The tables that comprise the conceptual models are very long and probably comprehensive, but they need to be much better supported by data and the relationships need be carefully reviewed for accuracy. Many of the table entries were effectively meaningless and some incorrect. For example, listing "all development" as a threat is uninformative and, in some instances, incorrect. Similarly it's not clear how ozone leads to deforestation at NCRN parks. More and better diagrams both highly aggregated and more detailed, are needed to articulate and effectively' communicate important ecological relationships - these need to be informative not comprehensive, and they must highlight the key ecological components and processes.
Chapter 3: Vital Signs		
• Does the report present the vital signs clearly and justify why each one is a priority?	1	The relevance of each vital sign needs to be justified by linking it to a key management goal or by its merit as. -i information-rich indicator of ecosystem health or trajectory. Especially for the later, credibility must be established by citing scientific studies that show the relevance of the vital sign and that indicate how measured values can be interpreted. See comments below.

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
• Are vital sign monitoring goals and objectives clearly stated?	2	See: http://science.nature.nps.gov/im/monitor/vsmTG.htm#GoalsObj. First, there should be only Servicewide goals, and the goals for each vital sign should be rolled into the "objective". The objectives need to be ecologically meaningful, measurable, and you must be able to evaluate them. There are many problems with the vital signs in section 3.2. As an example, 3.2.6.4. should probably be "Landscape pattern" or "Spatial pattern of important habitats" rather than "Fragmentation indices" which is just one (controversial) class of pattern metrics. The monitoring objective could be: Detect changes in the total area and spatial arrangement of important habitats within and adjacent to park units. The specific measurable objective could be- Obtain maps at a 10m resolution of important land cover types every 5 years and report changes in total area, cover, connectance, patch size distribution, and shape of native vegetation patches in parks and within relevant buffer zones (zones habitat types, and other details to be determined during Phase III process). The Summary of / this indicator (or justification elsewhere in the report) should cite studies on habitat area, fragmentation, edge effects, etc. The invertebrate vital signs seemed to be particularly poorly considered Most of the proposed relationships are assertions not supported by any data, and many of these don't even make sense, (e.g. 3.2.3.1, 3.2.3.2, etc.). E.g., what basis do you have for asserting that invertebrates are suitable "indicators" for monitoring habitats that haven't been identified? Inventories are not monitoring activities (e.g., 3.2.3.5.) Many of the vital signs in section 3.2 can be criticized for the characteristics noted above. The scholarship in this section needs to be dramatically improved. The time frame "5 years" appears in a number of vital sign descriptions (e ° 3 2 4 1- 3.2.4.6). Is there any basis for this, and if so, what? Presumably this is the Interval between sampling events, and not the duration of the program. I don't understand "Politics" as a relevant vital sign. How does this meet any identified goal?
• Are the reasons for grouping vital signs monitored with similar protocols clearly explained?	1	This section needs to be much better developed. There is a strange separation of vital signs that appear to measure almost exactly the same thing. For example, 3.2.4.2 is "amount of forest interior" and 3 2 6 4 is "fragmentation indices". There are other examples, but the lack of even a table of vital signs makes it more difficult to identify overlaps in vital signs. Serious work is needed to reconcile the information that will be provided by the vital signs.

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
		At a minimum, the vital signs need to be summarized in several different ways (eg. °tables or figures) that make the relationships between them apparent. The GRYN" ' Phase II report includes particularly good examples of ways to informatively communicate this information.

General Comments:

Does this Phase II Report provide a sound foundation for a scientifically credible monitoring program that will meet the most important information needs of the parks in the network?

No. There's a lot of information in the report, but the level of scholarship needs to be greatly improved. Each vital sign needs to be justified by a clear connection to a stated management goal, or by valid scientific studies. There are now a number of excellent examples of this. In most cases I've seen, the majority of scientific background information is contained in the narrative part of the conceptual models. See the GRYN, SCPN, NCPN (among others) for very good examples. As it is, this report and the selection of vital signs is not sufficiently integrative and is inadequately supported by cited studies. Many of the proposed vital signs are much too vague and they are not credible as currently presented.

Which areas of the report require additional work, in your view, before the network moves into the next phase of program development?

The network critically needs to develop a general framework and useful conceptual models that articulate linkages between the ecosystems and ecosystem components. Ecosystems are more than the sum of their parts, and in many cases the interactions are more important than any single part. The lack of a conceptual framework has many implications to the design and execution of the program -you can't realistically evaluate the relative merits of different vital signs without knowing something about the connections between the parts. Selecting an integrative set of vital signs also requires knowing the "value added" by each additional (and costly) vital sign. As an example, in this report monitoring of N shows up in the air, soil, and water components, but there's not connection between these ecosystem compartments. If you monitor N deposition and water chemistry, how much additional information do you obtain by monitoring soils - i.e., do you obtain most of the information from air and water chemistry?

Additional Comments:

It is particularly disturbing that many deficiencies in the Phase I report were not corrected. The last evaluation noted the need to more clearly organize background information and to integrate the individual components. There is still no "big picture" and the fragmented parts do not form a coherent program.

Given the time constraints, the NCRN will need to (quickly) contract additional scientific staff to develop major sections of the monitoring plan, perhaps with a focus on specific systems like oak forests, cultural park systems, streams/rivers, etc. Additional input is clearly needed to assist in developing an overarching conceptual framework that will help ensure a systematic approach that can provide the foundation for general and specific system conceptual models. A far more integrative approach is critical before making major investments to develop specific protocols.

2. Comments from Dr. Craig Snyder, USGS, Leetown Science Center. 10/3/03.

I have reviewed the draft Phase II Report of the "Monitoring Plan for the National Capital Network of the National Park Service". The goal of the report is to describe progress to date in the design of a monitoring program for the National Capital Region network. In particular, the Phase II report provides an overview of the National Capital Region network parks, illustrates conceptual models constructed to aid in the design of the monitoring plan, and a list of vital signs selected by the Science Advisory Committee to monitor the region's "ecosystem health."

As a member of the Science Advisory Committee I was privy to the process and discussions leading up to the formulation of this document. I was impressed from the outset with the leadership provided by the National Park Service at both the national (Steve Fancy) and network levels (Ellen Gray and Marcus Koenen and others). I believe the quality of work reflected in this document is, in large measure, due to the organization, leadership and hard work of these folks and their staffs.

The document clearly does what it was intended to do. The reader gets a clear picture of the goals and objectives of the program (network and national), complete descriptions of the environmental settings and important resources within component parks, and a good understanding of the process for formulating the plan and justifications for the selected vital signs. I do not believe the document requires any substantial changes beyond some minor editorial and clerical revision.

However, the next phase of the process may be even more challenging. That effort will involve attempts to integrate the selected vital signs and sampling protocols into a monitoring program that meets its lofty goals in a cost-effective way. By necessity, most of the process of prioritizing and selecting vital signs so far has been compartmentalized into groups. In the future, I recommend a new committee comprised of SAC members from each component resource group and representatives from National Capital Region management, and charging the group with ensuring that all of the important ecosystem components (landscape, grasslands, forests, streams, other aquatic habitats, etc.) are well represented in the vital signs monitoring program and that ‘ duplication (i.e., more than one vital sign that represents essentially the same ecosystem component) is minimized.

I did find a few omissions and clerical errors in the document. Those, along with my reviewer rankings are detailed in the attachment. I hope my review is helpful. Please let me know if there is anything else I can do.

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
Chapter 1: Introduction and Background		
• Is the purpose of the monitoring program explained?	5	
• Are the following included and adequate:		
– summary of legislation relating to inventory and monitoring	5	
– NPS policy and guidance	5	
– servicewide and network-specific goals for monitoring,	5	
– servicewide and park-specific strategic goals for performance management that are relevant to monitoring,	5	
– statements from park enabling legislation that establish the need to monitor natural resources presented?	5	
• Does this report answer the question, "who is interested in the information provided by monitoring, and why?"	5	

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
• Are the objectives of the monitoring introduced? (Note that specific, measurable objectives will be defined at later stages of program development.)	5	
• Is an overview of the important resources in each park in the network presented and is their importance in a regional or national context described?	5	
• Is water quality monitoring included? If applicable, lists of waters having protective designation for water quality standards, such as Clean Water Act 303d waters or Outstanding National Resource Waters, should be presented. If this information is not presented, does the report explain why not?	5	
• Are the most important management and scientific issues summarized for each park, and are the most important agents of change presented in a meaningful way?	5	
• Is an overview of other monitoring efforts, within and outside NPS, presented so as to demonstrate how the program will learn from and build upon these efforts?	4	The USGS ARMI program is not "Amphibian And Reptile Monitoring and Inventory." It is "Amphibian Research and Monitoring Initiative."
• Does the report describe the overall process used, or to be used, to determine the goals and objectives for the monitoring program and for selecting vital signs to monitor?	5	
Chapter 2: Conceptual Models		
• Does the report present an overview of the current understanding of the region's ecosystem, focusing on aspects of the ecosystem that are relevant to the monitoring program?	5	
• Do the conceptual models that are presented appear to be useful and relevant to the development of the monitoring program?	4	Some of the conceptual models are clearly better than others.
• Was the overall process that was used to develop the models clearly described?	5	
Chapter 3: Vital Signs		
• Does the report present the vital signs clearly and justify why each one is a priority?	5	
• Are vital sign monitoring goals and objectives clearly stated?	5	
• Are the reasons for grouping vital signs monitored with similar protocols clearly explained?	5	

3. Comments from Dr. Doug Sampson, Maryland/DC Chapter, The Nature Conservancy. Date: Sept. 22, 2003

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
Chapter 1: Introduction and Background		
• Is the purpose of the monitoring program explained?	4	Yes. Purpose is clearly conveyed in section 1.1 and justification is clear in section 1.1.1. However, somewhere between these two sections, the "inventory" part of the I&M program gets dropped, without explanation. For example, the phraseology used in the section heading and in the first sentences in the second and third paragraphs refer to "monitoring" only, not "inventory and monitoring". Inventory work in NCR started earlier (in 2000) and this report is titled a "Monitoring Plan", so the de-emphasis on inventory is perhaps justified. But you need to know what you've got before you can monitor it, and there's a heck of a lot that's unknown about natural resources in the parks in NCR. So the absence of any discussion of inventory needs, and the constraints that such gaps may place on monitoring – at least in the short term - seems odd. If this is only a "Monitoring Plan", is there already a separate "Inventory Plan"? How could these be separate, given the interdependence of the two? I also would have liked to have seen a short discussion of what's included in the definition of "natural resources" that might be included in potential monitoring programs. While the term has been in common usage for decades, and is often used to encompass both physical and biological components of natural systems, different people may define the term differently. More importantly, explicit identification of what is and is not included in the National Park Services' definition is needed here to circumscribe the limits of what will be considered in the I&M Plan.
• Are the following included and adequate:		
a summary of legislation relating to inventory and monitoring	3/4	Yes. The summary is in 1.1.2 and is adequate. There's a bit too much detail on endangered species legislation, especially at the state-level (fifth paragraph), for this introductory section. While the material in Appendix C should probably stay in an appendix, the format (i.e., a table) makes it difficult to read, and important points could have been highlighted (with bold, italic font, etc.).
b NPS policy and guidance	3/4	Yes. See 2a above
c servicewide and network-specific goals for monitoring,	5	Yes. These are clearly presented in section 1.2
d servicewide and park-specific strategic goals for performance management that are relevant to monitoring,	1	No. Neither servicewide nor park-specific strategic goals for performance management appear to be included.

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
e statements from park enabling legislation that establish the need to monitor natural resources presented?	2/3	Yes and no. Although this issue is referred to in the last paragraph of section 1.1, park-specific enabling legislation is only presented within each park summary in Appendix C; that is, it takes some work to find and digest the material. Aside from the document organization/formatting challenge, the enabling legislation for many of the NCR park units makes no mention of the need to monitor natural resources (because they were established to preserve historic & cultural features).
• Does this report answer the question, “who is interested in the information provided by monitoring, and why?”	3	Yes and no. The general need for the information by park managers in order to make management decisions and allocate resources is clear, as is the general need to have such information to better protect park resources into the future. The importance of the information for NPS divisions, partner agencies, academic institutions and other organizations – both for cooperative work on NPS lands and on other natural resource lands nearby – is also clear. Potential interest in NPS monitoring information by local governments, neighboring community associations and many other stakeholders in the vicinity of NPS parks is not mentioned. What’s missing, however, is an explicit discussion of who is actually going to be implementing the final I&M Plan, and how. While the steps in the planning process for the Monitoring Plan are listed and discussed, it’s not clear who will be reading the Plan on a regular basis as part of their job thereafter. That is, will the final Plan report be a guidance document provided to each park for implementation as appropriate and feasible? Or will NCR I&M staff be the primary “users” of the Plan? Is the Plan meant to be primarily an internal document for NPS staff, or a report to be widely shared with state & local agencies, academic researchers, nonprofit organizations, and so on? If the former, much of the material describing NPS policy, enabling legislation, etc., can probably be omitted, since that stuff is already familiar and/or can be readily accessed.
• Are the objectives of the monitoring introduced? (Note that specific, measurable objectives will be defined at later stages of program development.)	?	Not sure I understand what level this question is directed at, and how it differs from 2c above. Monitoring Objectives are not presented as a topic in Chapter 1 per se. “Monitoring needs” and “research needs” are presented unit-by-unit in Appendix C, as park of each park summary.
• Is an overview of the important resources in each park in the network presented and is their importance in a regional or national context described?	3	Yes and no. A brief summary of the NCR region is presented in section 1.4, with brief reference only to the regional significance of the Potomac Gorge. A discussion of the major resources in each park is presented in each summary in Appendix C, but not every resource is discussed, and there’s little discussion of the regional or national significance/context of resources. However, since most of the parks in NCR fall in a region lacking unique or dramatic landscape features, and were established for historical/cultural reasons and/or recreation, natural resources of regional or national significance are generally lacking.

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
• Is water quality monitoring included? If applicable, lists of waters having protective designation for water quality standards, such as Clean Water Act 303d waters or Outstanding National Resource Waters, should be presented. If this information is not presented, does the report explain why not?	2/3	Yes and no. Appendix G provides supplemental information about "aquatic and geologic resources" at each park, including discussions of groundwater and surface water monitoring, hydrology, fish and macroinvertebrate monitoring, etc. Appendix H provides a discussion of, and tables listing, waters having protective designations in NCR. Whether or not these materials are "included" in Chapter 1 is debatable. Absent any summary/overview discussion of the significance of this information, or conclusions that can be drawn from it as to what should or should not be included in the NCR Monitoring Plan, the relevance of this information is not clear. If it's important and relevant, it should be summarized and discussed in the main body of the report.
• Are the most important management and scientific issues summarized for each park, and are the most important agents of change presented in a meaningful way?	2/3	Yes, to the extent possible given the constraints on compiling such information. In other words, this information is clearly presented in bullet/list form in each park summary in Appendix D, but it is based on a questionnaire sent to each park. Far more rigorous approaches for objectively evaluating management issues and research needs are available (e.g., TNC's Site Conservation Planning approach, facilitated workshops, etc.). But these methods require a lot of staff time, money and effort to complete, and would have had to have been done separately for each park unit. So identification of the "most important agents of change" here is moderately subjective, given the questionnaire approach. In addition, there's no text discussion of the bulleted items, so assessing their significance – both absolutely and relative to each other - is not possible. At the same time, for the National Capital Region, the most important agents of change are likely to be the same across many park units. Thus, the synthesis of threats, management issues, monitoring and research needs across all parks would be an important approach for identifying these agents. While the tabular synthesis in Appendix F is quite clear and "user-friendly", none of this information is summarized or discussed in the text in Chapter 1 (see also **Additional Comments**, below). Simple, important conclusions about regional threats (development, deer, invasives, gypsy moth, etc.) are evident in this tabulation, but not presented, per se, in the main body of the Report.

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
• Is an overview of other monitoring efforts, within and outside NPS, presented so as to demonstrate how the program will learn from and build upon these efforts?	2/3	Yes and no. The text discusses how information on other monitoring efforts was compiled by I&M program staff, and briefly mentions some of the kinds of information that are out there. The information about other monitoring programs is presented in far greater detail in Appendices I, J and K, and also in part in Appendix G (#6 above). However, there is no clear, concise summary in the main body of the Report of what all this other monitoring tells us about conditions (e.g., water quality, air pollution, invasives, etc.) in the Mid-Atlantic region, or how that knowledge might be used to develop, expand, modify, set priorities for, etc., monitoring efforts by NPS on NCR park lands.
• Does the report describe the overall process used, or to be used, to determine the goals and objectives for the monitoring program and for selecting vital signs to monitor?	5	Yes. The seven-step planning process is described in detail in section 1.3. Additional discussion is provided at the beginning of Chapters 2 and 3.
Chapter 2: Conceptual Models		
• Does the report present an overview of the current understanding of the region's ecosystem, focusing on aspects of the ecosystem that are relevant to the monitoring program?	5	Depending on one's perspective, Chapter II in the Report either lacks an overview, or is entirely "overview"! That is, the text in section 2.1, "Overview", describes what conceptual models are and briefly how those presented in the Report were developed. But there is no overview or summary, per se, of the "current understanding of the region's ecosystem", which presumably would be a general discussion of the health & condition of eastern deciduous forested landscapes (and their embedded aquatic, wetland, rare, etc., habitats) in the Mid-Atlantic region. There is a fair amount of regional "overview" information presented on air resource components (section 2.1), and there are occasional statements assessing multi-park or regional level parameters scattered throughout the different resource component sections in Chapter 2. There is also a very brief summary in section 2.3 of the most frequent threats cited by workgroups. But a reasonable argument could also be made that most of the material in Chapter II is "overview" in that the resource components are only generically described, as are the stressors, sources and ecological effects, with little or no reference to actual conditions in the region, and only occasional reference to specific parks in NCR. That is, detailed or quantitative or spatially explicit discussions of the status of these resources in the National Capital Region, or specific parks in NCR, is minimal; the text is so general, it could apply to almost any place around the country. For more comments, see 11 below.
• Do the conceptual models that are presented appear to be useful and relevant to the development of the monitoring program?	4	For the "conceptual models" presented in Chapter II/Appendix P, the answer is "No", for several reasons:

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
		a) They are too generic (see above), describing processes and relationships that might hold for any location in the eastern US, without sufficient explicit reference to resources, stressors, sources and ecological effects in the NCR region, or at specific parks. Thus, they provide very little guidance for assessing the relative importance of different linkages within and among resource components, and consequently for setting priorities for monitoring, within and among resources, much less within and among parks in NCR. b) The ranks (low, medium, high, etc.) for Priority of Threat to Resource are presented only in the tables in Appendix P (which is really an appendix to the earlier draft Monitoring Report making it all very confusing, and very difficult to read/assimilate; see below), with no references to the ranks in the text, and no description of the process by which they were developed until Chapter III. c) The overlap/redundancy between the material in Chapter II, Chapter III, Appendix P and the tables in the Monitoring Workshop Report makes for very difficult and tedious reading, while trying to sort out what's the same, what's different & why, which came first, which text is based on which tables, etc. The organization of the Phase II report is extremely difficult and cumbersome to follow. Having Appendix P be an appendix of the Monitoring Workshop Report, which itself is an appendix of the Phase II report, but with the latter having the revised/final "conceptual model" tables along with the details of the Threat ranks, vital signs and monitoring goals & objectives, is all totally confusing and nearly impossible to follow. This already tough situation is not helped by the fact that: 1) there is considerable sloppiness/inconsistency in the use of names, phrases and terminology between the sections (e.g., stessors in the text in 2.2.1 include "nitrogen deposition", "carbon dioxide", "VOCs" and "ultraviolet radiation", while the corresponding stressors in Appendix P include "nitrogen", and "greenhouse gases" with no listing corresponding to VOCs or ultraviolet radiation); 2) the subheading format is often very hard to follow from section to section.

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
		d) There is a moderate amount of confusion as to how resource components, threats, stressors, sources and ecological effects are identified and categorized. As one example, particulates are listed as both a resource component and a stressor in the Air Resource conceptual model (p. 16, section 2.2.1 and Appendix P). This happens repeatedly in the text material in Chapter II, in Appendix P and in both the text and figures in Chapter III. There is also a fair amount of overlap/redundancy among resource components, and their stressors, sources & ecological effects (especially water, vegetation). Some of these are mentioned in the text, but the rationale for categorizing them one way or the other is generally lacking. Also, while a "Threat" is defined as the combination of a stressor and a source (p.14), and thus there are dozens of stressor x source "threats" for each resource component, only a single Priority Threat Rank is assigned in Appendix P for each resource component. This obviously carries over directly to the identification of the most significant threats, and thus the vital signs selected. (Some workgroups have ranks for each Threat in the Monitoring Workshop Report tables, but whether or not these differ from or are the same as the single ranks in Appendix P is unclear.) e) Conceptual models are really only useful if they tell you something you don't already know, and/or allow you to make decisions among many choices. Thus, a conceptual model not only "maps the important ways that ... resources are linked and... shows *the relative importance of those linkages* [italics added], but also provides a "framework for evaluating *which processes are most important* [italics added]" (p. 14). To my way of thinking, Appendix P is not a "conceptual model"; it's a tabular listing of brainstormed biotic and abiotic processes and relationships, with workshop participant opinion (see below) thrown in as to which subcomponents of the resource components and which stressors are probably the most significant in our area. Chapter II is a expanded text discussion of Appendix P, so it's not a conceptual model either. The simplified, graphical versions of the "conceptual models" for the resource components are not even presented until Chapter III, but even here they contain no information that allows stressors, sources or ecological effects to be assessed or compared as to their relative importance or significance for each resource component (though one might argue that the filtering of priority threats has already been done, so all of these are important).
• Was the overall process that was used to develop the models clearly described?	5	No; see 11c & d above.

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
Chapter 3: Vital Signs		
• Does the report present the vital signs clearly and justify why each one is a priority?	5	Yes and no. Section 3.2 summarizes fairly clearly how the Vital Signs were selected, including the process by which priority ranks for the Threats were developed. But all of the details of the process, and how the process varied among workgroups – and therefore resource components – is contained within the Monitoring Workshop Report (Appendix N), which is mentioned but nowhere cited (parenthetically) in Chapter III. Once the reader figures out where to go to look for the detailed information (which didn't happen for me until very late in my review), trying to read back & forth from Chapter III to the Monitoring Workshop Report is a challenge. Beyond the challenges presented by the report organization, the identification & justification of the Vital Signs is not always clear, especially within Chapter III per se. There is considerable overlap between Vital Signs and resource components, and between Vital Signs and Threats. For example, the first Vital Sign under Air is "vegetation community structure" which seems to be the same thing as the Vegetation resource component (3.2.6). Also, Vital Sign 3.2.2.1, "Sediment loading and deposition, wetland extent and condition" seems to be more or less the same as Vital Sign 3.2.2.4, "Innundation of wetlands, erosion and sedimentation processes" and how these differ from the Threats listed – "Erosion and sedimentation" for 3.2.2.1 and "Shoreline change" for 3.2.2.4 – is very unclear. Similarly, it's not at all clear what the difference is between Vital Sign 3.2.2.2, "Physical failure, rock falls, landslides, sinkhole collapse" and its Threat "Geo-hazard". Major overlap between Vital Signs and their Threats also occurs with 3.2.1.3, 3.2.1.5, 3.2.3.5, 3.2.4.3, 3.2.4.5, 3.2.6.2 and others.
• Are vital sign monitoring goals and objectives clearly stated?	5	Yes and no. Some of the Monitoring Goals are clear and fairly straightforward as stated, while others are too vague or general and/or unclear. Since there's no explanation and/or justification of the Goals in the Chapter III text, I had a lot of questions about what they mean, why they were chosen, how feasible they are, and whether or not they would provide the desired information or achieve the desired results. Many of the Monitoring Objectives are identical (more or less) to the Monitoring Goals, so they provide little additional understanding or clarification. Some are more specific, detailed and task-oriented, so they indicate more clearly what monitoring would be done, where and how.

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
• Are the reasons for grouping vital signs monitored with similar protocols clearly explained?	5	No. Section 3.3 summarizes how this was done, but: 1) it's unclear who did the grouping of Vital Signs by protocols (presumably, the I&M team?); 2) how the seven protocols around which 30 Vital Signs were grouped were developed, since very few of the workgroups had the opportunity to draft protocols during the Workshop (looking at the Report/Appendix N); 3) most of the grouped and independent "protocols" listed in Chapter III (i.e., 3.3.2.1 through 3.3.3.10) are not protocols at all, but instead are the targets of monitoring efforts (e.g., "Birds", "White-tailed deer", "Lichens", "Invasive Invertebrates") or sources of information for monitoring (e.g., "Aerial surveys", "Satellite imagery"). Some of the listed "protocols" are also Resource Components (e.g., vegetation, invertebrates) or Threats (e.g., deer), further confusing and confounding the entire analysis.

General Comments:

Does this Phase II Report provide a sound foundation for a scientifically credible monitoring program that will ultimately meet the most important information needs of the parks in the network?

It's too early to tell. I do have some serious concerns about the "scientific credibility" of the process used to accomplish the work to date. Having participated in a score of such professional planning endeavors myself over the last 10 years, I feel that there are major pros & cons to using a facilitated, brainstorming, workgroup + workshop approach (seems like there should be a name for this process!...). On the pro side, it engages many of the staff (or stakeholders), gives them buy-in to the process, often makes use of a large pool of accumulated knowledge and experience, allows progress on multiple parts of a project simultaneously, helps sort out & resolve differences of opinion before the final draft, facilitates cooperation and partnerships for implementation, and so on.

But at the same time, the use of break-out groups/workgroups to get work done has a number of problems, even in situations where instructions/guidance to the groups is good and facilitation is strong. First, many members of the larger group from which subgroups are drawn are not experts on the topic they engage on, even if they are allowed to self-select the group they participate in. The result of this process is that "expert knowledge" & expertise can differ markedly among and within groups. Second, if the workgroups meet several times over a long time period, the membership of the group often varies among meetings, as some folks can't attend, others are new, switch workgroups, etc. This reduces the consistency and effectiveness of their work. Third, workgroups, especially small ones, can be significantly influenced by one or a few "strong personalities" in the group, people who dominate the discussion and disproportionately affect the direction the group takes and the outcome of the work. Good facilitation minimizes but does not eliminate this latter phenomenon. Poor facilitation, or poor communication and/or consistency among different workgroup facilitators leads to products that may or may not resemble the desired endpoint, that are different from each other, or which are completed to a greater or lessor extent. Thus, "quality-control" is poor among groups, and some groups may not have even produced the right product.

Finally, and perhaps most importantly, using a "brainstorming workgroup" planning approach may simply not be the best way to achieve particular planning goals. Getting a large number of intelligent but generalist professionals together in a room and asking them to "brainstorm" ideas often results in many flip chart pages of generalities, evidence that most people know a lot about a bunch of topics. But even with clear instructions and great facilitation, it's often difficult to "force" a group of people to focus clearly and concisely on a specific question or need, in order to complete a specific desired objective in a workgroup setting. The fewer experts versus generalists there are in the group, the harder this becomes.

The products (i.e., the conceptual models/tables) that the various workgroups have contributed to the current draft Monitoring Report show a lot of the characteristics I mention above; differences in definitions, scope, approach, precision, completeness, and so on. Overall, the consistency among groups and the degree to which they were on-target is notable here, given the total number of participants, the number of groups, their differing compositions, and the extended time frame over which the work was done. But thrown up against the criteria of being a “scientific” process, the answer would have to be that it falls short. It is a compilation of best-available-knowledge, collected in a semi-standardized way, from a large number of people who know many of the resources through personal experience, but many of whom are not “experts” on one particular resource or site. *This may very well be the best that can be done on this kind of project given the circumstances and constraints, and the expectation that such a process be scientifically based & credible may be setting the bar too high.*

In addition, the vast majority of the workgroup information was collected and compiled without reference to specific sites or park units in NCR. While this approach was perhaps intentional, in order to try to plan for multiple parks at once, it produced an enormous amount of material that is so generic in nature that it’s not clear how monitoring would be implemented, where it should be implemented, and why. The Report does not yet say, “X (resource/process) will be monitored at Y (site) because Z (reason)” and it’s not clear if/when the Report will get to that point.

Which areas of the report require additional work, in your view, before the network moves into the next phase of program development?

Chapter II needs a lot of work. Currently, it is a way-too-generic, superficial treatment of a wide variety of very complex resources and processes, with almost no apparent relevancy to specific park units in NCR. At the same time, some of the information most important to identifying Vital Signs – like the Threats ranks – is “buried” in Appendix P and/or the Monitoring Workshop Report, which is a bizarre appendix to the main Report, since it has it’s own appendices!

Ideally, Chapter II should be a true synthesis of the earlier products of the workgroups, thoughtfully filtered, edited and reorganized by members of the I&M Team. The actual draft and revised tables produced by the workgroups during the planning process can be referenced as appendices where appropriate, but for many of the reasons discussed under #16 above, the workgroup products can’t reliably be used “as is” (perhaps the NPS guidance for doing an I&M Plan recommends documenting all work unedited?).

Regardless, the organization and readability of Chapter II needs significant improvement, vis a vis cross-referencing with Appendix P and the Monitoring Workshop Report, in order for the casual reader to even begin to follow the presentation of conceptual models for the Resource components. And, as noted above (#11, especially 11c), somebody really needs to clean up the inconsistencies in terminology between the various text sections and tables. I honestly don’t know what to say about the many places where Resource components, Stressors, Threats and Vital Signs are confounded, within and between sections.

Note that some of these same comments apply to Chapter III (see #13 above).

Additional Comments:

Since I’ve failed to be constructively critical so far, I guess I’m not about to start now.

I’m wondering if there wasn’t a simpler, quicker, more directed way to have gone about this whole planning exercise. Rather than getting 100+ people together and asking them to brainstorm ideas about resources, stressors, sources, ecological effects, etc., in a region the size of NCR (with all of its attendant diversity of species, natural communities, landscapes, ecological and anthropogenic processes and impacts), why not start with all of the <u>known</u> priority threats and <u>existing</u> significant management issues, and also the current monitoring programs and known monitoring needs? All of this information was collected through the questionnaires sent to each park unit, and compiled in Appendix F. A quick glance through this table immediately demonstrates that a relatively small number of threats – deer, gypsy moth, invasive plants, water quality, development - are impacting almost every park unit in NCR, that these threats are the major management problems for most parks, that many parks are already monitoring for most of these threats, and that most parks feel they need more monitoring for several, as well as more resources for management and monitoring overall. Inexplicably, there is almost no discussion anywhere in the Monitoring Report of the results shown in Appendix F.

The correspondence between this list and the conclusions of the workgroups + conceptual modeling process – the final list of Vital Signs - is striking. But it's also an expected outcome, given that the people who filled in the questionnaires were also many of the same people who participated in the workgroups. Beyond that, almost anyone involved in natural resources management in the eastern U.S., if asked to name the most significant threats to parks and natural areas, would probably come up with the same list. Thus, I can't help thinking that the long, hard I&M planning process followed to date might have been shortened and simplified by starting with the known, common threats and monitoring needs across the NCR parks, and asking the question, what's missing? or, what else do we need? or, where should the next dollar of monitoring effort be spent, once these major threats and needs are addressed? A much more narrowly focused and directed process of identification and assessment of monitoring needs, carried out by a small group of I&M staff, might well have arrived at the same conclusions found in the current Report, but with far less time and energy invested. While this approach might not have satisfied agency interest in conducting an open, participatory planning process, it might have allowed the work of the I&M Team to be conducted far more efficiently and effectively.

4. Comments by Dr. Vic Serveiss, Environmental Scientist US EPA (8623-D) 1200 Pennsylvania Ave, NW, Washington, DC 20460; 202 564-3251, serveiss.victor@epa.gov. 31 October 2003.

Note I am an ecological risk assessor. The purpose of ecological risk assessment is to collect, organize, analyze and present scientific information to improve decision making. As a result, my comments reflect the view that a monitoring program should provide information that when assessed would be useful for decision making.

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
Chapter 1: Introduction and Background		
• Is the purpose of the monitoring program explained? • Are the following included and adequate: – summary of legislation relating to inventory and monitoring – NPS policy and guidance – servicewide and network-specific goals for monitoring, – servicewide and park-specific strategic goals for performance management that are relevant to monitoring, – statements from park enabling legislation that establish the need to monitor natural resources presented? • Does this report answer the question, "who is interested in the information provided by monitoring, and why?"	3	Yes, but slightly differently in three places. These should be more consistent with one another, because it was not clear. In Purpose 1.1. "Program goals are to develop basic natural resource inventories and implement long-term monitoring of ecosystem health." The last paragraph of 1.1.1 leads me to understand that the purpose is to use vital signs to detect changes in ecosystem health and that this information would be useful for decision making, research, education, and promoting public understanding. 1.2 states "the overarching purpose is to provide a scientific basis for management actions." Several sentences of detail from appendix C should be presented in the introduction before sending the reader there as the document does after the first paragraph in 1.12 and then again at the end of 1.1.2. Also, what happened to appendix A and B. Does this report answer the question, "who is interested in the information provided by monitoring, and why? Generally yes, but not specifically. Who exactly in NPS will use it and how? After answering that, provide some examples even if hypothetical, such as NPS interpretive staff could use taxonomic butterfly information for visitor station exhibits. Also if the purpose is for scientific information for decision making, rarely will the information provide what is needed to establish the link between threat and effect. Furthermore, it's difficult to project what the potentially implementable management action would be to correct problem uncovered by the data, especially since many potential management actions (e.g., controlling acid rain) fall outside the purview of NPS authority.
• Are the objectives of the monitoring introduced? (Note that specific, measurable objectives will be defined at later stages of program development.)	3	No. First, the Service wide objectives do not match up with the regional ones. Data for reference sites and for legal mandates is not included in the latter. Regional objective #2 is quite good in terms of ecosystem management, but as stated in reply to preceding question the data collected rarely provides what's needed for making management decisions. Second, page 14 states that during the workshop "51 vital signs, monitoring goals and objectives" were identified. It does not appear as if these include the same goals shown on page 12 and the objectives are not provided.

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
• Is an overview of the important resources in each park in the network presented and is their importance in a regional or national context described?	3	Not really. The last sentences of chapter send the reader to Appendices D and F. Include a table in chapter 1 to summarize this and then send the reader to the appendices for more detail. Also, what happened to Appendix E?
• Is water quality monitoring included? If applicable, lists of waters having protective designation for water quality standards, such as Clean Water Act 303d waters or Outstanding National Resource Waters, should be presented. If this information is not presented, does the report explain why not?	3	No.
• Are the most important management and scientific issues summarized for each park, and are the most important agents of change presented in a meaningful way?	3	Not really. The last sentences of chapter send the reader to Appendices D and F. Include a table in chapter 1 to summarize this and then send the reader to the appendices for more detail. Also, what happened to Appendix E?
• Is an overview of other monitoring efforts, within and outside NPS, presented so as to demonstrate how the program will learn from and build upon these efforts?	3	They are presented. I recognize such collaboration is difficult but a description as to how any collaboration will be achieved is not provided.
• Does the report describe the overall process used, or to be used, to determine the goals and objectives for the monitoring program and for selecting vital signs to monitor?	3	The activities of the monitoring workshop are summarized but more detail (possibly in Appendix N) could be included here. Though a description of the process would be useful more importantly, it's not clear what the goals are and the objectives are not presented at all.
Chapter 2: Conceptual Models		
• Does the report present an overview of the current understanding of the region's ecosystem, focusing on aspects of the ecosystem that are relevant to the monitoring program?	3	Yes. However, 10 conceptual models, one for each resource, does not establish what aspects of the ecosystem are an overall priority nor the priority threats and components. Based on my experience with watershed scale ecological risk assessments, it would have been useful to first develop some management objectives for the region or identify key components. It appears that a "jump" was made by assuming that the management objective is to establish a monitoring program. Management objectives could have been done by looking at the management objectives for each resource, or each park, and then developing an overall set of management objectives. Then develop several conceptual models for those components that the management objectives addressed. Then develop an overall conceptual model showing the most key pathways for the most important components. Using the existing structure of 10 resources, another way to get this would have been to determine what the priority components and threats are for each resource and then work from there. While the sources, stressors and effects are described, the relationship to a management objective with the model and subsequently the vital sign is not established. It's usually not clear how cause and effect are linked and what analysis could be performed to describe the magnitude of the association In addition, the models usually do not tie to a management action that could be implemented to rectify a problem.

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
• Do the conceptual models that are presented appear to be useful and relevant to the development of the monitoring program?	3	Response to this was included in reply to prior question.
• Are resource stresses, the sources of each stress, and consequent ecological effects clearly identified?	3	Yes, except for a few places where arrows are missing.
Chapter 3: Vital Signs		
• Does the report present the vital signs clearly and justify why each one is a priority?	3	The general description of how vital signs were selected is provided. The relationship to the criteria for selecting each vital sign is not. This would be useful. Some points are not described in adequate detail - such as how macroinvertebrates can be a great descriptor of ecosystem condition, loss of visibility (though important to humans) is not an ecological effect. Others should not be priority vital signs. For instance if little data on biodiversity of invertebrates is known then why make it a vital sign. However, if the purpose is to provide a scientific basis for management actions, then the criteria are not ideal. To achieve that purpose vital signs should use the same criteria used in selecting assessment endpoints in an ecological risk assessment: relevant to the management objective, ecologically important, and susceptible to the stressors of concern. In addition, for a mitigating action to be action, there must be a potentially implementable management action.
• Are vital sign monitoring goals and objectives clearly stated?	3	Yes, but as stated in a few prior replies it is not clear what mitigating treatment option is available to NPS or how NPS could influence another organization to take the management action. Furthermore, from the data collected it's usually not clear how cause and effect are linked and what analysis could be performed to describe the magnitude of the association. It was not clear how data related to objectives for effects of visitors and politics but later it was recognized that more information was needed for these. There are numerous references to activities occurring outside the parks (e.g., "development outside of the parks", in 3.2.6.5, for which it is unrealistic for NPS to take corrective management actions.
• Are the reasons for grouping vital signs monitored with similar protocols clearly explained?	3	Yes

General Comments:

Does this Phase II Report provide a sound foundation for a scientifically credible monitoring program that will ultimately meet the most important information needs of the parks in the network?

No. I see here as R.C. Ward stated in 1986 and 1996 publications "where's the beef" and "the data rich information poor syndrome". Reasons why and recommendations for achieving this were provided earlier and in response to next question.

Which areas of the report require additional work, in your view, before the network moves into the next phase of program development?

As stated several times, developing conceptual models related to management objectives (which were not developed) or key vital signs, having vital signs meeting the criteria for assessment endpoints (relevant to management objectives, susceptible to stressors of concern and ecologically important). There needs to be a potentially implementable management action that could be taken pending assessment of the monitoring results. There needs to be a diagnosis of cause and effect and a way to quantify the magnitude of the association. There are numerous references to activities occurring outside the parks (e.g., "development outside of the parks", in 3.2.6.5,) for which it is unrealistic for NPS to take corrective management actions.

Additional Comments:

For such a large report and undertaking the introduction chapter is too brief. Please contact me if you want references or more details about the proposed recommendations.

5. Comments by Pat Bradley, EPA, 6 October, 2003.

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
Chapter 1: Introduction and Background		
• Is the purpose of the monitoring program explained?	5	Very well written and quite thorough. Minor editorial comments attached.
• Are the following included and adequate:		
a summary of legislation relating to inventory and monitoring	5	
b NPS policy and guidance	5	
c servicewide and network-specific goals for monitoring,	5	
d servicewide and park-specific strategic goals for performance management that are relevant to monitoring,	5	
e statements from park enabling legislation that establish the need to monitor natural resources presented?	5	
• Does this report answer the question, "who is interested in the information provided by monitoring, and why?"	5	
• Are the objectives of the monitoring introduced? (Note that specific, measurable objectives will be defined at later stages of program development.)	5	Yes
• Is an overview of the important resources in each park in the network presented and is their importance in a regional or national context described?	5	Yes
• Is water quality monitoring included? If applicable, lists of waters having protective designation for water quality standards, such as Clean Water Act 303d waters or Outstanding National Resource Waters, should be presented. If this information is not presented, does the report explain why not?	5	Yes
• Are the most important management and scientific issues summarized for each park, and are the most important agents of change presented in a meaningful way?	5	Yes
• Does the report describe the overall process used, or to be used, to determine the goals and objectives for the monitoring program and for selecting vital signs to monitor?	5	Yes
Chapter 2: Conceptual Models		
• Does the report present an overview of the current understanding of the region's ecosystem, focusing on aspects of the ecosystem that are relevant to the monitoring program? • Do the conceptual models that are presented appear to be useful and relevant to the development of the monitoring program?	4 4	I like the conceptual models but think more time should be spent on flushing them out — first individually and then combined.
• Are resource stresses, the sources of each stress, and consequent ecological effects clearly identified?	4	See notes.

Report Section	Rank (1 = Inadequate 5 = Excellent)	Comments
Chapter 3: Vital Signs		
• Does the report present the vital signs clearly and justify why each one is a priority?	5	Yes
• Are vital sign monitoring goals and objectives clearly stated?	4	See comments.
• Are the reasons for grouping vital signs monitored with similar protocols clearly explained?	5	Yes

General Comments:

Does this Phase II Report provide a sound foundation for a scientifically credible monitoring program that will ultimately meet the most important information needs of the parks in the network?

Yes! I think this is an excellent document. I enjoyed reading and think it is, and will be, very useful.

Which areas of the report require additional work, in your view, before the network moves into the next phase of program development?

Mainly the models. I recommend inviting some experts in each area to help you flush them out. It is really useful to identify all the linkages.

Additional Comments:

Also – link the models together and see if they are still logical – things are named differently in different models and models are at different levels of detail.

Detailed Comments on Chapter 1

Page No.	Comment
8	need a transition to para 3 - suddenly moved from general monitoring discussion to T&E species
8	bottom para - capitalize “Act”
9	2nd para - last sentence should read: “A summary of park...
9	bottom para - previous monitoring programs (this occurs 2X)
10	#4 - among NPS divisions, and with educational... and other organizations
10	Maryland Department of Natural Resources (not history)
11	1st line - highlight each park’s
11	para 1 - synthesis is Appendix F
11	Park Specific Summaries are in Appendix D
General	Appendices should be lettered for the order mentioned in text
11	para 4 - literature search summarizing
13	last para - Appendix D is actually summaries of parks - not an overview of NCRN regional context.

Comments on Chapter 2

Page No.	Comment
16	1st para - However, the air.
16	1st para - what is meant by oxygen () and carbon ()?
16	1st para - line 9 does not make sense.
16	delete the sections that begin with Visibility and end with Climate
17	N02 also affects visibility because it absorbs
17	replace existing definition of urban heat islands with 1st sentence of Sources paragraph
17	move 1st sentence under Air Toxics Eco Effects to Air Toxics definition.
18	Eco Effects -EPA and other regulatory agencies will be relied upon to inform park managers
18	not sure if first sentence under Mercury is true. What about other metals?
18	Mercury paragraph - .... combustion sources, mercury body burdens in
19	3rd sentence, Eco Effects doesn't make sense
19	03 Sources - sunsets are not mentioned above
19	03 Eco Effects, 1st sentence - change to read.. ....dangerous molecules "free radicals" that are highly destructive of these tissues.
19	03 Eco Effects, 3rd sentence - delete "that"
20	Nitrogen Deposition, 4th sentence - This process, called ... watershed, and has damaged. (Note: eutrophication doesn't cause eutrophication)
20	Sources, 2nd sentence -... farms and other agricultural sources, but forests
21	Eco Effects, 5th sentence - ....strong acid) dissolves
22	Eco Effects - other changes in MARA report
23	VOCs not VOC's [plural, not possessive]
23	1st paragraph - last sentence doesn't make sense
23	Sources, last sentence - VOCs
23	Eco Effects - Many VOCs
23	Eco Effects - what are the effects? You never say!
25	Note: you might want to stay abreast of Baltimore Ecosystem Study (BES) soil findings
28	Eco Effects, 1st paragraph - break into 2 sentences. Insert and before decreased regeneration of vernal and ephemeral pools. Start 2nd sentence @ Changes in riverbank location
28 & 29	Note: BES findings re: biodiversity, non-natives, etc.
29	Sources - also global change see MARA and MAIA
31	Invertebrate, paragraph 3 - either direct or indirect
31	Conceptual Model - Instead of..., we prioritized a series of projects
General	need to do a thorough grammatical and spell check
32	Forest Interior, 2nd sentence - ...microhabitat with these areas that is preferred
33	Species Specific, 3rd sentence - Changes in land use that alter habitats
36	what did MARA say re: RTE species?
38	Eco Effects of Erosion - check MD Streams Report
40	White Tailed Deer - might want to discuss Lyme disease and deer – Jennifer Orme-Zaveletta ecological model showing relationships, as well as other recent studies re: Lyme disease and biodiversity
40	Sources, 1st sentence - ...wave of logging has led
41 and 41	should call this Pathogens & Parasites and discuss others such as dogwood anthracnose and wooly

Page No.	Comment
	hemlock adelgid
42	1st line - delete (Appendix P,....)
42	streamside trees also provide shade, which cools water temperature. This is important for some aquatic species.
43	Physical habitat - revise as follows: The abiotic and biotic components ...organisms to be its physical habitat.
43	use a better definition of watershed
43	water quality and water quantity - find a better definition - EPA?
43	Flow Regime, Sources - High and low flows are exasperated in urban areas having
44	1st paragraph - climate effect on flows?
44	Eco Effects - generalists: specialists (don't capitalize - not proper names)
44	Eco Effects - stenothermal: eurythermal (don't capitalize - not proper names)
45	check Kent's article on forest/stream interface
47	Global Warming - wildlife? MARA

Comments on Chapter 3

Page No.	Comment
52	6th bullet - and/or are very numerous,
55	Mercury Summary - intermediates and is » only
58	3.2.2.1 Monitoring Goals - delete commas
58	3.2.2.3 Monitoring objectives (3) - information ... to determine aad nutrient and..
58	3.2.2.5 - again, BBS
61	3.2.3.2, Summary - Status of invertebrates,.... is are not well known ...
62	3.2.3.3, Summary - Priority monitoring was placed on 1. invertebrates and 2. common habitats that are well.....
62	3.2.3.5, Threats - Invasive species are a threat to flora and fauna throughout....(research is showing that gypsy moth damage to trees has a cascading effect throughout the ecosystem, effecting fish as well as the trees themselves.)
63	Summary, 2nd paragraph - ReVA may have some of the literature review already completed. I'll check for you.
64	suggest the model be changed - development and landuse are basically the same thing - so have them in one box, have park management in a separate box, and natural stressors (precipitation, hydrology in another habitat alteration would then lead to changes in population as well as increase in exotic or pest species, the accidental introduction can be off to the side, as should be some form of contagion.
65	O'Connell - actually was not designed to monitor quality of forest interior habitat, rather the BCI is an index of ecological condition, with the reference condition for the highlands being interior mature forest. Tim O'Connell has now completed the BCI for all the ecoregions of the Mid-Atlantic region, so it is available for the NCRN parks. You can also use the data collected by the North American Breeding bird survey to generate a BCI score, you might want to establish BBS routes through the NCRN parks, if there aren't any already.
68	development is one category of land use - might want to start with land use type, then do to the various types, and then the effects
71	Summary - Many of the priority species....

Page No.	Comment
71	I'll check on what ReVA has re: vegetative communities
74	3.2.6.5, Monitoring Objectives - revise to read: Maintain GIS layer of external development surrounding NCRN parks Update annually).
74	3.2.6.6 - might also want to consider mapping gypsy moth infestations to determine proximity to streams
74	3.2.6.7 - could partner with US Forest Service FHM/FIA to establish plots within the NCRN parks
General comment	1 like the conceptual models, but think you might want to spend more time really fleshing them out. I'd have some experts in each area help you. It is really useful to identify the linkages between all the factors (driving forces, pressures, stresses, exposures, effects, and actions) Another thing you could do would be to link the various models together and see if they are still logical - things are named differently in various models, and models are at different levels of detail. You might want to spend a day with a small group of outside experts just doing the models.
75	3.2.6.8, Monitoring Objectives - Document the number of times per year that political mandates affect resource.
75	3.2.6.8, Summary, last sent - These include monitoring the percent of superintendents....
75	3.2.6.10, Monitoring Objectives - Monitor the relationship between population size...
Section 3.2.7	this is an area where partnerships will be particularly important since water bodies generally are not wholly contained within any park. you might want to include some language about the need for partnerships, who the partners will be (CBP, USGS, States, Counties) and what roles each will play.
78	3.2.7, 1st para, 2nd sent - revise to read: The four core vital signs that are measured within the water column are water temperature.....
78	3.2.7, 1st para - what are the two other core vital signs? You never explicitly state them.
79	3.2.7.5 - do you already have groundwater observation wells, or is USGS establishing some for you? This would be a good investment.
80	Priority Monitoring Sites - WRD provided guidance to determine priority locations....
81	climate and development should be near each other, since they each contribute to altered flow regimes, you might also want to add sudden weather events (which are not necessarily climate change). I think erosion might be more accurately reflected as an effect of altered flow regime, you should probably also reflect water withdrawal, since it has a profound long-term effect on GW levels and in some places in the Mid-Atlantic on surface water flows
82	3.2.8, 1st para, 4th sent - Land use changes, for ...... because they range outside of the parks into areas where land use changes are ....
82	there was a rather large study of climate change and the Mid-Atlantic conducted by Penn State as part of EPA's Global Change program.
84	Deer Distance Sampling
99	3.3.2.1 - don't you mean "adopting" the ARMI protocols? They cover both populations and malformations (also disease)
99	3.3.2.3 -1 don't understand what you mean by the last bullet. The Bird Community Index is already developed. Do you mean collect the data for the BCI? If so, that data is not vegetation, but birds.
100	3.3.2.5 - don't you mean "adopting" the MBSS protocols?
100	3.3.2.6 - Aerial surveys can.... monitor distribution of specific habitat types, track areas defoliated by gypsy moth during periods of peak outbreak,.
100	3.3.2.6 - the Bird Community Index has been developed.

Page No.	Comment
100	3.3.3.3 - The Forest Service has monitoring protocols for lichens as well as an established indicator (see http://fia.fs.fed.us/librarv/Factsheets/lichen.htm)
101	3.3.4.1 - should be “IMPROVE”
101	3.3.4.4 - need to spell out what “HAFE” is.

Comments on Appendix G

Page No.	Comment
183	Surface Water, 3rd sent - Sixty percent of the stream reaches are first order ....
210	Need to revise the write-up about Maryland. Maryland anti-degradation information is available at: http://www.mde.state.md.us/ResearchCenter/Data/waterQualityStandards/Antidegradation/index.asp

Comments on Appendix K

You might want to update it add BBird (Breeding Biology Research & Monitoring Database) - they have a site in Rock Creek park. http://www.pwrc.usgs.gov/bbV you should reference the MAIA Inventory of Federal Monitoring Programs, which was developed for the CENR. www.epa.gov/monitor it is a geo-referenced web-based inventory that can be queried on a wide variety of variables you should also reference the MAIA Restoration Inventory. http://yosemite.epa.gov/water/restorat.nsf7. It is a web-based inventory to which programs can upload information on their restoration programs.

SUMMARY OF RESPONSE TO PHASE II REVIEW COMMENTS

CHAPTER 1: INTRODUCTION AND BACKGROUND

Chapter 1 now includes a summary of park specific GPRA goals. In addition, the chapter articulates how GPRA goals and other factors such as existing laws, policies, inventories, and special interests influence the monitoring program in order to provide an overarching conceptual framework for selecting and prioritizing vital signs. A graph is presented to show how the interaction works. It should be noted that an inventory study plan has been developed separately from the monitoring plan and is referenced. Details from the results, however, were not discussed because they are pending. New data, however, will be considered as monitoring protocols are developed.

Network goals are now presented as network objectives as requested.

The discussion of the ecological context of the NCRN has been revised. Certain sections have been shortened while others have been lengthened to provide a more even treatment of the subject.

CHAPTER 2: CONCEPTUAL MODELS

The conceptual models have been revised and synthesized. Models are no longer discussed in chapters three but is now the focus only of chapter two. The chapter provides models at multiple scales and levels of resolution. The models were designed to demonstrate the interrelationships among the ecosystem components including the threats and ecological effects to key resources. The models are still very general reflecting the multi-park approach of the regional program. It should be noted that the models are still largely the result of subject matter experts involved in the planning process. The revised chapter, however, provides additional support from the scientific literature.

Previous models including the one presented in the monitoring workshop report were not revised despite the many acknowledged problems such as the use of various naming conventions and misinterpretation of field definitions by subject matter experts. The models are retained as drafts and demonstrate the various stages of the planning process.

CHAPTER 3: VITAL SIGNS

This chapter has been revised significantly. The chapter presents the prioritization process for selecting vital signs. A graphic model walks the reader through the prioritization process and demonstrates the how the vital signs were refined through the planning process. Selection criteria are discussed. A summary is presented of vital signs that were originally considered but later removed along with their justification. Inventory projects and vital signs relating to invertebrates, for example, were removed because they did not meet the strict definition of vital sign indicators. Several vital signs developed by different working groups were grouped together when it was determined that they measure almost the same thing. Justifications are for combining the vital signs are provided. For each priority vital sign, we now present a summary of the major threats and monitoring question addressed. Monitoring goals are stated in broad terms. Monitoring objectives will be refined as protocols are developed and meaningful detection limits are established. The parks where the vital signs are important are listed. A summary justification for each vital sign also provides supporting literature. The information relating to vital signs is presented in both text formats and summary tables to provide readers with multiple avenues to understand the prioritizing process. A table was added presenting all of the priority vital signs using nationally agreed upon vital sign naming conventions.

MISCELLANEOUS COMMENTS

Typos have been corrected as suggested by reviewers.

The Phase III Report attempted to draw a strong connection between GPRA goals, management needs, the scientific literature, and selected vital signs. Support for vital sign selection is provided throughout the text and through various tables and graphs to provide multiple platforms for reinforcing a solid understanding of the issues.

A glossary has been added at the end of the program with frequently used terms such as “natural resources.”

APPENDIX T

PEER REVIEW FORM PROVIDED TO REVIEWERS FOR THE PHASE III REVIEW

This appendix contains the comments provided by peer reviewers of the Phase III Monitoring Plan. There were three anonymous reviewers representing other federal agencies. The reviewers read and commented on the entire monitoring plan. Reviewers 4, 5, and 6 represented the following NPS divisions: Air Resources Division (ARD), Geological Resource Division (GRD), and Water Resource Division (WRD). Each of these reviewers focused on the sections in the monitoring plan devoted to their respective resources. The seventh anonymous review was represented academia. Summaries of how each chapter of the monitoring plan was modified based on the reviewers are provided at the end of the appendix.

Reviewer No. 1
Review of National Capital Region Network Vital Signs Monitoring Plan

- After reviewing the plan and the associated appendices, I have to say that I think the report needs to be redone. Several of the required sections, tables, topics appear to be missing, hidden, or deferred to in reports not included or things left to the future. The text presented supplies words to the page on most of the topics, but those words appear to be words taken from other documents, projects, and books and not put into the context of the issues confronting the NCRN plan or region. One gets little sense of the interconnections between the components or that an overarching plan or strategy exists. The individual chapters are not woven together and seem to have little connection to one another and one gets no vision of how they will help achieve project goals.

- Fundamentally, the reader needs to have a better understanding as to why the chosen vital signs are important to NCRN, the region, and how they will be measured, implemented, reported, and what all that means to the ecology and management of the parks and region.

- It is difficult for me to tell whether there is a flaw in the system that produced this document or simply not put together well. In either case, I don't think it reflects well on the plan and suggests that, at minimum, a new set of authors be brought in to work on the document.

- I have written some general comments below about some of the chapters, but those should be viewed as broad statements of the problem not something that can be fixed with a few words here and there.

Executive Summary

- I would remove almost all of the material presented here and place it under Chapter 1. Elements of the NPS Inventory and Monitoring Program and Vital Signs are presented, but the reader learns almost nothing about the process within NCRN. Listing the component parks is useful, but I think the rest of the section can largely be dispensed with or contracted into a couple of sentences. I think it will be more valuable for readers if the components of Chapters 2 – 10 were briefly listed and summarized.

Chapter 1

1.1.4 It might be useful to mention that Parks East is actually a conglomerate of a number of diverse park units, some of them fairly large.

1.4.2 Actually the Baltimore and Washington Parkway is in the Patuxent River watershed.

1.4.2.3 These are primarily descriptions of the physiographic regions in terms of geology. While these descriptions are accurate, they don't say anything that most people don't already know. I would either simply mention which parks are in which region, or go into more detail as to the biological aspects. I would suggest the former as you are unlikely to enlighten anyone of the readers with general descriptions.

1.4.2.4 Actually the primarly use of fire by Native Americans was to clear the forest understory and keep hunting grounds open. Fire was often used during the hunting process itself. Fire's use in agriculture was comparatively minor. There is good evidence that areas around the Monacacy and the Great Valley were largely fire-maintained grasslands, with only small amounts of woody cover. In addition to water powered sawmills there were lots of additional mills established for milling grain. I think it would be important to mention that most of the Anacostia's thriving wild rice marshes were filled in during the 1900's. The Eastern race of the Peregrine Falcon should be mentioned as having gone extinct (it used to nest in the gorge) and the Bachman's Sparrow (not Bachman's Warbler….it did not occur in the area) has disappeared from the region.

1.4.5 This needs a bit more explanation or the reader will be confused. These are pre-existing monitoring programs that are being run in NCRN that may or may not be incorporated into the Vital Signs network. It would be good to point out that this situation is perfectly fine as the Vital Signs are not meant to take over all monitoring nor preclude additional efforts by the Park units.

1.5 This needs more explanation too. How were the monitoring objectives chosen? You mentioned this briefly in the early part of the report, but it would be good to devote a paragraph to how these were chosen, why, and by whom or point explicitly to where we can read about that process in the document. This seems to come out of the blue.

Chapter 2

- I do not understand this chapter. Everything is far too abstract. Take the first paragraph:
- "Conceptual models are a key element of environmental monitoring programs. They can be used to integrate current understanding of system dynamics, identify important ecosystem processes, facilitate communication of complex interactions, and illustrate connections between indicators and ecological states or processes. Well-constructed conceptual models provide a scientific framework to select indicators for monitoring environmental resources."
- That is all very fine, but how does that relate to NCRW? How does it relate to the mysterious table 1.5? How does it relate to all those people who got together to talk about environmental stressors – the SAC folks? How does it relate to the Board of Directors? Is the model selecting the indicator or people?
- The remainder of the chapter reads as a disjointed set of declarative statements, there is little context here. The issues of determining ecological thresholds and determining cause-effect relationships will be nearly impossible to achieve given the resources the Park have, so I would drop that section also.

- I would suggest starting over. In table 1.5 is a set of monitoring objectives. Why not create a set of flowcharts that shows the major biotic and abiotic components to that system and what the stressors are. Use your own words to describe this and directly link your chosen vital signs to your diagrams. In that way people can see where the notion of monitoring amphibians comes from…..that is, stresses of air pollution, water contamination, habitat loss. Then for each vital sign write a paragraph or two that basically says…The reason this vital sign is important to measure is….. and the Parks will benefit in the following ways once a change is detected……

2.5.10 Not all amphibians need water to complete their cycle, but the statement is true of the species in the NCRN region.

2.5.13 Note that the reason that many of the species have disappeared off of Plummer's Island has largely to do with simple plant succession.

- The coverage of Management Concerns are brief and seem adequate to me, but perhaps others would want to see more details as to specifics per park or at least refer people to appendix 4 for the details per park.

Chapter 4

- This chapter also needs to be rewritten. It appears to be an appropriate sampling design but it uses so much unnecessary insider jargon that few people will be able to understand the approach. Here are a few of the many examples of things to replace with their appropriate English counterparts:
  - Spatially-balanced design
  - Linear segments of a stream
  - Spatially-referenced samples along a line
  - Grid intensity
  - Recursive portioning procedure
  - Inclusion probabilities
  - Parameterize different variance components
- George Bush should be able to read this chapter and understand it.

Chapter 5

- There is no table outlining when each protocol will be implemented and in which parks, nor one that summarizes the PDS documents.
- There is no notion as to what the priorities will be in terms of implementation and budget. It would be nice to see some sort of timeline of activities for evaluating and implementing.
- The objectives listed in the tables in this chapter often do not reference the measurement of change. They might say "track parameters" or "assess visibility." A number of objectives talk about "annual change" when I think they might be more accurately written as assessing long-term changes.
- For amphibians I would suggest something like, "Detect changes in selected amphibian species' populations."

- For birds I would suggest something similar, "Detect changes in species populations of birds." You may want to be more specific however and limit it to breeding species, which seems more feasible than doing all birds.

- For RTE I would suggest, "Detect trends in population or area occurrence for selected species."

- For shoreline features, "Assess long-term changes in shoreline features in tidal portions of the Potomac and Anacostia Rivers."

- The PDS's need to be reworked. The current format is inconsistently applied, some sections are extensive, others not, formats are often slightly different, and the wording often appears to be co-opted from other projects without clear applicability to the NCRN priorities or constraints. I find that at the end I have no real understanding of any of these monitoring efforts other than the group is thinking that it might be a good idea to monitor something about water chemistry, shoreline development, birds, etc.

- The objectives are laid out under the heading: "Specific Monitoring Questions and Objectives to be Addressed by the Protocol." This category is populated by vaguely worded questions and objectives (e.g. What is the status of the watershed). Some of the questions are clearly research not monitoring questions, in particular, those having to do with associations between monitoring variables and correlations with other variables, the effects of deer browsing, etc. In almost all cases there needs to be more details and specifics incorporated into these accounts.

- Almost everything in this chapter is written in the passive rather than the active voice which further adding to the sense of vagueness.

- In the PDS documents there is a lot of loose wording regarding where things will be sampled and the scope of a "measurable objectives." These objectives need to be honed and clarified with more precision and logic. It would be helpful to at least broadly specify the time intervals that the vital sign will be measured (e.g., once a year, only in spring, every 5 years, periodically if money was available), be very specific as to what kinds of species will be sampled (e.g., potential pest species and amphibians are inadequate descriptions as those categories are far too broad), where the samples will take place in each of the park units (e.g., over every square inch, certain kinds of streams, certain habitats).

Chapter 6

- This chapter has some boilerplate language about data management, cast in the broadest of terms, leaving the reader with no information about how data will be managed within NCRN. This chapter needs to be completely redone.

Chapter 7

- This chapter starts out by saying that "Project specific data analyses are discussed in each monitoring protocol (see Chapter 5 for details)." However there are no details about data analyses in Chapter 5 or in the associated PDS documents.

Chapter 9

- The tables in this chapter don't make any sense. The column headings are dates and the reader is left very puzzling over the meaning of a table cell with an "x" in it or not.

Chapter 11

- To save space and paper I would suggest reformatting this chapter into more of a traditional journal format. There are also quite a few formatting issues, spacing, punctuation, incomplete references etc.

Appendix 4

- On page 2 the section under Historic Trees seems like an odd outline element.
- On page 13 you mention that a final report on amphibian monitoring would be produced in 2001.

Appendix 11

- This section appears to need some grooming. In some instances a survey is given a great deal of detail in others, one line. I would suggest that most of the detail be truncated and that the following issues be covered in a sentence or two:

- Species or things covered, how often will the survey run or is planned to run, what geographic coverage does the survey have, what class of survey is it – inventory, ongoing monitoring, report; when was it started, what agency, group, or individual is responsible; and then contact information. Keep the format the same in each case. I would also suggest ordering the information by agency as that would make for more a succinct report. If the species covered were the first category in each section, people could quickly scan through the document for the required information.

- Page 2. The section on the BBS should mention that the Prince William BBS route is a special survey that was created at the request of the Park. This survey follows the protocol of the BBS, but is not part of the random set of surveys used to estimate continental trends. Also note that it should be data "are." Christmas Bird Counts also cover much of Parks East including Greenbelt National Park.

- Page 8. Should be "Anne Arundel."

Appendix 21

- This appendix appears to have some of the species names in the third column missing. See for example those under Antietam.

- There are two figure 2-15's.

- There are quite a number of grammatical errors throughout.

Reviewer No. 2
Overall Organization and Presentation of Monitoring Plan

Is the overall monitoring plan well organized and clearly written?

- This report is well written and coherent. It is well supported with appropriate citations throughout with only a couple of minor omissions noted below. The background really sets the stage for the management issues with which the network must contend. The conceptual model approach is explained thoroughly. The prioritization process could be explained a bit more clearly and concisely with more of a direct connection made to the models. Protocol placeholders are appropriate and consistent. Overall sampling design is explained well, showing obvious forethought. Data management, reporting, scheduling, etc. are all written and supported well, though the summary of the DMP could be more complete. Excellent work.

Executive Summary

Is the executive summary informative of the overall network effort, and does is adequately reflect the content of the final monitoring plan? Do you have any specific recommendations to improve the structure or content of the executive summary?

- The NCRN executive summary is really more of an introduction. While the material is relevant, it really should be more like an abstract from a journal article, summarizing the key processes and findings from each section of the report. What process was used to identify key park and network management questions? What were the key management questions? How were these used to build conceptual models for the network? What was the framework for the conceptual models? How were these used to select and prioritize vital signs? What were the high priority vital signs? Etc. I recommend abbreviating the introductory material (which is very well written) or lengthening the executive summary to include all the key summary material.

Chapter 1 – Introduction and Background

- General introductory information is pretty standard and explains the purpose of the I&M program and its goals adequately. The site map in Appendix 1 is very helpful in placing the parks in context of their locations. I'd recommend having a simpler version of it (state borders and points at least) placed in the text for immediate reference for the reader.

- I think the table that constitutes Appendix 2 is very useful. How are the NPS handbooks relevant to the I&M program and specifically the NCRN?

- Excellent use of citation throughout this chapter!

- Figure 1.1 is helpful.

- You have to tell the reader what BOD and SAC stand for when the switch is made on p. 5.

- Table 1.1 is a good start. Put labels on the columns so that the reader knows what they stand for.

- Appendix 3 is good background information, but I'm not sure it is entirely relevant here given all of the other background materials that could be included.

- Appendix 4 is a brilliant collection of information on each park. Don't bury it in an appendix somewhere. Please summarize (text, tables, figures) it in the main text for the reader so that the context of the NCRN can be realized beyond the framework of the national program.

- I really appreciate the discussion of how the NCRN conducted the 7 step monitoring process, particularly what worked and what did not. But, mostly I liked the discussion of how NCRN dealt with the obstacles. This will be very useful to other networks behind you and to other interested parties reading this in the future.

- Similarly, I think the inclusion of the Phase I and II comments and responses would be very useful to future readers of this report. Thanks for including them.

- Good summary of NPS legislation and park enabling legislation. Very concise. I would recommend reorganizing sections in this chapter based on similar topics, though. So, take the beginning of section 1.4.1 and put it together with earlier mention of legislation that is discussed relative to monitoring. And combine it with the more recent legislation mentioned after the enabling legislation. (So, start big and work down to the network rather than working chronologically.) It seems very incoherent to jump around in this way, giving the text the appearance of disorganization, particularly when the reader has already consulted appendix 2 for relevant legislation. (N.B. –Some of the boiler-plate material Steve Fancy has prepared on his website is available for direct use. This captures all of this very well in a clear and concise manner. I'd recommend using it.)

- Good discussion of the importance of GPRA!

- Excellent summary of the ecological context of the parks and network. I think this presentation would be a good example of information other networks should include in the text to set the stage for the rest of the report (and not bury it in an appendix).

- Very well written and excellent summary of the complex anthropogenic influences in the NCRN. I think this will really assist in the reader's understanding of the conceptual models and park management issues. Very readable.

- Could use a map within the report for references given in the anthropogenic and management issues sections.

- Good summary in table 1.4.

- Appendix 4 has a wealth of information on the network parks, but it could be summarized more effectively into about 10 pages to make it less daunting for the reader.

- Appendix 6 (resources, threats, issues, current and historic monitoring projects, etc.) does a great job of summarizing the information and should be included in the body of the report directly!

- Same for Appendices 10 (air quality table) and 13 (vegetation). Any kind of summary information in a table like this really should be in the text because it summarizes so much information for the reader very quickly and isn't really expounding on existing information summarized in the text.

- In section 1.4.5 (and throughout the report), remember that "data" is a plural word.

- Discussion on monitoring is very good and helps justify why there is a need for an overarching program with standardized protocols, consistency, and solid data management. I think much of this information could be summarized in a table of historical and current monitoring projects by topic which includes reference to which agency/organization does the monitoring.

- Table 1.5 is very helpful and essential. I would include some explanation here of how you got from the park context information and park issues to the monitoring objectives. There is a bit of a quantum leap here. Also note that more refined monitoring objectives should be defined BEFORE the protocols are developed (p. 20) because they should guide the details of what, how, and why you monitor and, hence, the protocol.

Is the material clearly presented such that the average reader will understand why long-term monitoring is being done and be convinced that it is important?

- Initial sections of the chapter are a bit scattered but they come together in the park context sections (with some noted gaps).

Does the plan include a set of monitoring objectives, or a list of monitoring questions, that have an obvious connection to the monitoring goals and provide additional focus and understanding of the purpose of the network's monitoring program?

- They are there but the obvious connection has not been made.

Does the monitoring plan include a good and thorough summary of existing natural resource monitoring work in the parks, the network, and surrounding landscapes?

- This could be summarized more succinctly (see CUPN example in their appendices).

Does the monitoring plan do a good job of describing the process that was used to determine monitoring objectives or questions, develop potential vital signs, and then prioritize and select vital signs to be monitored (additional detail on the process and criteria for ranking vital signs should be put in Chapter 3)?

- Yes. The network does a very good job of summarizing this information. It is a bit out of place with the other materials in the chapter. I recommend some reorganization to make the chapter more coherent.

Chapter 2 – Conceptual Ecological Models

Has the network effectively used conceptual models to help organize, summarize, and communicate complex information?

- Excellent introduction to conceptual models and explanation of the NCRN approach to modeling. Good use of citations to support introductory materials as well as conceptual models.

- All of the drivers, stressors, and biotic and abiotic factors relevant (with an explanation of those not considered as well) to the NCRN were discussed and represented appropriately in the network's models. Ecosystem types for NCRN are captured effectively in Table 2.3. The discussion and accompanying figures and tables do a great job of making the connection to the management and monitoring issues related in Chapter 1.

- Stick more closely to the National Program definitions (e.g., vital signs).

- Figure 2.1 is very helpful in setting the stage for the NCRN conceptual modeling process.

- Figure 2.4 also is helpful as a general upper level model to start with.

- Figure 2.7 the airsheds legend categories need to be color-coded to match the closed curves in the diagram.

- Great use of citations throughout to support models and components. Could use a few more in the discussion of specific air quality factors.

- Excellent discussion of ecological thresholds.

- I feel that the text and supporting materials are very well articulated and informative to the reader. Abbreviating the Chapter 2 discussion may be a goal of the National Program, but I think doing so would be a mistake.

- I don't recall reading a discussion of and reference to the draft models contained in Appendix 15 as part of this chapter. I would summarize the significance of these materials and their relevance to the ecosystem models developed by NCRN. This would be useful to other networks to follow and other interested parties. It also would make the connection to Chapter 3 and help clarify the selection and prioritization process described in Chapter 3.

Chapter 3 – Vital Signs

Does this chapter clearly describe the structured decision-making process and the criteria used by the network to identify, prioritize, and select the vital signs or monitoring questions to be monitored?

- I think this chapter adequately describes the decision-making process. It could use a diagram or flow chart to illustrate the process more effectively and make the discussion easier to follow. Also there could be a brief discussion of how the prioritization process relates back to the conceptual models. This isn't completely clear, but can be guessed at. The way it is written now, though, it seems as if the conceptual models in Chapter 2 were developed and then the brainstorming sessions of the SAC were conducted to generate potential indicators which, in turn, were used to develop additional draft conceptual models. Weren't the models developed to help inform participants as to which indicators would make useful vital signs?

- Why is there a jump from referencing Appendix 16 to Appendix 22 in one page without mention of other appendices in between? It's a bit confusing trying to follow this order after the first 20 appendices were mentioned in Chapter 1. I would take out the mention in the first chapter and keep the numbering related to when the appendices are significantly referenced in the text.

- The section describing the vital signs removed along with the justification as to why this happened is essential and well done. The same goes for the combining of vital signs.

- Table 3.2 includes a summary of the top priority vital signs, relevant measures, and relevant parks in the network. This was very useful.

- Were there any vital signs that applied to a single park only? If so, how were these dealt with in terms of the prioritization process. Were overall network priorities given a greater weight even though the vital sign may have been representative of a significant issue for the park? If not, it would be worth the time to add a sentence that says that most vital signs were consistent across all network parks in terms of priority.

- Overall, this chapter could incorporate a few more tables and diagrams to make the process more understandable and to summarize the resulting information more effectively.

Chapter 4 – Sampling Design

- The network's explanation of their sampling approach for both terrestrial and aquatic systems is excellent. It provides a clear, concise sampling framework and as much detail as can be expected for integration of sampling multiple vital signs.

Chapter 5 – Sampling Protocols

Is there a well-organized table or list that clearly shows which protocols the network plans to implement within the next 5 years and in which parks?

- Information provided includes a table of protocols already being implemented by other agencies or organizations, a table of protocols that already exist but need to be adapted to NCRN, and a table of the five new protocols that need to be developed for NCRN. All tables are very helpful and contain relevant, informative summaries.

Do the Protocol Development Summary documents for protocols that are still in development follow the program guidance and include (1) a strong justification statement, (2) a set of objectives that meet the test of being realistic, measurable and specific, (3) the approach to be followed, (4) a list of parks where the protocol will be implemented, (5) a schedule and budget for protocol development, and (6) the name and contact information for the cooperator/contractor who will conduct the work and the lead NPS person responsible for ensuring that the work is done? For each protocol, has the target population or "sampling frame", and the sampling units, been identified?

- All PDSs follow a standard, consistent format that includes each of these elements.

Chapter 6 – Data Management and Archiving

Does the plan provide an overview of the agreed-upon process for entering, editing, storing, and archiving data collected by the various components of the monitoring program, including metadata procedures? For most networks, this chapter will duplicate or be largely the same as the executive summary of the network's data management plan. The full Data Management Plan should be posted on a website or attached as an appendix.

- The full data management plan is included with the report as a separate document. The summary given in this chapter gives a good overview of the goals of the data management plan but doesn't address all the components that the full executive summary from the DMP does, including metadata. I would recommend--as the guidelines here suggest--including the entire executive summary from the DMP.

Does Chapter 6 provide an overview of the network's role in overall management of I&M and other datasets, as well as summarize the key aspects of data management that are presented in more detail in the data management plan and individual protocols?

- No, there is only some mention of the potential expansion of the network's data management role to other natural resource information.

Chapter 7 – Data Analysis and Reporting

Does this chapter give a good summary of the various reports and other products of the monitoring effort, including a summary of the intended audience for each report, content, reporting schedule, and who is responsible for ensuring that data are analyzed and reported in a timely manner?

- The text and Table 7.1 do this very effectively.
- I think the idea of an I&M quarterly newsletter is brilliant and should be required (strongly suggested) of all I&M networks. After all, if I&M efforts aren't being communicated to other NPS programs, etc., there isn't much sense in having I&M.

Is there a summary table or brief narrative (details should be in the individual protocols) that describes who is responsible for analyzing the data for each vital sign, and the basic approach that will be followed?

- Yes, Table 7.2.
- This section and the data management plan do not have a mechanism or hierarchy for dealing with a response to an issue that needs immediate attention. For example, there is no mention of a means to disseminate information within a park, across parks, across networks regarding the detection of an invasive species or the outbreak of a new species or population of a forest pest. The shipment of nursery stock infested with sudden oak death from the CA to the East Coast would be a recent example.

Chapter 8 – Administration/Implementation of the Monitoring Program

Does the plan include a brief listing of the members of the network Board of Directors and Technical Committee (and Science Advisory Committee if it exists), and describe their roles?

- The organizational charts (figures 8.1 and 8.2) are particularly helpful in illustrating the groups involved and their responsibilities, and the positions involved, respectively.
- All of the key components are presented well and explained adequately, including integration with other programs. Does the network integrate or provide technical assistance to the Exotic Plant Management Team? They will need assistance with effectiveness monitoring in the near future.

Chapter 9 – Schedule

Is there a schedule that identifies the target completion dates for protocols still to be developed, or for other tasks that have not yet been completed?

- Yes. Effective.

Is there a figure or table that summarizes the frequency of sampling for each of the protocols, and identifies key events for the monitoring program?

- There is a table that identifies implementation dates for the protocols with reference to specific dates in the protocols for frequency of sampling. It would be helpful to have a chart illustrating the sampling dates of the different protocols side-by-side.
- There also is a table of key events in the NCRN monitoring program.

Chapter 10 – Budget

[Optional] Is there an overall budget that summarizes the annual and periodic costs of the monitoring program? (the budget should use the same categories as in the annual administrative reports and work plans).

- Yes.

[Optional] At least 30% of the funding the network receives from the monitoring program, in terms of funding and network staff time, must be directed to data management, analysis, and reporting. Do the staffing plan and budget demonstrate that adequate resources have been allocated to these activities?

- Not readily apparent that this is so.

Chapter 11 – Literature Cited

Are all of the literature citations placed in this single chapter and consistently formatted? (We recommend that literature citations follow the format and punctuation style used in the journal Ecology).

- An excellent set of citations, brilliantly used throughout. The format of the citations is consistent, but it is bit out of sorts in the digital version most likely because of page margin changes.

Reviewer No. 3
Overall Organization and Presentation of Monitoring Plan

Is the overall monitoring plan well organized and clearly written?

- The writing and organization of this plan could be improved. Certain chapters flowed pretty well, others seemed quite long and bulky. Further details on which chapters could be improved in which ways appear in the following text. Engaging the help of a technical writer could help shape the plan up quite a bit. Chapter 4 needs technical help as well.

Executive Summary

Is the executive summary informative of the overall network effort, and does is adequately reflect the content of the final monitoring plan? Do you have any specific recommendations to improve the structure or content of the executive summary?

- It is pretty good – probably all but the last paragraph should be kept. The summary doesn't get to the "meat" of the plan though – it needs to mention that 21 vital signs were selected, possibly listing what they are. Then it needs to briefly address what will be done now, and how the parks and the public will all benefit from this – why should we keep this program? Tell us how we have no choice but to push on with this wonderful effort!

Chapter 1 – Introduction and Background

- Overall, Chapter 1 covers the information necessary, but could benefit from streamlining and better organization. All of the necessary information is covered between this chapter and the supporting appendices, but the reader is expected to flip back and forth between the text and appendices a lot. Several of these appendices could be summarized briefly in the text to save on this flipping back and forth, specifically Appx 4 (park summaries), Appx 6 (summary of threats, mgmt issues, current monitoring and needs), Appx 11 (existing monitoring). There is too much detail given on the 7-step process undertaken for development of the program, the reader gets lost in the details. It is not necessary to describe the composition of the Board of Directors or the makeup of the staff at this point – these topics are covered in later chapters. All of the references to the various appendices again create a lot of flipping back and forth, and in several cases it is too early in the report to be referencing all of this information. For example, save the references to appendices on vital signs were selected for Chapter 3. Keep this description brief and concise, go into more details in later chapters.

Does the monitoring plan (and any supporting documents or appendices) include a good and thorough summary of legislation, NPS policy and guidance, Servicewide and network-specific strategic goals for performance management relative to VS monitoring, and elements from park enabling legislation relevant to VS monitoring?

- Yes, this information all appears in Chapter 1, but the text bounces around. GPRA and park legislation are mentioned very briefly early on with NPS policy and guidance, but no discussion is made of specific park GPRA goals or how the I&M program helps the parks to meet these goals at this point. Then park legislation and GPRA goals are summarized nicely in tables several pages later. So the information is all there, it just seems disjointed and jumpy.

Is the material clearly presented such that the average reader will understand why long-term monitoring is being done and be convinced that it is important?

- Yes, section 1.1.1 sounds quite familiar – good justification for monitoring.

[Optional] All networks are required to use the 5 Servicewide monitoring goals (not the I&M programmatic goals) as THE goals for monitoring, as opposed to developing their own goals. Did they clearly present the Servicewide goals as the goals for monitoring? If any additional goals are presented, is there a darn good/convincing reason for them?

- The Servicewide goals were included; need to capitalize "Congressional" in 4th goal, four other objectives were added, with no justification

Does the plan include a set of monitoring objectives, or a list of monitoring questions, that have an obvious connection to the monitoring goals and provide additional focus and understanding of the purpose of the network's monitoring program?

- Yes, Table 1-5 neatly states the network's monitoring goals by the Level 1 category from the VS Framework.

Does the monitoring plan include a good and thorough overview of park and network natural resources and describe their local, regional, and broader significance?

- Yes, this section in Chapter 1 is a good, concise synthesis of the resources, their context, and significance. Much more information appears in Appendices, and this is how info throughout the chapter should appear – a neat summary in the text, more details in appendices.

[Optional] For air quality monitoring, is there a table or some clear, thorough presentation of all existing air quality monitoring within the network? Are Class I air quality parks in the network identified?

- Appx 9 provides a summary of air quality monitoring, conditions, and trends in NCRN parks. Table 10 is a summary of air quality monitoring in the parks – this is easier to digest than the text and could even go in the main body of the report.

[Optional] For water quality monitoring, is there a table or some clear, thorough presentation of all waterbodies within the network that are listed on State 303d list, or are Outstanding Natural Resource Waters or have other special protective status?

[Optional] For water quality monitoring, has information content of available past aquatic data (for each waterbody being considered for monitoring) been adequately summarized in terms of hints of trends or other important issues of concern?

Does the monitoring plan include a good and thorough summary of important natural resource management and research issues for each park, the network, and surrounding landscapes?

- Appendix 4, Park Summaries detail parks' most valuable resources, threats and management issues, existing monitoring and needs, and current research and needs by park, sufficiently covering this information.

Does the monitoring plan include a good and thorough summary of existing natural resource monitoring work in the parks, the network, and surrounding landscapes?

- Appendix 11 is a very thorough summary of existing monitoring in parks and surrounding areas. There is no such summary of past monitoring efforts.

Does the monitoring plan do a good job of describing the process that was used to determine monitoring objectives or questions, develop potential vital signs, and then prioritize and select vital signs to be monitored (additional detail on the process and criteria for ranking vital signs should be put in Chapter 3)?

- text on 7-step process seems very long (redundant with later chapters?) – could be streamlined considerably

Additional Notes

- need to reference Appx 1 (map of network parks), or better yet, put it in the main text; also, text on map is so tiny – can't really read it!
- should use the NPS definition of a vital sign rather than Feinsinger's (2001), as the NPS definition is broader
- info on NCRN staff (section 1.1.5) probably belongs better in Ch 8
- info on the BOD (p 1-5) and SAC (p 1-6) belong better in Ch 8

Chapter 2 – Conceptual Ecological Models

Has the network effectively used conceptual models to help organize, summarize, and communicate complex information?

- The network has thoroughly discussed system stressors, effects, and interactions and their links with selected vital signs. The diagrams do help summarize some of the information; I'm not certain how effective these really are. The chapter is long and bulky, there may be ways to streamline this information. The Jenny-Chapin model is a good basic synthesis.

Have the major ecosystems within the network of parks been identified?

- Rather than working at the ecosystem level, the network developed resource-based models, focused around air and climate, geology and soils, water, aquatic biota, and terrestrial biota. This seems like a logical categorization, and some effort is made to address linkages across the groups.

Have the major ecosystem drivers been identified?

- Yes, these are summarized in several of the figures.

Have both biotic and abiotic (air, water, and geological resources) ecosystem components/drivers been identified?

- Yes, the Jenny-Chapin model, which is the "broad overview" model encompasses both biotic and abiotic system drivers. Additionally, the categories described for resource-based models cover both biotic and abiotic drivers.

Are the conceptual models sufficiently detailed to provide support for selecting, justifying, and interpreting potential vital signs?

- The models do demonstrate straightforward links between ecosystem stressors and drivers and the selected vital signs.

Are the tables and figures, and the narrative supporting the tables and figures in this chapter, clear, complete, and understandable?

- Yes, the figures are straightforward and fit well with the supporting text.

Is relevant literature cited; do citations provide valid, credible, and sufficient scientific justification for the models?

- The citations for the summaries seem sufficient.

Is the treatment and presentation of conceptual models systematic, synthetic and integrative such that interactions within and linkages among ecosystems are described?

- Interactions and linkages are explicitly described under each resource model.

Additional Comments

- In more than one place, the network highlights the utility of conceptual models to test causal hypotheses. Monitoring does not help establish causality, nor is its intent to test hypotheses. This should be reworded.

Chapter 3 – Vital Signs

Does this chapter clearly describe the structured decision-making process and the criteria used by the network to identify, prioritize, and select the vital signs or monitoring questions to be monitored?

- Yes, the ranking system/consensus-based approaches are described sufficiently. Sections 3.3.1-3.3.8 could be combined to streamline this section – address it as "here are the workgroups that did not strictly adhere to the quantitative process…"

- Table 3-1 is a good way to present vital signs that have been removed since the Phase II plan, with very short justification for their removal. The supporting text could be placed in an appendix, as it is not as critical to the main message of this chapter.

Is there a single list of vital signs that is consistent with the vital signs framework scheme and clearly shows the resulting "short list" of vital signs, including vital signs monitored by other programs and agencies? The list may include vital signs that the network hopes to implement in the foreseeable future, but may not currently be able to fund.

- Yes, Table 3-2 presents the network's 21 vital signs in the Framework table, including those monitored by other agencies.

Is there some obvious connection between the conceptual models and the high-priority vital signs that were selected for implementation?

- Yes, in the figures in Chapter 2, the conceptual models tie in directly with the selected vital signs.

Are the high-priority vital signs all adequately justified through either the narrative or conceptual models, such that the average reader will be convinced of the value of them being monitored?

- Yes, the text in Chapter 2 describes ecosystem stressors, drivers, and effects sufficiently such that the vital signs are justified.

Additional Comments

- The first sentence in section 3.5.4 is worded strangely, and sends the wrong message. A better wording could be something like, "Final costs for vital signs monitoring will be determined during protocol development."

Chapter 4 – Sampling Design

Has the network provided an overall sampling design that promotes integration of the various monitoring components over the long term and allows inferences to be made beyond the areas actually sampled? [The details of the sampling design for each protocol will go in the sampling protocols are not needed here, but "big picture" decisions on co-locating sampling of vital signs, and decisions to stratify or not stratify the park should be included in this chapter.]

- This is difficult to say… it appears that the network is going with a grid design, but then discusses GRTS, and doesn't really discuss how either one will be implemented very well (see specific comments below).

Is there an adequate description of any decisions to stratify or not stratify the park for various monitoring components?

- Is NCRN using stratification?? Mention is made in section 4.5 of strata, but these strata are not defined, it is not clear whether stratification will be used for any or all of the vital signs, and there is no justification for using stratification. Stratification can be very dangerous, as strata can change over time (especially vegetation types – which where the ones mentioned here). Upon further investigation of Table 4-3, I'm wondering if all of this can be avoided by simply not using the word "strata" in this text and table, as it appears the network isn't actually implementing stratification.

[Optional] For water quality monitoring, does the plan contain a network map that shows the location of waterbodies to be sampled and an accompanying table that briefly summarizes the parameter(s) to be sampled at each site, sample frequencies, who will collect the samples, and the protocol(s) to be used? Additional protocol-specific details (such as a map that shows the detailed location sampling sites within each waterbody) should be placed in each protocol, but a brief overview of the overall sampling design (within the network as a whole) should be included in this chapter.

[Optional] For water quality monitoring, data representativeness typically must be documented as a quality assurance basic. Does the plan (or the protocol for water quality monitoring that is referenced by the plan) adequately explain how the sampling scheme chosen will insure that the values obtained will be representative of the target population being studied? Is the sampling design appropriate to help answer previously identified questions?

Additional Comments

- Introduction: the report states that it is daunting to select sampling locations such that inferences can be made over the entire region because the region is so large and diverse. The size and diversity should have nothing to do with inference; if a sample is randomly located, inference can be made to that entire population.

- The report states that several of the parks in the network are composed of several units and that these units "may or may not have significant biological resources." This sounds like a personal judgement – is there information or data to back this statement up? Figure 4-1 is referenced with this statement, but this map has nothing to do with the significance of the resources.

- Why are there 2 different grid sizes?

- The description of the use of GRTS to select samples along a line was confusing – are you confusing two different methods here?

- How do the grids relate to sampling locations?

- The description of sample selection for aquatic systems is pretty good, but the supporting figure and table do not help make the points more clearly. If a figure is desired that demonstrates the network's approach (as the text claims), a figure more like that which appear's in Tony Olsen's work fits better – one which shows the ordering of the stream segments and then the selection of sites using step size "k" along this line of stream segments. I'm not sure why table 4-1 is included; it's not that helpful.

- The description of the generalized sampling objectives for aquatic systems is good, this sort of description could be broadened to encompass terrestrial sampling as well, since there is no such description for these vital signs. However Table 4-2 tells us nothing.

- The description of trends in biological components in aquatic systems doesn't belong here – this section should be about sampling design. Instead, this paragraph states the monitoring objectives and the protocol that will be used. If the protocol specifies the sampling design, then it should be discussed – as well as how that sampling design fits within the overall sampling design (or doesn't).

- The introduction to Section 4.5 uses the word "protocol" a lot, in context that doesn't make sense and leads me to believe the author misunderstands the term. Did you mean *sampling methods* rather than *protocol methods* in the first paragraph? Did you discuss existing protocols at the workshop? Or potential sampling methods?

- Section 4.5 is entitled, "Stratification and Collocation", but collocation isn't addressed until section 4.6.

- Section 4.6.1 – inappropriate use of the word "protocol" again – a protocol is a detailed account of how the sampling will take place, what will happen with the data, etc… so you aren't actually collocating the protocols (which are paper documents), you are collocating the sampling locations for these vital signs.

- Table 4-3 gives sample sizes for various vital signs – how were these selected? There is no discussion of how "step size 'k'" was actually selected for any VS's.

Chapter 5 – Sampling Protocols

[Note to Peer Reviewers: The actual protocols will be reviewed separately by experts in the particular field. Many of the protocol documents, which must follow the standards published by Oakley et al. (2003), are still in development. However, please give special attention to the Protocol Development Summary documents included with this plan, which are required for all protocols to be implemented within the next 5 years.]

- Chapter 5 is pretty bare-bones, though the required information is mostly there. The introduction states that this chapter covers how protocols will be developed and expected completion times, but this information doesn't actually appear in the chapter. It would be helpful to the reader to briefly summarize this information (that appears in the PDSs) in the main text – state things like, "NCRN anticipates collaboration with external cooperators for the development of XX protocol…"

Is there a well-organized table or list that clearly shows which protocols the network plans to implement within the next 5 years and in which parks?

- Not explicitly – vital signs are split into 3 tables: those for which protocols already exist (for other agencies), those for which protocols need to be adapted, and those for which nothing currently exists. There is no mention of which protocols will be implemented when – the reader is left to assume that the ones that already have protocols are those which will receive attention first. There is also no indication of which vital signs will be monitored in which parks in this chapter.

- The first two tables are also a bit confusing…it took me a while to realize several protocols were submitted with the plan… maybe it was just me, but I thought that that key point wasn't highlighted well.

Does the chapter, at a minimum, include a table that summarizes key information from the protocols or Protocol Development Summary documents for each protocol to be developed? Key information should include the name of the protocol, a brief justification statement, the specific measurable objectives of the protocol, a list of the parks where it will be implemented, and a link to the protocol or PDS document.

- Justification and objectives for the various vital signs appear in tables 5-1 through 5-3. Names of associated protocols and a list of parks are missing. PDSs appear in Appx 23 and cover all relevant/required information.

Do the Protocol Development Summary documents for protocols that are still in development follow the program guidance and include (1) a strong justification statement, (2) a set of objectives that meet the test of being realistic, measurable and specific, (3) the approach to be followed, (4) a list of parks where the protocol will be implemented, (5) a schedule and budget for protocol development, and (6) the name and contact information for the cooperator/contractor who will conduct the work and the lead NPS person responsible for ensuring that the work is done? For each protocol, has the target population or "sampling frame," and the sampling units, been identified?

- All of the PDS's include the justification statement, objectives, an approach, and the parks where it will be implemented. Not many have a budget or a timeline. Comments for specific PDS's appear below:

Ozone	• These objectives could be more detailed. What sort of trends do you want to monitor – annually, monthly, weekly, hourly? Do you care how ozone concentrations track with meteorological variables or other vital signs?
	• What is the approach the NCRN is taking? The PDS states the agencies currently monitoring ozone, but it needs to address what NCRN will do to get that data, what it will do with the data once they get it, etc.
Visibility and PM	• What sort of trends do you want to monitor – annually, monthly, weekly, hourly? Do you care how PM concentrations track with meteorological variables or other vital signs?
Mercury	• The monitoring objectives don't totally match the monitoring questions.

Weather/Climate	• One of the objectives is to try to get at causality – this is wrong. • Third monitoring question is more of a research question than a monitoring question • Development schedule needs to be updated to reflect work done prior to Phase III plan submission
PHI	• what about trends? Only status is mentioned in monitoring objectives
Surface Water Dynamics	• the monitoring questions are good – but not all of the questions are captured in the objectives
Water Chemistry and Water Nutrients	• the monitoring questions are good – but not all of the questions are captured in the objectives
Aquatic Macroinverts	• the monitoring questions are good – but not all of the questions are captured in the objectives • what about trends? Not addressed in objectives
Fish	• the monitoring questions are good – but not all of the questions are captured in the objectives • what about trends? Not addressed in objectives
Invasive Plants	• what about trends?
Insect Pest Species	• several of the questions are more research questions than they are monitoring questions
Landscape Dynamics and Land Cover Change	• these objectives sound more like steps in an analysis – can be worded more briefly and more like long-term monitoring objectives

Chapter 6 – Data Management and Archiving

[Note: Each network must submit a separate Data Management Plan. Our advice was to take the executive summary of that detailed Data Management Plan and include it here as Chapter 6. Data Management, Data Analysis, and Reporting are a big deal for us. At least a third of the network's resources, in terms of staff time and funding, must be to directed to ensuring that once data are collected, that they are managed, archived, analyzed, and reported to various audiences.]

Does the plan provide an overview of the agreed-upon process for entering, editing, storing, and archiving data collected by the various components of the monitoring program, including metadata procedures? For most networks, this chapter will duplicate or be largely the same as the executive summary of the network's data management plan. The full Data Management Plan should be posted on a website or attached as an appendix.

- This chapter gives the sense that appropriate attention is being given to the issues of data quality, security, longevity, availability and integration. The summary highlights the criticality of proper data treatment and the importance of sufficient documentation. There is not enough detail to ascertain from Chapter 6 what the agreed-upon processes for entering, editing, storing, or archiving data will be. It does appear that this chapter consists of the Executive Summary from the DMP. Some more detail on the hardware structure; the flow of information; the roles played by different individuals over the life of a project to ensure proper data handling, documentation, and archiving; and the data editing process would help this chapter. The purpose of this chapter is to demonstrate that

NCRN has carefully considered the issues of data management and has a viable long-term plan in place to ensure the data are useful for the life of the program. Therefore, more details along these lines are needed.

Is the full data management plan for the network attached as an appendix or supporting document?

- Yes – supporting document

[Optional] Specifically for water quality monitoring data, does the plan specify how that data will be reported to WRD for entry into the Environmental Protection Agency's STORET database?

- No, this is not addressed within the Phase III Monitoring Plan, maybe it is in the DMP

Does Chapter 6 provide an overview of the network's role in overall management of I&M and other datasets, as well as summarize the key aspects of data management that are presented in more detail in the data management plan and individual protocols?

- In broad terms, the network's role in data management is addressed. The key aspects of data management are also discussed in general terms. The text isn't specific enough to differentiate between I&M data and external datasets, but it is understood that the same aspects apply. This component seems to be sufficiently addressed.

Chapter 7 – Data Analysis and Reporting

- This chapter provides the required information, but seems a little weak – less writing could be spent detailing the various reports and more could be given to the network's overall approach to data analysis and information sharing, making sure that the proper messages reach the right ears. The sections on scientific presentations and publications probably don't need to list the anticipated journals or meetings, as this should be obvious, given the various audiences. There also should be stronger assurance that appropriate staff time and budget will be set aside for data analysis, management and reporting – going back to that 30% (or more) rule.

Does this chapter give a good summary of the various reports and other products of the monitoring effort, including a summary of the intended audience for each report, content, reporting schedule, and who is responsible for ensuring that data are analyzed and reported in a timely manner?

- Table 7-1 summarizes several types of reports and communications, which are further discussed in the text. Some of this supporting text is redundant and could be streamlined. Yes, the components required for each type of communication appear in this table. Some of these types of reports need further explanation. For example, where do Final Project Reports come from? Are these projects specific to protocol development, or some projects of some other origin? Also, for Data Analysis and Synthesis reports, it is stated that data will be analyzed every 3-5 yrs. It seems data should be summarized at least annually, even if briefly, to determine whether there are any problems with data collection. Additionally, park staff and the public would likely be interested in annual summaries of various datasets, if at least out of general curiosity.

- The Program and Protocol Review Reports section states that protocols are subject to review ever 5 yrs. However, there is no mention that protocols must undergo peer review before operational monitoring is implemented – this would be worth including.

Is there a summary table or brief narrative (details should be in the individual protocols) that describes who is responsible for analyzing the data for each vital sign, and the basic approach that will be followed?

- Table 7-2 provides a list of the vital signs along with individuals responsible for preparing analysis and synthesis reports, brief analyses, and reporting cycle. The report does not address quantitative or qualitative methods that will be used to perform the types of analyses desired, making me wonder if NCRN has given these much thought. The reporting cycle for many of the vital signs is every 5 years, which seems long. It is fair to admit that trends cannot be ascertained well from year to year due to natural variation, but it is still worth synthesizing the data on a shorter interval to ensure protocols are working properly and data are not corrupt.

Chapter 8 – Administration/Implementation of the Monitoring Program

Does the plan include a brief listing of the members of the network Board of Directors and Technical Committee (and Science Advisory Committee if it exists), and describe their roles?

- The roles of these groups are described sufficiently, but there is no listing of the members of any of these groups.

Is there a staffing plan for the network that summarizes the role and responsibilities and duty station of staff involved in the monitoring program?

- Yes, the roles, responsibilities, and duty station is described for the current I&M staff members. The plan states that several of the I&M staff members are currently term positions. There is no mention of how long these terms will last, or of whether these positions will be made permanent at some time. A discussion of the network staffing plan into the future would enhance this chapter a great deal.

Is there a brief description of how the monitoring program integrates with other park operations such as interpretation, law enforcement, and maintenance?

- This part is not well addressed. The network commits itself to reporting findings and results to various groups including Administration and Interpretation. This will mainly occur through various meetings – Board of Directors, GIS work group, and Interpretation group. The ways in which I&M will support these operations is not clear, and I am not convinced from this report that there will be integration beyond I&M generating reports that will be given to the various groups. This network has a lot to work with, as they have a Learning Center and a Museum in close proximity. The report names several individuals and commits to working with them, but a more in-depth summary of the specific ways in which they can benefit from their coordination would help this section a lot.

Is there a listing or other summary of key partnerships with agencies and individuals that are part of the monitoring program, and a list of relevant cooperative agreements and other partnership agreements?

- No, there is no mention of partnering agencies or cooperative agreements. Members of regional and park staff that support the program are mentioned, but from this report, it appears that I&M is not partnering with other agencies. I'm sure that's not true; those partnerships and the benefits of them should be highlighted here.

Does the plan discuss the need for periodic reviews of the overall monitoring program as well as individual protocols or other components?

- The discussion of the plan for periodic program review is sufficient.

- The Program and Protocol Review Reports section states that protocols are subject to review ever 5 yrs. However, there is no mention that protocols must undergo peer review before operational monitoring is implemented – this would be worth including.

Chapter 9 – Schedule

- Chapter 9 is weak. The information that needs to be communicated can be summarized in tables, but there needs to be at least some supporting text to explain and clarify what appears in the tables. Additionally, some information is missing.

- What is table 9-1 trying to communicate? It doesn't make sense at all.

- Is there a schedule that identifies the target completion dates for protocols still to be developed, or for other tasks that have not yet been completed?

- Is there a figure or table that summarizes the frequency of sampling for each of the protocols, and identifies key events for the monitoring program?

- I think table 9-2 is trying to communicate when protocols will be implemented and the frequency with which they will be sampled, but this is not clear either from the table content or the title. This needs some work.

- I'm guessing that Table 9-3 was added to address "key events for the monitoring program", but this doesn't really fit here – at least not with sufficient supporting text. This information is redundant with what appears in Chapter 7 and 8. "Key events" are more likely landmarks such as a draft protocol is prepared, field testing begins, protocol is reviewed by peers, operational monitoring begins.

Chapter 10 – Budget

[Optional] Is there an overall budget that summarizes the annual and periodic costs of the monitoring program? (the budget should use the same categories as in the annual administrative reports and work plans).

[Optional] At least 30% of the funding the network receives from the monitoring program, in terms of funding and network staff time, must be directed to data management, analysis, and reporting. Do the staffing plan and budget demonstrate that adequate resources have been allocated to these activities?

Chapter 11 – Literature Cited

Are all of the literature citations placed in this single chapter and consistently formatted? (We recommend that literature citations follow the format and punctuation style used in the journal Ecology).

- Kind of a strange way to format them, but the information is there…

Nit-picky stuff/typos:

- when listing several references in the same citation, put citations in chronological order

- verb tense often shifts over the course of a paragraph

Chapter 1	•	need column headings on Table 1-1
Chapter 4	•	p. 1, last paragraph: change “subdivide” to “subdivided”
Section 4.6.1	•	, first sentence: missing and “of” between “pairs” and “vital signs”
Chapter 5	•	Table 5-1: title is a little misleading… these are monitoring efforts that were initiated years ago, so to say they are “being implemented” is inaccurate.
Chapter 8	•	p. 8-5, under “Biotechnician”: remove “serves”

Reviewer No. 4
Air Quality Reviewer

Chapter 1 – Introduction and Background

[Optional] For air quality monitoring, is there a table or some clear, thorough presentation of all existing air quality monitoring within the network? Are Class I air quality parks in the network identified?

- Yes to both.

Specific Comments on Chapter 1

Pages 1-19 and 1-20 – NADP monitors wet deposition only. Dry deposition is monitored by CASTNet. CASTNet does also monitor ozone; however, the ozone data collected by states and local governments, i.e., MD, VA and DC, are not associated with CASTNet. Those data are entered into an EPA database (http://www.epa.gov/air/data/reports.html . The correct spelling is IMPROVE.

Chapter 2 – Conceptual Ecological Models

Has the network effectively used conceptual models to help organize, summarize, and communicate complex information?

- The conceptual models are too generic to provide any meaningful information.

Have both biotic and abiotic (air, water, and geological resources) ecosystem components/drivers been identified?

- Yes for air and water.

Are the conceptual models sufficiently detailed to provide support for selecting, justifying, and interpreting potential vital signs?

- No.

Are the tables and figures, and the narrative supporting the tables and figures in this chapter, clear, complete, and understandable?

- No, most need some explanatory text.
- Table 2-1 – How do air pollutants affect hydrology?
- Figure 2-6 and 2-8 – Ozone (stressor) affects vegetation and human health (response variable).
- Page 2-13 – Should mention that ozone affects human health. This is a significant issue relative to NCRN parks. While it's not NPS's responsibility to protect human health (that responsibility lies with EPA and the states), many argue that NPS does have a responsibility to inform visitors and employees about unhealthy ozone levels in parks.

Chapter 3 – Vital Signs
Specific Comments on Chapter 3

- Page 3-7, Chlorotic Mottle – Need to clarify that monitoring foliar injury does not adequately indicate physiological or ecological impacts. It does indicate ozone levels are elevated and that such effects could be occurring. Need to provide further explanation of ARD research project or simply say that the issue will be revisited if future research indicates foliar injury monitoring is an appropriate indicator of ecological response.

Chapter 5 – Sampling Protocols

Is there a well-organized table or list that clearly shows which protocols the network plans to implement within the next 5 years and in which parks?

- Yes.

Does the chapter, at a minimum, include a table that summarizes key information from the protocols or Protocol Development Summary documents for each protocol to be developed? Key information should include the name of the protocol, a brief justification statement, the specific measurable objectives of the protocol, a list of the parks where it will be implemented, and a link to the protocol or PDS document.

- Table 5-1 – Justifications are appropriate. Suggest rewording objectives so they are consistent. In essence, the objective is the same for all of these vital signs: track concentration or deposition and trends of each vital sign at a regional scale. Lead agency for ozone is EPA (delete CASTNet). For wet and dry deposition, suggest using N and S in objectives because wet and dry monitors measure different ions. Lead agency for wet and dry deposition should be NADP and CASTNet. Under objective for visibility, fine is misspelled. Also, states monitor fine particles independent of IMPROVE. Is the Hg fish tissue sampling already being implemented by another agency? Who? It is not MDN.

Do the Protocol Development Summary documents for protocols that are still in development follow the program guidance and include (1) a strong justification statement, (2) a set of objectives that meet the test of being realistic, measurable and specific, (3) the approach to be followed, (4) a list of parks where the protocol will be implemented, (5) a schedule and budget for protocol development, and (6) the name and contact information for the cooperator/contractor who will conduct the work and the lead NPS person responsible for ensuring that the work is done? For each protocol, has the target population or "sampling frame", and the sampling units, been identified?

- Ozone PDS – No mention of budget or schedule. Suggest changing primary data source from CASTNet to "EPA".

- Wet Deposition PDS – Second monitoring question. I'd be more comfortable with changing "contributing to" to "correlated with". While it would be relatively straightforward to assess the contribution of N and S deposition to water and soil changes, there could be a lot of difficulty determining how much a change in deposition affects invasive species. The NPS GPRA trends report only analyzes data from NPS NADP sites. Since the majority of NADP sites in the NCR region are not NPS sites, you will not be able to rely on the GPRA report for the trend analyses. NADP does post individual site trend analyses on their website. No mention of budget or schedule.

- Visibility PDS – PM2.5 and O3 should be sub- not super-scripted. Measurable objective: how is PM2.5 going to serve as an indicator for climate-related stressors? No mention of climate in the justification. No mention of budget or schedule.

- Mercury Deposition PDS - Monitoring question 2: What "other indicators"? Fish tissue is the only indicator discussed in the justification. List the MDN sites that will be used for the analysis. Need more detail on the mercury mapping model, including the variables used in the model and how the model will be applied to NCRN. No discussion of the fish tissue analysis protocol development. No mention of budget or schedule.

Chapter 7 – Data Analysis and Reporting

Is there a summary table or brief narrative (details should be in the individual protocols) that describes who is responsible for analyzing the data for each vital sign, and the basic approach that will be followed?

- Table 7-2: For ozone, wet and dry deposition, visibility and mercury, I suggest saying you'll be analyzing regional concentrations, deposition and trends and evaluating the potential for ecological effects. For ozone, add "exceedances of the human health-based standard". For wet and dry deposition, use N and S, and add "CASTNet dry deposition sites". If the intent is to look at long-term trends in weather as stated in Table 5-1, why the necessity to produce annual reports?

Reviewer No. 5 — Geologic Resources Reviewer
Review of National Capital Region Network Vital Signs Phase 3 Monitoring Plan

Overall Organization and Presentation of Monitoring Plan

- Since the plan is so big, it would be helpful to have tabs inserted for each of the appendices so that the reader can easily find the material he/she is looking for.

Executive Summary

- Good concise executive summary – since this is generic it could be used in all of the phase 3 reports.

Chapter 1 – Introduction and Background

Does the monitoring plan include a good and thorough overview of park and network natural resources and describe their local, regional, and broader significance?

- This information is well presented in Appendices 4 and 7 of the report.

Does the monitoring plan include a good and thorough summary of important natural resource management and research issues for each park, the network, and surrounding landscapes?

- Section 1.4.4 lists the major stressors in the network. Appendix 6 lists the issues and resource management needs in each park, but does not have a separate summary of the research issues.

Does the monitoring plan include a good and thorough summary of existing natural resource monitoring work in the parks, the network, and surrounding landscapes?

- This is presented in Appendix 6 and is very well organized.

Chapter 2 – Conceptual Ecological Models

- The conceptual models mention the role of geology but do not really address the role that weather plays in affecting the geology of the network. Geologic hazards (landslides, rockfalls, streambank erosion) associated with weather events and land uses have an effect on park resources, particularly at Harper's Ferry and should be incorporated into the conceptual models in some way.

Have both biotic and abiotic (air, water, and geological resources) ecosystem components/drivers been identified?

- Yes

Chapter 3 – Vital Signs

- The justification to remove geo-hazards from the vital signs list is weak. Stating that the park is only concerned with visitor safety does not take into account that when a landslide or rockfall occurs, it also has the potential to effect park resources. Monitoring potential geohazards should be within the scope of the I&M program.

Is there a single list of vital signs that is consistent with the vital signs framework scheme and clearly shows the resulting "short list" of vital signs, including vital signs monitored by other programs and agencies? The list may include vital signs that the network hopes to implement in the foreseeable future, but may not currently be able to fund.

- There is a list of vital signs that is consistent with the vital signs framework.

Chapter 5 – Sampling Protocols

Is there a well-organized table or list that clearly shows which protocols the network plans to implement within the next 5 years and in which parks?

- This is shown in Chapter 3 Table 3-2

Does the chapter, at a minimum, include a table that summarizes key information from the protocols or Protocol Development Summary documents for each protocol to be developed? Key information should include the name of the protocol, a brief justification statement, the specific measurable objectives of the protocol, a list of the parks where it will be implemented, and a link to the protocol or PDS document.

- This chapter includes a summary of existing protocols but refers the reader to Appendix 23 to review the protocol development summaries. There is no table or summary of the PDSs.

Do the Protocol Development Summary documents for protocols that are still in development follow the program guidance and include (1) a strong justification statement, (2) a set of objectives that meet the test of being realistic, measurable and specific, (3) the approach to be followed, (4) a list of parks where the protocol will be implemented, (5) a schedule and budget for protocol development, and (6) the name and contact information for the cooperator/contractor who will conduct the work and the lead NPS person responsible for ensuring that the work is done? For each protocol, has the target population or "sampling frame", and the sampling units, been identified?

- The justification and objectives for shoreline features PDS are fine, but I would suggest changing the title of the PDS to "shoreline change" since the amount of change along tidal streams is what is actually being monitored.

Chapter 7 – Data Analysis and Reporting

Does this chapter give a good summary of the various reports and other products of the monitoring effort, including a summary of the intended audience for each report, content, reporting schedule, and who is responsible for ensuring that data are analyzed and reported in a timely manner?

- Table 7.1 is a good summary of the reports, who will prepare them and the primary audience for each report.

Reviewer No. 6 — Water Resources Reviewer
Network: National Capital Region

Specialty: Water Quality

- General Comment: A bit long, try to condense and make more use of appendices. GRYN plan (short and concise but less comprehensive in the main plan text) is the other extreme you may want to compare to.

Chapter 1

Were water quality servicewide goals, monitoring objectives/questions, listed water bodies/ONRWs, historic data & trends listed and discussed?

- Yes, covered but could be condensed further.

Chapter 2

Were biotic and abiotic water ecosystem components/drivers identified and were water quality conceptual models integrated into the overall ecological model, presented clearly to communicate complex information or concepts, and are linkages shown?

- The T of C hierarchy used needs revision. Shouldn't Stressors and Effects be indented/subcategories of Air, Geology & Soils, Water etc. This could all be summarized with text and a table in the main plan and then go to an appendix with most of this discussion.

- Section 1.5 Some monitoring objectives still appear too general to be very meaningful.

Chapter 3

Is the water quality vital signs selection process clear and justified, connections to conceptual models made clear, and is a short list of WQ vital signs presented?

- Most of this VS discussion reference might go to an appendix, but keep the short list and discuss it in detail and briefly how you got there. Vital signs removed and justification to an appendix(?) as well.

- Table 3-2 – good

- Noted: In Table 3-2 that nearly all parks have all the same vital signs (not much of a rigorous screen or much to distinguish then?) or does this reflect a fear of sacrificed or not being in the funding mix for some VS (NCR parks are pretty similar tho)

- In addition to stream order, you will want to be distinguishing among the sampling stratum (e.g. pools vs riffles) for macroinvertebrates, I presume. Will need to be better define in protocols if not here.

Chapter 4

Is vital signs water quality integration promoted and a network map with water bodies to be sampled shown? Is a table presented summarizing parameters, sampling frequency, who will be doing the sampling and the protocols used etc?. Is there discussion of the sampling scheme to obtain representative values of a clearly defined target population?

- Yes but specifics need to be worked out (in protocols)

- No sampling sites depicted as yet, or map referenced(?)

Chapter 6

Is a data management overview provided and is the WQ data specified how it will be reported to WRD?

- No, interaction with WRD not specified nor details of NP STORET, nor WRD template specifically, flow of data not represented.

Chapter 7

Is it specified who will be analyzing the WQ data and the basic approach to this analysis?

- WQ only in general terms. Not specified who will collect WQ data as yet. (Who , what , where to be specified in protocols, frequency was specified in table however). Lots of details remain to be worked out.

Chapter 8

Is the WQ monitoring staffing needs adequately covered/discussed in the staffing plan?

- Single Biotechnician mentioned but role in WQ monitoring not specified – presumably done in conjunction with other aquatic sampling. Network may contract out some WQ sampling field work(?) or will be subject to protocol development and cost/benefit analysis, availability of park staff assistance.

Chapter 9

Are target dates for WQ protocol completion provided?

- Yes

Chapter 10

Is WQ a part of the budget summary and is the 30% objective for data management, analysis, and reporting indicated?

- WQ cost breakdown not specified as yet (developed after protocols). No mention of 30% budget reservation for data management or breakdown by individuals time.

Chapter 11

Is there sufficient literature cited particularly in reference to water quality?

- Yes

Protocol Development Summaries (water/aquatics)

- Use of State of Maryland MBSS for macroinverts protocol (per PDS) is good. Should be a proven way to go and is presumably acceptable for use in other states should credible data protocol need to be documented in future. State should have reference sites for comparison.

Summary Comment:

- Given the long list of impaired waters for this network, this is an obvious focus in meeting GPRA goals and coordination with the various states (explore) should be an objective to see what near term effect through TMDLs or otherwise in getting some of these water bodies removed. Sometimes additional monitoring will show there is no longer an impairment or the initial listing was in error. Because this is a relative high percentage of the impairments on a nationwide basis, this network could have substantial impact in reaching GPRA goals if several of these listed impairments were removed or shown to be natural.

- A good plan and comprehensive but probably more material covered than you need in the main text.

General Comments to all 12 Networks from Water Resources Reviewers:

To: Phase III Networks
From: WRD Staff (Water Quality)
Subject: General Comment on Monitoring Plans from Review of First 12

In general, the first four chapters of many of the network monitoring plans covered much of the content criteria specified in the VS monitoring plan review guidance and checklist. However, some seemed more effective, concise, or complete at making their points than others. Summarizations of the meaning of past data, objectives/questions, and study design sections still need some work in several plans. Progress on protocols, SOPs, and protocol development summaries (Chapter 5) varied greatly between networks, with only a few networks having developed good water protocols to date. Some of the best monitoring plans had short, concise text in the central plan and supporting details in protocols and the appendices.

One conclusion is that much of the key vital sign component content for an integrated plan is not in the plan text, which has to be somewhat general, but in the VS component-specific (e.g. water quality) protocols and SOPs. The first five chapters of the plans all lead up to developing protocols. For those networks that have developed draft protocols, the real proof of how good some of the first phases of the planning process have been can be found in the protocols and attached SOPs. If protocols are inadequate, then much of the value of the hard work that led up to them will be negated.

Therefore, we not only reviewed the broad plans but also concentrated on finding relatively good examples of draft (developing, none are totally complete yet) water quality protocols and attached SOPs. The best protocol narratives were those that seemed "complete" and flowed well together. They tended to repeat and elaborate on issues summarized more broadly in Plan sections on the meaning of past data, questions to be answered, the type of issues tackled (regulatory or not), the target population, how the measurements relate to values to be protected, and how the random (or not) study design will assure that the samples are representative of the target population. The best example protocols made it easy for reviewers to find the important pieces and determine how they fit together in a logical way and also had all basic QA/QC elements summarized in a QA/QC SOP.

After reviewing these initial 12 monitoring plans, we will soon be posting additional observations/lessons learned and updated short guidance on the I&M monitoring website adjacent to other WRD guidance. These will be short summaries that we believe the networks will find useful in aquatic Protocol and SOP development. These documents relay our primary focus in reviewing monitoring plan details. Those networks at earlier stages may also find these short summaries and discussions of lessons learned useful in their monitoring plan development. We will try to update and keep this document current as new topics, information, and protocol examples become available. This document "Summaries of Water Quality Protocol Guidance and Lessons Learned" will be posted shortly and may be found at: http://science.nature.nps.gov/im/monitor/vsmTG.htm#TechGuide. These initial summaries will include:

Topic 1: Relatively Good Examples from the Standpoint of Water Quality Monitoring

Topic 2: Suggestions Organized According to Original VS Monitoring Plan Checklist

Topic 3: Additional Comments from WRD Reviewers on the First 12 Phase III Plans

Topic 4: "Part B Lite" (just the basics)

Topic 5: Revision of Estimated Flow Guidance

Topic 6: Protocol/Protocol Narrative Content "short list"

Reviewer No. 7 — Academic Review
Review of the National Capital Region Network Draft Monitoring Plan

Completed 3/1/05

INTRODUCTION

The National Capitol Region Network (NCRN) draft monitoring plan is an impressive document. With 12 chapters, 26 appendices and 20 pages of references to back up the text, it is a comprehensive description of plans for monitoring the condition of ecosystems in the 11 parks within the network. Overall, the monitoring plan is an excellent guide to the NCRN parks and their natural resource issues. With some editing I suspect it might be publishable as a book by Island Press for use in college curricula on park management and for more general audiences.

As noted in Chapter 4, developing an appropriate monitoring plan for the NCRN is a "daunting task" because of the diversity of kinds of parks and their geographic range over three states and the District of Columbia. The need for a plan is great however because of the importance of these parks. Their unique features and their location in proximity to the nation's capitol gives them an especially high profile, which is indicated by the fact that they have the highest visitor use in the entire National Park Service, as noted in the text. The need for the plan is also urgent because so little monitoring is currently being conducted in the parks, as noted in the lists given in Appendix 4.

Figure 1 provides a systems overview of the overall strategy for the monitoring plan. Inventory and Monitoring (I & M) staff in the parks and their collaborators will gather information on vital sign indicators of the park ecosystems and transfer the information to park managers. The information will be used as a basis for management actions that will feedback to the park ecosystems in order to ensure that their condition is maintained in a high quality state. A critical limiting factor, as is usually the case, is the funding to support the monitoring phase of the circuit.

A major issue facing park administrators is the self organization of these small, isolated, fragmented pieces of nature within the non-natural context of urban/suburban/agricultural landscapes of the mid-Atlantic region. With stresses from whitetail deer, invasive plants, urban runoff, air pollution, visitor impacts and other sources, how much nature in the parks can we hold on to? Long term monitoring data as described in this document will help the park staff to understand and to address this challenge.

Some of the critical chapters of the monitoring plan are reviewed next, with attention to leading questions from NPS I & M Program Coordinator at the University of Idaho. Finally, several particular aspects relevant to ecological monitoring are discussed. The intention of this review is to be critical in a constructive manner, but always with full respect to the "daunting task" that the authors of this plan face.

CHAPTER REVIEWS

Several chapters are reviewed in detail below as requested.

Chapter 2 Review

- Chapter 2 is the most critical part of the whole monitoring plan because it establishes the overall approach and sets a framework for choice of things to be monitored. The approach chosen was derived from "multiple iterations based on input from the network's scientific advisory committee (SAC), subject material experts, and an exhaustive literature review" (from p. 2-1). It would have been informative to see a list of names of people on the SAC and those who served as experts, but I could not find a list in the document.

- The strategy taken by the authors of the plan follows an approach given in the literature and it is summed up in Figures 2-1, 2-3, 2-4, and 2-5. This is a logical strategy that is backed up by literature citations. The authors suggest an attractive feature of the strategy is that it explicitly separates stressors from their effects. In general the literature review is appropriate and extensive but several key references are missing. James Karr's work is cited but his summary text (Karr and Chu 1999) is not. Also, Busch and Trexler (2003) provide an excellent overview of monitoring issues.

- From the overall approach noted above, individual conceptual models are presented for Air and Climate (Fig. 2-8), Geology and Soils (Fig. 2-11), Water (Fig. 2-12), Aquatic Biota (Fig. 2-13) and Terrestrial Biota (Fig. 2-14). All of these conceptual models have the same graphic form of relating stressors to effects. Each of the individual conceptual models is discussed with an appropriate amount of text coverage and literature review. In my opinion these individual conceptual models are, perhaps, a little too conceptual and I would like to have seen a more mechanistic modeling approach taken. The authors reference model complexity issues early in the chapter (see Fig. 2-2) but they end up choosing graphic diagrams that do not explicitly show causal relationships in any depth. To some extent this issue is brought up later in the chapter in an interesting section entitled "Quantification of Ecological Thresholds" but this subject is not well developed in the text. The causal relationships between stressors and effects, implied in the individual conceptual models, could have been formalized or portrayed explicitly by using causal diagrams as a modeling approach (see Figure 6-14 in Odum 1983, also Chorley and Haggett 1967). A great deal of qualitative, verbal detail on causal pathways for the conceptual models is included in Appendix 15, which is appropriate given the space limitations imposed on the text. Good qualities of the individual conceptual models are that they are easy to communicate and to build a consensus around. These are important qualities given that the models were apparently developed by sizeable committees of people. Another good quality of the individual conceptual models is that they do directly support the selection of potential vital signs.

- I can think of few gaps in the models or omitted vital signs but a few topics that were mentioned might deserve a little more attention.

    1. Phenology is mentioned on the top of p. 2-27. Study of the timing of phenological events for selected species might be an interesting indicator of climate change. Perhaps collaborators could be found in local horticultural societies that monitor flowering times, etc.

    2. Condition of riparian buffers is mentioned in several places (at the end of section 2.5.5 and on p. 2-22), but it does not seem to have been singled out as an indicator. As noted in the text, buffers are at the interface of soil erosion and water pollution and they form an important vegetation type. There is also regulatory interest in the condition of riparian buffers throughout the Chesapeake Bay drainage as a best management practice, so collaborators may exist.

    3. There is an interesting nexus of urban hydrology, impervious surfaces, stormwater runoff pollution and land use change which is mentioned in numerous places in the chapter. These somewhat scattered notations may deserve a focal synthesis, especially given the urban context of the NCRN. I wonder what percentage of the parks' watersheds, both inside and outside the legal boundary, is covered with impervious surfaces?

    4. Finally, there seems to be an issue throughout the chapter about balancing the rare versus the common in monitoring programs. Which is more important? In general, it seems the authors do a better job addressing this issue for species than for communities. Thus, rare species will be monitored but rare environments (eg., shale barrens, talus slopes, bogs, vernal pools, springs) are mentioned but not singled out for special attention.

Chapter 3 Review

- This is a relatively short chapter but it is important because it concludes with the list of vital sign indicators to be used by the NCRN. Chapter 3 mostly concerns the process by which the final list of vital sign indicators was chosen. Basically, committees of experts including the I & M staff as workgroups were given the task of choosing vital signs and through several sessions of selective prioritization, the list was reduced from more than 200 to 21. The final list is given in Table 3-2 with detail of distribution across all of the parks in the NCRN.

- The definition of a vital sign is given on p. 3-3: "any measurable feature of the environment that provides insight into the state of an ecosystem".

- Eleven characteristics of vital signs are listed at the top of p. 3-4, based on several literature citations. To qualify for the final list, a vital sign had to match with these criteria. Later in the chapter it is noted that the function of monitoring these vital signs is to identify trigger points to initiate management actions (such as streambank stabilization).

- The distribution of the 21 vital signs in Table 3-2 is as follows: Air and Climate 5, Geology and Soils 2, Water 4, Biological Integrity 8 and Ecosystem Pattern and Processes 2. The vital signs listed are actually groups of parameters that include several "measurable features". Most of the parameters listed under the 21 vital signs are clear and precise (such as ambient temperature and precipitation or nitrate concentration), but some are rather undefined (such as rate of shoreline change). Also, in several cases with vital signs concerning biota, the parameter lists species abundance without reference to particular species. Thus, the list of vital signs could be clarified so that the reader knew what was going to be measured in each case. Perhaps this level of refinement is under development now.

- The process and criteria used to develop the vital signs is logical and clearly presented. The final list of vital signs is reasonable and matches the criteria given in the chapter. The only deficiency that I could identify is that no ecosystem processes are included for measurement, even though Chapter 2 suggested that these kinds of measurements would be made. In my opinion this is a relatively serious deficiency since it will mean that managers will be provided with no information about the direct functioning of the park ecosystems. How can the parks be managed as ecosystems without this information? The list of vital signs indicates that the parks will be monitored as collections of independent components, not as interacting systems.

Chapter 4 Review

- Chapter 4 is a short, abstract, but succinct description of sampling design for the monitoring program. This is an important chapter because it covers the strategy for data collection, including sampling locations and frequencies. The overall strategy will be based on randomly selected sampling sites using a systematic spatially-balanced design. The strategy will be multi-level in using a large scale regional grid and a fine scale park specific grid. This approach will ensure that all habitat types are included. Sampling in terrestrial systems will be grid based and sampling in aquatic systems will be watershed based. Table 4-3 is a key summary of the sampling design, which includes number of samples to be taken and sampling frequency.

- This chapter clearly states an outline to the sampling design. However, there are so many individual parameters to be measured within the 21 vital signs within the 11 parks that it is not possible for the authors to include much detail in a short chapter. Much more information is needed to judge for example, if the nitrogen sampling in the park streams or if the deer populations in the park forests will be adequately sampled. Given the relative amount of text that the authors had available for this chapter, they did an adequate job of describing the monitoring plan's sampling design.

- As a final note, section 4.6 is a very interesting part of the chapter. In this section an effort is made at facilitating the integration of different sampling programs, especially through “collocation”. Thus, sampling routines will overlap for at least three sets of components: 1) surface water quality and benthic invertebrates, 2) upland amphibians and terrestrial vegetation and 3) land birds and terrestrial vegetation. This approach allows for integration of more than one vital sign, which is a good strategy.

DISCUSSION

To conclude this review of the NCRN’s monitoring plan, additional issues are discussed below under four subheadings.

Capitalize on existing data bases

- Although there isn’t much monitoring data in place for the NCRN, a number of potentially interesting, existing data bases are listed for various parks in Appendices 4 and 7. For example, a fair amount of references are made to stream water quality and aquatic macroinvertebrates in several parks. Bird lists and counts are also noted. These kinds of records may be gems of old data that could be opportunistically used in the modern, coordinated, comprehensive monitoring plan being proposed.

- On one hand, some old monitoring that has been continuous may be judged to be important enough to focus on with new efforts of sampling so that long term records can be maintained without interruptions. Thus, if sampling of aquatic macroinvertebrates in Antietam Creek has been undertaken since 1981, make sure it continues by subjectively identifying it for future monitoring. On the other hand, some old monitoring may have been done for only a single year but it can be used as a baseline for temporal comparison. Thus, if an electrofishing survey was conducted at Manassas in 1982, focus on it for restudy with similar methods in order to judge change that has occurred over time.

- These old fragments of data can be very usefully incorporated into the modern monitoring plan, outside of the random sampling design. In a sense, these old data can be mined for new perspectives. This task would involve first, identifying and obtaining the old data and second, creatively and subjectively organizing the old data for use in the new monitoring plan. Perhaps this task is already planned by the I & M staff of the NCRN. If not, perhaps an outsider could be employed to do the work, such as a local university faculty member on a sabbatical leave or a consultant. This would be a job for a generalist who could span all of the vital signs that have been chosen.

Weakness in ecological theory

- The monitoring plan uses an elementary level of ecological sophistication throughout. This is not surprising since the problem has been noted in the literature for similar efforts (Noon 2003, Woodward et al. 1999). Most of the ecological monitoring will involve basic physical-chemical data or population data on selected species with little integration into an ecosystem context. Also, as mentioned earlier, no functional properties of the ecosystems will be measured. Modern ecological theory is missing from the report on many topics such as food web theory (Pimm 1982, Polis and Winemiller 1996), assembly rules (Temperton et al. 2004, Weiher and Keddy1999), stoichiometry (Sterner and Elser 2002), network analysis (Wulff et al. 1989, Fath and Patten 2000) and emergy analysis (Odum 1996). The problem with not addressing the latest thinking in ecology is that the information gathered in monitoring does not reflect the state of the art. Also, important kinds of data are completely overlooked. Perhaps “the old story about the blind men trying to visualize an elephant from a disconnected set of tactile impressions” (Hedgpeth 1978) applies here.

- I still believe the proposed monitoring plan will result in a good deal of very interesting and useful data. The authors chose an approach that they are familiar with and comfortable with, in terms of personnel and mind-set. However, I also believe they will be missing a lot of interesting ecology.

- Perhaps it could be argued that the criticism is mitigated by the way vital signs are to be used – as trigger indicators for management action. If management can be done without ecological theory, then it is not necessary to gather data and analyze it in this context. For example, ecological theory is not needed to know that streambank stabilization is needed on an eroding stream. But I wonder whether or not certain non-obvious aspects of park management could be improved with input informed by ecological theory.

Bias against microbes

- In general the monitoring plan reflects the normal bias towards macroscopic biota with little mention of microbes. This bias is common to many environmental studies but at least it needs to be acknowledged. Microbial ecology has long been recognized as being important (Wiebe 1971) but it is seldom integrated into ecosystem scale field studies because the methods differ so much from methods for macroscopic biota. However, microbes are of critical importance in ecosystems. For examples, Lodge et al. (1996) classify microbes as keystone species and Jefferies (1999) describes their role as "pacemakers" in biogeochemical processes. Some aspects of disease ecology are covered in the monitoring plan but new discoveries, such as relates to the resistance of microbes to antibiotics, may indicate that certain additional aspects of microbial ecology deserve more attention. Finally, a field guide to bacteria now exists (Dyer 2003) so perhaps microbial ecology will become more a part of general natural history studies.

A role for urban ecology

- Urban ecology is a subdiscipline that is gaining a significant amount of attention but it is not addressed with depth in the monitoring plan. Much research is currently being carried out on urban ecosystem (Adams 1994, Collins et al. 2000, Pickett et al. 2001) and a major long term, NSF-funded study (an LTER) has been underway in nearby Baltimore for several years (Parlange 1998). According to the monitoring plan, the models used "are meant to emphasize the unique urban nature of the National Capital Region (NCR) parks" (p. 2-6), but there is little direct reference to the growing literature on the subject. The best connections with the urban context are made in sections on climate and air quality but urban ecology could be a theme utilized throughout the plan and that could be highlighted in the beginning. Perhaps it would be useful for the I & M staff to meet with the Baltimore LTER group for possible collaboration, if this has not already been done.

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Summary of Response to Phase III Review comments

Executive Summary

The executive was updated and expanded so that it clearly summarizes each chapter.

Chapter 1: Introduction and Background

This chapter was shortened by removing sections describing staff and Board of Directors. In addition, the planning process was summarized in a table format while the details were retained and presented in an appendix. In addition, the section on enabling legislation was reorganized so that it summarizes national laws and then focuses on park enabling legislation. Some of the details were also removed. The discussion unifying GPRA goals, legislation, and monitoring objectives were slightly reworded. Sections describing significant natural resource, their threats, and ongoing monitoring efforts were enhanced by summary tables taken from appendix 6. Appendix 6 was removed entirely. Appendix 11 was also summarized in a new table. Appendices 4 and 11 were also shortened but much of the information was retained for future reference.

Chapter 2: Conceptual Models

This chapter was edited to provide a stronger link between the legal and environmental context presented in chapter 1 and the vital sign selection process described in chapter 3. The iterative process by which the models were developed over time through consultation with subject matter experts and the scientific literature was described in more detail. These revisions provide a more transparent connection between the monitoring objectives described in Table 1.5, the draft models described in Appendix 15, and the final models presented in this chapter.

In general, the text was streamlined to present the models as a more succinct and linear story. Language referring to the use of models in a hypothesis-testing framework was considered inappropriate and removed from the chapter. The ecological threshold/quantification section also was removed on the advice of the reviewers.

Finally, one reviewer asked for a more mechanistic set of models that provided more causal relationships. The chapter was edited to emphasize that although the models allow a causal link to be statistically established, a deeper understanding of the detailed mechanisms that might be involved is beyond the scope of I&M monitoring. One additional model was added that consolidated the scattered references to urban hydrology, impervious surfaces, stormwater runoff pollution and land use change into a focal synthesis related to the urban setting in which NCRN monitoring is being conducted.

Chapter 3: Vital Signs

The discussion about the prioritization process was streamlined and shortened. A graphic was added to help describe the vital sign selection process. The detailed justifications for why vital signs were removed are now presented in appendix xxxx instead of this chapter. Table 3-2 was modified to easily show the difference between vital signs monitored by other agencies, by NPS, and for which vital signs protocols must be developed. Important vital signs that were originally removed because protocols would not be developed were added back to Table 3-2 to help identify future monitoring priorities.

Chapter 4: Sampling Design

This chapter has been rewritten to reflect the sampling design strategies for 1. terrestrial and 2. aquatic systems. The chapter presents justification for using GRTS and selecting 250 m grid design using simple English instead of technical jargon.

Chapter 5: Sampling Protocols

The tables in this chapter were expanded to provide more information about the justification and measurable objectives for each protocol. One table was added to show which protocol applied to which vital sign. Another table was provided to summarize the vital signs for which protocols would not be developed but need to be considered for the future. The justification discusses why the vital signs are important and why protocol development received a lower priority than other vital signs.

Chapter 6: Data Management

This chapter has been updated to reflect the most recent version of the Data Management Plan's Executive Summary. Topics specific to the NCRN data management strategy were inserted to make the chapter more relevant.

Chapter 7: Data Analysis and Reporting

Chapter 7 significantly expanded its discussion for analyzing vital sign data. The reporting section was updated to include the State of the Parks Report Card. Questions about the need for final reports and annual analyses were inserted.

Chapter 8: Administration and Implementation of Monitoring Program

The sections discussing the program's staffing plan were updated to reflect new developments since the Phase III report. The chapter also presents a more detailed discussion for integrating the monitoring program into park management. The chapter fully integrates water quality monitoring in the implementation section. The staffing plan has been updated.

Chapter 9: Schedule

The revised chapter includes a detailed annual sampling schedule. In addition, the schedule table is revised to show the timeline for completing and implementing protocols.

Chapter 10: Budget

The annual budget was updated to reflect better cost estimates. In addition, the table was revised to show how 30% of the annual budget is dedicated to data management. The chapter also reflects a new staffing plan and we have made a 10-year budget projection.

Literature Cited

The Lit Cited was reformatted to conform with requested format.

APPENDICES

Some appendices were edited as requested. Changes to the content are documented below. The following appendices from the Phase III report did not change in content but were renumbered: 3, 5, 9, 10, 12, 19, 20, 21, 22, 24, 25, and 26.

Appendix 1.

This appendix was removed. A map was incorporated into chapter 1.

Appendix 3

Despite comments to remove this appendix, it was retained as reference material.

Appendix 4

Despite several comments to shorten the park summaries, we decided that all of the information was relevant and important reference material that is not readily available in another format. Instead of shortening the appendix, a very short summary is presented in table format in chapter one. Another table which summarizes each parks key natural resources and management issues are presented within the appendix for quick reference.

Appendix 6

This appendix was removed. The content was shortened considerably and integrated into chapter 1.

Appendix 7

This appendix was removed. The content will be incorporated into the Water Chemistry Protocol.

Appendix 8

This appendix was removed. The content will be incorporated into the Water Chemistry Protocol.

Appendix 11

This appendix was shortened somewhat. Much of the information, however, is very useful reference material especially for new staff who need to know about all the regional monitoring efforts. A summary table, however, was created and inserted in Chapter 1.

Appendix 14

This appendix was removed but the content is explained in chapter three.

Appendix 15

This appendix was shortened by removing threats column. The information was only preliminary and was not used to establish any prioritization. It was also clarified that the model was really just a list of comprehensive monitoring issues and questions generated early in the planning process.

Appendix 16

This appendix was removed but the content is explained in chapter three.

Appendix 17

This appendix was removed because it was not actually used for prioritization. In part it was combined with appendix XXX which discussed the seven-step implementation process.

Appendix 23

The Protocol Development Summaries were updated. Most significant changes include revisions and clarifications of objectives for each protocol.

Appendix XX

Appendix XX was added to document comments received from peer reviewers and to document our responses.

Appendix XXX

Appendix XXX was added to document comments received from peer reviewers and to document our responses.